FISH RESOURCE MONITORING PROGRAM FOR THE UPPER FLATHEAD BASIN

Prepared by

Bradley B. Shepard
and
Patrick J. Graham

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SUMMARY

This report recommends a fish abundance and aquatic habitat monitoring program for the Upper Flathead Basin. We recommend estimating fish abundance, age and growth, inventorying bull trout spawning sites, and assessing streambed composition in bull trout spawning areas in selected tributaries to the North and Middle Forks of the Flathead River. Habitat surveys should be repeated in tributary drainages as development occurs or following catastrophic natural events. We also recommend monitoring relative fish abundance in five areas of Flathead Lake during the spring and plankton populations at one site in Flathead Lake from mid-April through mid-October.

I. North and Middle Forks of the Flathead River

A. Fish abundance

1. Electrofishing

a. Estimate numbers of fish by species for fish 75 mm and larger.

b. Block fences (nets can be used in streams less than 10 cfs).

c. Bank shocking techniques must be used in stream 10 cfs or larger. Backpack shockers may be used in inaccessible streams less than 10 cfs.

d. Two-catch estimators may be used in streams less than 20 cfs, providing probability of capture is great ($\hat{p}>0.6$). Calculate probability of capture in the field:

($\hat{p} = \frac{C_1 - C_2}{C_1}$, where C_1 = number of fish captured during first pass
C_2 = number of fish captured during second pass)

e. Mark-recapture estimators must be used in streams larger than 20 cfs and in all streams smaller than 20 cfs where probability of capture is low ($\hat{p}\leq 0.6$).

2. Snorkeling

a. Count fish by species and age class while moving upstream through 150 m sample sections in tributaries.

b. Count fish by species and size class while moving upstream in every pool, 50% of the runs and two or three representative riffles and/or pocketwaters in two 3.0 km sample sections of the Middle Fork of the Flathead River.

B. Age and growth

1. Take scale samples from above the lateral line between the dorsal fin from ten fish in each 10 mm size range captured during electrofishing.

2. Make cellulose acetate impressions of scales.

3. Read scales and measure distances from the focus to each annuli and the scale's edge.

4. Analyze data on computer programs.

C. Bull trout redd inventories

1. Conduct preliminary surveys during the fall when maximum daily water temperatures drop to approximately 9°C.

2. Conduct final redd counts when few fish and numerous redds are found in the spawning grounds.

3. Classify all redd observations according to established criteria and locate each redd within the survey area by pace number.

4. Measure depth of the water over the front edge of the depression.

D. Streambed composition in bull trout spawning areas.

1. Remove 10 kg samples from four sites along each transect.

2. Take a 1.0 liter Imhoff cone sample of water from within the corer and let settle for 20 minutes before reading the settleable material as mg/l.

3. Record the depth of water within the corer.

4. Transport the sample to the USFS Soils Laboratory, dry and shake through a sieve series consisting of 76.1, 50.8, 16.0, 6.35, 2.0 and 0.063 mm sieves.

5. Weigh the material in each sieve.

6. Analyze data using appropriate computer programs.

II. Flathead Lake

A. Relative fish abundance

1. Set two-38.1 by 1.83 m (125 by 6 feet) standard floating

gill nets and standard sinking gill nets tied end to end at three sites in five areas of the lake during the spring.

2. The lake should be isothermal at 4 to 5°C at the time of sampling. Measure temperature profiles at the netting area to document this isothermal condition.

3. Record lengths and weights of all fish by species.

4. Check gonadal condition and collect scale samples for all trout and salmon.

B. Zooplankton

1. Two 15 m vertical plantkon tows should be collected biweekly near Bigfork from mid-April to mid-October.

2. Combine both samples into a single sample bottle.

3. Count the number of each species in three to five 1 ml samples on a Sedgewick-Rafter cell after diluting with a known volume of plankton preservative. Expand the numbers to a total sample.

4. County Leptodora and adult Epischura for seven to 10 percent of the sample.

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INTRODUCTION

The Flathead River Basin Environmental Impact Study was initiated in 1978 to collect baseline natural resource information. The Montana Department of Fish, Wildlife and Parks (MDFWP) was responsible for the fisheries portion of the study. During this study, methodologies to document fish abundance and the condition of the aquatic habitat were developed and evaluated (Montana Department of Fish and Game 1979, Graham et al. 1980, Leathe and Graham 1981, Fraley et al. 1981, Leathe and Graham 1982, Shepard et al. 1982). Another aspect of the fisheries investigation dealt with the utilization of the fish resource by the angling public (Fredenberg and Graham 1982, Fredenberg and Graham 1983, Graham and Fredenberg 1983). Other fish resource investigations presently being conducted in the upper Flathead Basin by the MDFWP include: 1) assessing kokanee salmon populations in Flathead Lake, and their use of lakeshore and upriver spawning areas (Hanzel 1964, McMullin and Graham 1981, Fraley and Graham 1982, Decker-Hess and Graham 1982); 2) sport fish use of the Swan River drainage above Swan Lake, and potential impacts of micro-hydro development on this resource (Leathe and Graham 1983); and 3) the response of cutthroat and bull trout populations and their habitat to logging activity in the Coal Creek drainage (Shepard and Graham 1983).

The purpose of this report is to recommend a fish abundance and aquatic habitat monitoring program for the waters of Flathead Lake and drainages of the North and Middle Fork of the Flathead River. The monitoring program is organized in two parts: 1) North and Middle Fork drainages and 2) Flathead Lake. Methods and monitoring procedures are presented, including: 1) rationale, 2) assumptions, 3) sample sites, 4) equipment needed, 5) procedures, 6) estimators, and 7) report format. These monitoring procedures could also be applied to other waters in the region. Sample sites and sampling frequencies were prioritized based on a desire to provide a variety of information in developed and undeveloped (control) sites. Lower priority sites would serve to increase sample size rather than provide more diversity of sites. Monitoring costs were computed by sampling procedure and by sample site using 1982 dollar values (Appendix A).

The need for some type of long term monitoring in the basin was recognized by Graham (1980) and Fraley et al. (1981). Fish resource information collected during this study provides an exhaustive data base against which future data can be compared to evaluate changes in fish abundance and habitat. The relative merits of various methodologies have been evaluated during the five years of this study to recommend preferred methodologies for collecting data. The procedures selected for monitoring the fish resource described in this report must be followed precisely to facilitate meaningful comparisons between the baseline data collected to date and data collected in the future.

The major problem one faces in designing a long term monitoring program is balancing the need for precise and accurate data within a limited budget.

Methodologies presented provide for a range of resolution based on sampling intensities. An estimate not meeting the precision recommended can be reported but should be used cautiously. Reliability can be improved by increasing the number of sites sampled and the frequency of sampling.

The minimum monitoring program described will provide data to index trends in fish abundance and habitat conditions. The number of sample sites and sampling frequencies should be increased to fine tune monitoring both spatially and temporally.

NORTH AND MIDDLE FORKS OF THE FLATHEAD RIVER

The monitoring program is designed to collect information on fish populations in developed and undeveloped stream drainages. Monitoring undeveloped drainages in Glacier National Park and adjacent wilderness areas will provide "control" data on natural fluctuations in fish populations, in contrast to fluctuations in populations potentially impacted by man-caused perturbations. This monitoring program can provide fisheries professionals with the necessary information to assess cumulative impacts of seemingly unrelated impacts upon the fish resource. When monitoring a complex, dynamic biological system, such as fish populations in the upper Flathead Basin, data collection must continue over a long time period (several decades) to account for variability associated with environmental conditions, relative year class strengths in fish populations, and precisions of methodologies. More intensive investigations would be warranted when:

a) fish population levels seem to be decreasing, or

b) to provide information in areas where proposed development may affect fish habitat or fish abundance.

A factor complicating the development of a monitoring program in the upper Flathead Basin is the mixed ownership of land in the basin. Tributaries draining the west and south portions of Glacier National Park flow into the North and Middle Forks of the Flathead River, respectively (Figure 1). The upper and middle segments of the Middle Fork of the Flathead River and its tributaries flow through U.S. Forest service land comprising the Bob Marshall and Great Bear Wilderness areas, respectively. The U.S. Forest Service manages the majority of remaining land in the upper river basin under multiple use with a small portion of land under private and State ownership. These various land managers often have diverse management objectives, resulting in a wide range of land management activities occurring within the basin. For this reason, any long term monitoring effort must be coordinated with the various agencies and individuals affected.

FISH ABUNDANCE

Our study relied on a single fish abundance assessment technique to make meaningful comparisons between streams within the upper Flathead Basin. Snorkeling was chosen to assess fish abundance because: 1) the study area was extensive (≅7000 km^2) with large portions being inacessible by road; 2) waters inventoried included streams draining Glacier National Park and the Great Bear and Bob Marshall Wilderness areas where the use of motorized equipment is prohibited; and 3) snorkeling was reported to be an effective method to assess fish abundance in clear, low conductivity waters (Northcote and Wilkie 1963, Goldstein 1978, Whitworth and Schmidt 1980, Griffith 1981). Fish abundance was also estimated using electrofishing techniques in a limited number of

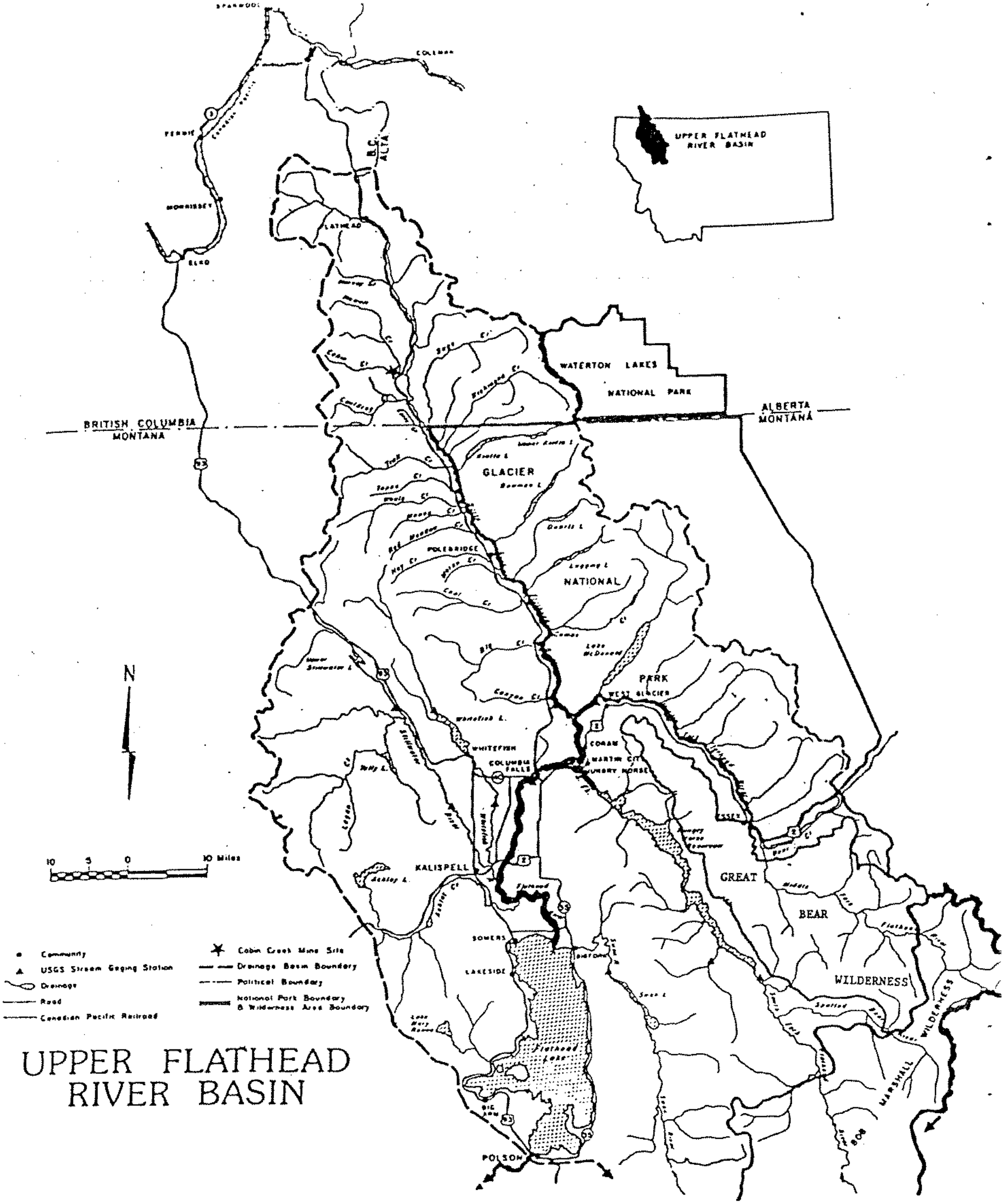

Figure 1. Map of the Upper Flathead River Basin. Adapted from Montana Department of Natural Resources and Conservation (1977).

accessible sites to evaluate the relative efficiencies of snorkel counts and estimates computed using mark-recapture (Vincent 1971), two-catch (Seber and LeCren 1967) and multiple-catch (Zippin 1958) electrofishing estimators.

Future monitoring will focus on quantifying yearly variation of fish abundance in stream sections sampled consistently year after year. We recommend using electrofishing techniques to assess fish abundance in accessible streams because:

1) the precision of electrofishing estimates can be estimated and reported, providing a measure of reliability;

2) There is less bias associated with changes in field personnel; and

3) estimates derived using electrofishing techniques are presently better accepted by fisheries professionals.

After analyzing fish abundance estimation data collected during this study and reviewing pertinent literature, we documented the rationale followed in developing the following fish abundance monitoring guidelines (Appendix B). Our conclusions were:

1) In streams less than 10 cfs, use a two-catch electrofishing estimation technique. In these small streams adequate numbers of fish can be captured using a back-pack mounted generator-Variable Voltage Pulsator combination (Coffelt or equivalent). Probability of capture ($\hat{p}$) should be higher than 0.6 to obtain reliable results.

2) In streams 10 to 20 cfs, two-catch electrofishing estimation can be used; however, $\hat{p}$ values must be higher than 0.6. Bank shocking techniques (see "Mark-Recapture Procedure," p. 10) must be used. If the $\hat{p}$ value falls below 0.6 for a sample site, a mark-recapture estimate should be used instead of the two-catch estimate.

3) In streams larger than 20 cfs, use a mark-recapture estimation technique and electrofish the sample section using bank shocking procedures.

Snorkeling is the only viable technique to assess fish abundance in streams within Glacier National Park and wilderness areas. Priorities were assigned to the recommended fish abundance sample sites based on a desire to adequately assess the diverse fish populations present within the drainage (Table 1).

Electrofishing

Sample Sites

Sample sections for monitoring fish abundance using electrofishing techniques were established in tributaries to the North and Middle forks of

Table 1. Summary of recommended fish abundance monitoring program for the upper Flathead River basin, including method (Bank = bank electrofishing, Pack = back pack electrofishing, M-R = mark-recapture estimation, 2-pass = two-catch estimation, snorkel = snorkel census and snorkel float = river snorkel census), target species (WCT = westslope cutthroat and DV = bull trout, time of estimate, field man days and priority. All sample sections are 150 m long.

Drainage	Creek	Reach	Method	Species	Timing	Days Field	Days Data Analysis	Priority
North Fork	Akokala[1]	I	Snorkel	WCT	August	2	1	1
	Coal	II	Bank, M-R	DV, WCT	August	8	2	1
	Red Meadow	II	Bank, M-R	WCT, DV	September	8	2	1
	Whale	I	Bank, M-R	DV	August	8	2	1
	Trail	I	Bank, M-R	DV	August	8	2	2
	Cyclone	I	Bank, 2-pass	WCT	August	3	1	2
	Langford	I	Pack, 2-pass	WCT	late June	2	1	2
Middle Fork	Ole[1]	II	Pack, 2-pass[2]	DV, WCT	September	3	2	1
	River[1]	Schafer Meadow	Snorkel float	WCT	August	3	1	1
	Morrison	IV	Pack, 2-pass	DV	September	2	1	1
	Challenge	I	Pack, 2-pass	WCT	late June	2	1	1
	Schafer[1]	III	Snorkel	WCT,DV	August	2[3]	1	1
	River[1]	Gooseberry	Snorkel float	WCT	August	6[3]	1	2
	Trail[1]	I	Snorkel	DV	August	2[3]	1	2

1/ Waters in Glacier National Park or Wilderness areas which can be used as "controls".
2/ Electrofishing in Ole Creek depends upon cooperation with Glacier National Park
3/ Man-days depend upon flight into Schafer Meadow in conjunction with sampling in Schafer Creek and the river at Schafer Meadow.

the Flathead River. Langford, Coal, Cyclone, Red Meadow, Whale and Trail creeks were selected for monitoring fish abundance in the North Fork drainage (Figure 2). Challenge, Morrison and Ole creeks were selected for monitoring fish abundance in the Middle Fork drainage (Figure 3). Maps showing exact sample site locations were prepared (Appendix C). Conduct all electrofishing estimates in the late summer except those in Langford and Challenge creeks which should be conducted in late June (Table I).

Equipment

Equipment needed to electrofish sample sections includes gear to block off the section, capture fish, collect information from fish and record data (Appendix D).

Mark-Recapture Assumptions

1) Marked fish suffer the same natural mortality as unmarked fish (or mortalities caused by marking are removed from the population and added to the final estimate separately).

This assumption can be met by handling captured fish with care and recording all mortalities.

2) Marked fish are equally vulnerable to the method of capture as are unmarked fish.

If fish are segregated by species and include only fish 75 to 250 mm, this assumption will be met.

3) Marked fish do not lose their mark.

Tag loss can be reduced by proper application of the mark.

4) Marked fish become randomly mixed with unmarked fish; or the distribution of fishing effort in subsequent sampling is proportional to the number of fish present in different parts of the body of water.

Assumption 4 can be reasonably met if all fish captured during the marking fishings are distributed throughout the sample section at the time of release and allowed two or three days to redistribute naturally before the recapture fishings.

5) All marks are recognized and reported on recovery.

This assumption will be met if assumption 3 holds and captured fish are examined carefully after the recapture fishings.

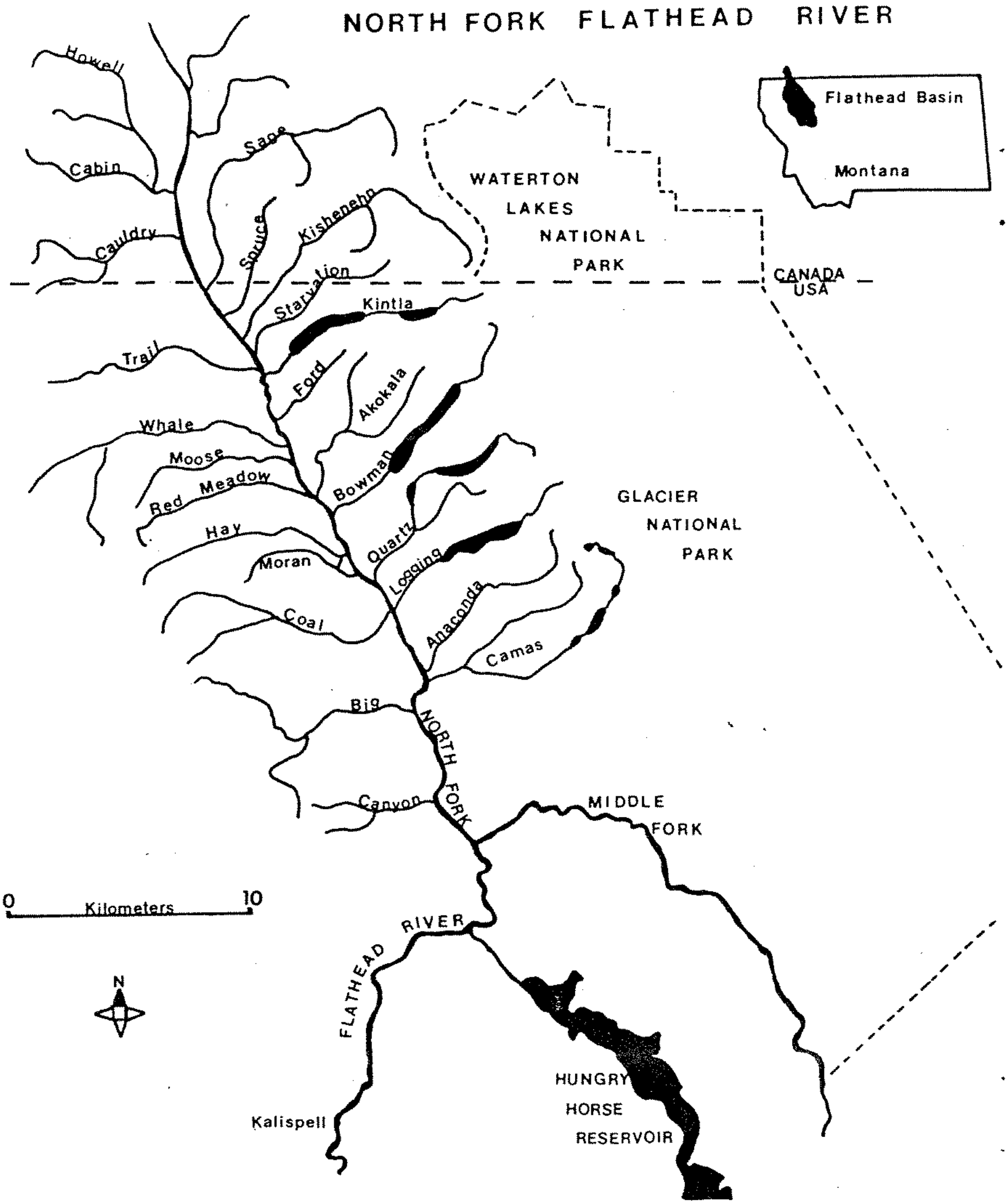

Figure 2. Map of the North Fork of the Flathead River showings its major tributaries.

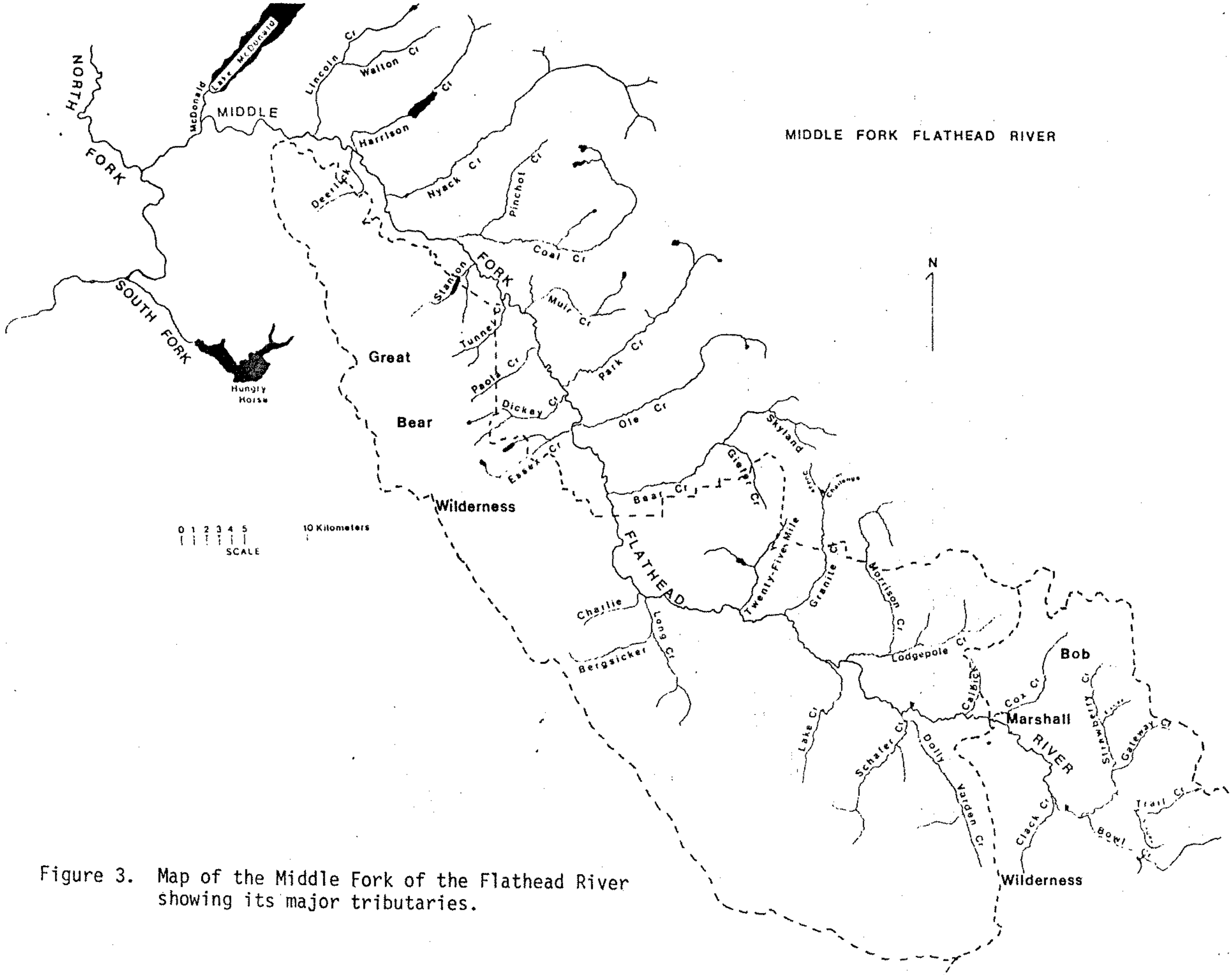

Figure 3. Map of the Middle Fork of the Flathead River showing its major tributaries.

6) There is a negligible amount of mortality, movement and recruitment to the catchable population between the marking and recapture fishings.

Assumption 6 can be satisfied by doing the recapture fishing a short time (2 or 3 days) following marking fishings and maintaining block fences of 12.7 mm mesh hardward cloth at the upstream and downstream boundaries of the sample section. Fish in upper Flathead tributaries were found to be highly mobile and movement frequently occurred during summer months when abundance estimates should be conducted. For that reason, we recommend using block fences during all electofishing estimates. We believe these block fences effectively block movement of fish 75 mm and larger, and recommend estimates be made for fish of that size.

Mark-Recapture Procedure

Place block fences (12.7 mm mesh) at the upper and lower boundaries of the shocking section. Pound fence post through the hardware cloth approximately 0.30 m above the bottom edge of the hardward cloth. The bottom edge of the hardware cloth must be facing upstream (Figure 4). Place rocks and gravel on the bottom portion of the hardward cloth and around the fence posts sealing the bottom of the block fences to prevent fish from moving under the fences. Tie a rope from a tree or rock on one bank and string this rope across the stream by tying it to the top of each fence post and securing it to another tree or rock on the opposite bank of the stream. Use bailing wire cut into 0.30 m lengths to wire the hardware cloth up to the rope holding the hardware cloth fence upright.

Set up generator and Variable Voltage Pulsator in the middle of the fish abundance section. Use either a stationary plate located in the water near the generator - Variable Voltage Pulsator setup or a hand held electrode as the negative electrode. The positive electrode must be hand held and is connected to the Variable Voltage Pulsator with enough electrical cord to extend over the entire fish abundance section. It is advisable to tie overhand knots in the electrical cord at all locking plug connections.

Electrofish the section starting at the upstream end and fish downstream. Hold all fish in live cars. Fish less than 75 mm should be held in buckets. After fishing the section down to the lower block fence, carefully check for stunned fish lying against the lower block fence.

Work the fish after anesthetizing them in groups of 20 to 25. Record species, length (to the nearest mm), weight (to the nearest g), tag numbers (on fish ≥ 100 mm but ≤250 mm use dangler tags and on fish >250 mm use floy tags) or clip a fin on fish less than 100 mm, take a scale sample (see AGE AND GROWTH, p. 23), note sex and state of maturity and return the fish to a live car. After working all fish, sum the fish captured and determine if enough fish were captured to obtain the level of precision desired (see "Mark-Recapture Population Estimators" p. 14). Be sure to identify mortalities on the data sheet.

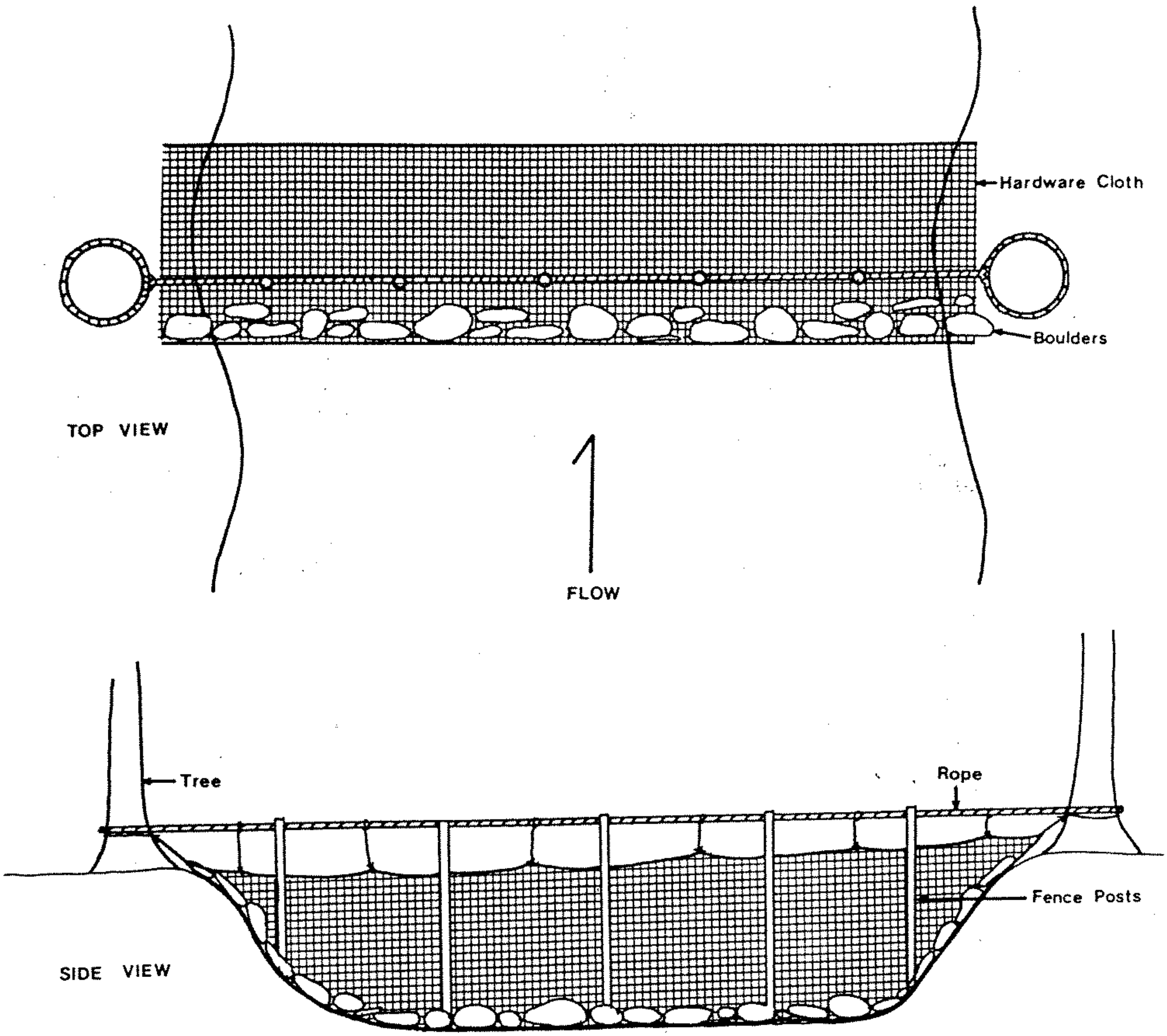

Figure 4. Schematic diagram illustrating the proper method of installing a block fence. Step one involves pounding in fence posts, rocking bottom of net, and tying a rope across the creek, (upper figure). Step two consists of stretching the hardware cloth up vertically and tying it off to the rope (lower figure).

If another pass is needed to mark the desired number of fish, be sure to keep fish captured during the second pass separate from those captured during the first pass. A two-catch estimate (see "Two-Catch Population Estimators" p. 16) can be made in addition to the mark-recapture estimate. Work fish as described in the preceding paragraph, keeping the two fishings separately identified.

After the fish have recovered, return them by redistributing fish throughout the length of the section. Be sure to record any mortalities by tag number or fish length. Maintain the block fences for two or three days. Check and clean the block fences every morning and evening. More frequent cleaning may be required. Record any fish mortalities collected along the fences within the section by tag number or fish length.

Recapture electrofishing is done two or three days following the marking run. Electrofish the section using the same procedure as the marking run. When working the fish, carefully examine all fish for marks or tags. Fish not previously marked can be marked at this time to provide movement information and/or allow for further recapture runs and application of a Schnable-type (1938) estimate (Appendix B). Record all fish collected during the recapture run as either newly marked fish or recaptured fish on Form FMD-A (Appendix E). Sum the total number of fish captured during the recapture run and determine if enough fish were captured to provide the level of precision desired (see "Mark-Recapture Population Estimators" p. 14 for an explanation).

After completing the electrofishing, estimate the wetted surface area of the shocking section by measuring its length and at least 10 widths.

<u>Mark-Recapture Population Estimators</u>

Formula to estimate population numbers:

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

Ricker (1975)

Where: $\hat{N}$ = Population size at time of marking

M = Number of fish marked

C = Catch or sample taken for census (Total catch on recapture run)

R = Number of recaptured marks in sample

Variance of the estimate:

$$V(\hat{N}) = \frac{N^2(C-R)}{(C+1)(R+2)}.$$

Calculate $\hat{N}$ (number of fish) by species for fish $\geq$75 mm and their associated 95% confidence intervals. The number of mortalities found during the marking pass and between the two passes must be added separately to the estimate (separated by parentheses since these fish were not used to estimate $\hat{N}$). When the numbers of marked and recaptured fish are sufficiently high, the advantage of stratifying by age or size classes should be applied (Vincent 1971). Calculations should also be done to estimate the density by species (number of fish per 100 m^2 of wetted surface area) using the formula:

$$\text{Density} = \frac{\hat{N}}{\text{Wetted Surface Area}} \times 100.$$

Sample sizes (the number of fish to mark and recapture) for the desired level of precision (95% confidence interval to be within 25% of the estimate) can be found in Robson and Regier's (1964) chart for $1-\alpha=.95$, $p = 0.25$ and $N \leq 100$ or by consulting Table 2 for equal mark and recapture efforts. At least four (Ricker 1975) and preferrably seven (Robson and Regier 1964) fish of each species must be recaptured to make a reliable estimate. As mentioned previously, we believe there is little difference in capture probabilities (efficiencies) for the size range of fish sampled (75 to 250 mm) in tributaries monitored.

Two-Catch Assumptions

1) Probability of capture (p) is large enough to have a significant effect upon population total (N).

This assumption can be tested by computing $\hat{p}$ after two passes are complete. If $\hat{p}$ is less than 0.5, assumption 1 probably has been violated (Junge and Libovarsky 1965) and a mark-recapture estimation technique should be used. We recommend $\hat{p}$ should be 0.6 or larger.

2) Probability of capture is constant. Fishing effort is the same for both catches and fish remaining after the first fishing are as vulnerable to capture as were those that were caught in the first fishing.

Assumption 2 has frequently been found to be faulty when electrofishing (Lelek 1965, Gooch 1967, Cross and Stott 1975, Mahon 1980). White et al. (1982) found if $\hat{p}$ was 0.8 or larger, two-catch estimates were reliable because failure of constant probability of capture (assumption 2) did not matter. We found that as long as $\hat{p}$ was 0.6 or larger and stream discharge was less than 10 cfs, estimates computed using two-catch estimators were similar to mark-recapture estimates (Appendix B). Zippin (1956) determined that if the probability of capture ($\hat{p}$) decreases with subsequent fishings, the estimate was an underestimate of the true population size. These estimates may still be reported, but should be used cautiously. They can be used to compare trends in population abundance, provided the same techniques are used throughout the monitoring program.

Table 2. Number of fish to be captured during each fishing (marking and recapture) for various estimated population sizes ($\hat{N}$) and error bounds (B, recommended $B \leq 25\% \hat{N}$) at the 95% level of confidence. From the formula:

$$B = 2\sqrt{\frac{N^2(N-M)}{MC}}$$

where M=C, presented by Jensen (1981).

Estimated Population Size ($\hat{N}$)	Error bound (B)		
	25% N 1/	50% N	100% N
25	20	14	9
50	33	22	13
100	54	33	22
150	71	42	23
200	86	50	27

1/ Recommended error bound

3) There is no recruitment, mortality, immigration or emigration between the times of the two fishings.

Assumption 3 can be easily met, since both electrofishing fishings take place within a single day and the section is blocked using block nets.

4) The first catch is removed from the population or, if returned alive, the individuals are marked so they can be ignored when counting the second catch.

This assumption can be met by removing the first catch from the population.

Two-Catch Procedure

Place a braided nylon block net (12.7 mm mesh) at the lower boundary of the shocking section in streams less than 10 cfs. In streams 10 to 20 cfs, hardware cloth block fences should be placed at the upper and lower boundaries allowing a mark-recapture estimate to be conducted, if necessary (see "Mark-Recapture Procedure" p. 11). When using a block net, place the net in the stream with the bottom edge facing upstream and place rocks on the weighted (bottom) edge of the net to hold it in position. Tie the ropes along the top edge of the net to a tree (or any available stable item) on each bank to stretch the net tight and hold it perpendicular across the stream. Place rocks along the entire bottom edge of the net to ensure no fish will move past the net. Support the net upright using willow or alder branches cut into 1.0 to 1.5 m lengths on-site.

In streams less than 10 cfs, a backpack mounted generator-Variable Voltage Pulsator combination can be used to electrofish the stream. In streams larger or equal to 10 cfs, use the bank shocking technique described in the "Mark-Recapture Procedure" (p. 10). The bank shocking method was more efficient for capturing fish and should be used where possible.

Electrofish the section working from the upstream boundary down to the lower block net as described in the "Mark-Recapture Procedure" (p. 10). We found that downstream electrofishing was more efficient than upstream electrofishing, and if two passes are needed for each catch (to provide a reliable estimate), both passes should be made downstream. It is important to extend equal efforts during each catch, so that if two passes were used for the first catch, two passes must also be fished for the second catch. Mahon (1980) believed longer time periods between catches improved the accuracy of catch per unit effort estimators. For this reason, we recommend waiting a minimum of 90 minutes between fishings. During this time, work all fish captured on the first catch (see "Mark-Recapture Procedure" p. 10).

It is advisable to mark fish ("Mark-Recapture Procedure" p. 10) from the second catch allowing movement information to be collected. It may also be necessary to conduct a mark-recapture estimate if the desired level of $\hat{p}$ cannot be met.

After working the fish from the second pass (see "Mark-Recapture Procedure" p. 10), compute $\hat{p}$ values for each species using the formula:

$$\hat{p} = \frac{C_1 - C_2}{C_1} \qquad \text{(see p. 10 for details)}$$

Where: $\hat{p}$ = probability of capture

C_1 = number of fish ≥75 mm captured during first catch (by species)

C_2 = number of fish ≥75 mm captured during second catch (by species).

If $\hat{p} \geq 0.6$ a reliable estimate can be made using the two-pass estimator; otherwise, more fishing effort must be expended. This effort can be expended for computing a multiple estimate (by completing additional electrofishings and computing a multi-catch estimate using formulas presented in Zippin (1958). Note: To apply multi-catch estimates, $\hat{p}$ must remain constant for each pass. This can be verified through calculations), or for a mark-recapture estimate (by marking all fish captured during C_1 and C_2 and completing a recapture fishing two or three days later). The choice will depend upon available time and the opinion of those in the field concerning the probability that additional effort will produce the desired precision using two-catch versus mark-recapture estimators.

Two-Catch Estimators

Formula to estimate population number:

$$N = \frac{C_1{}^2}{C_1 - C_2} \qquad \text{(Seber and LeCren 1967)}$$

Where: $\hat{N}$ = population size at time of first catch

C_1 = number of fish captured during first catch

C_2 = number of fish captured during second catch

Variance of the estimate:

$$V(\hat{N}) = \frac{C_1{}^2 C_2{}^2 (C_1 + C_2)}{(C_1 - C_2)^4}$$

Probability of capture ($\hat{p}$):

$$\hat{p} = \frac{C_1 - C_2}{C_1}$$

As stated previously, $\hat{p}$ must be ≥0.6 for a reliable, two-catch estimate to be made. If $\hat{p}$ <0.6, the estimate can be reported, but must be viewed with caution.

Report Format

When reporting the estimates of fish numbers computed by electrofishing, report the estimate, the 95% confidence interval in parentheses, the area of the section surveyed, the date, and the density calculated as shown for 1982 (Table 3). When reporting mark-recapture estimates, report the mortalities enumerated between the marking and recapture fishings. When reporting two-catch estimates, report the probability of capture ($\hat{p}$) with the estimate.

Snorkeling

Sample Sites

We selected snorkeling to monitor fish abundance in Akokala Creek, a Glacier National Park tributary to the North Fork supporting exclusively westslope cutthroat trout, and Schafer and Trail creeks in the Middle Fork drainage (located in the Great Bear and Bob Marshall Wilderness areas, respectively). We also recommend using snorkel techniques to assess trends in fish abundance in portions of the Middle Fork of the Flathead River located in the Great Bear and Bob Marshall Wilderness areas (see Appendix C, for exact sample site locations).

Equipment Needed

Equipment lists of all equipment needed are in Appendix E.

Assumptions

1) The number of fish present in a sample section of a stream or river can be counted by underwater observation.

Snorkeling was shown to be an effective method for enumerating age I and older westlope cutthroat trout in moderate size streams (5 to 20 cfs) of low gradient (less than 3%) with little instream debris and sparse riparian canopy, provided the counts are conducted during late summer when stream flows are low and water temperatures are high (Appendix B). Snorkeling can also be used as an effective technique to evaluate trends in fish population abundance and structure (Northcote and Wilkie 1963, Goldstein 1978, Whitworth and Schmidt 1980, Griffith 1981).

Procedures

In Akokala, Schafer and Trail creeks a diver should begin at the lower end of the fish abundance section and count the number of fish in each age class

Table 3. Estimated number ($\hat{N}$) of westslope cutthroat and bull trout (≥75 mm), associated 95% confidence intervals, probability of capture ($\hat{p}$) [or mortalities for mark-recapture estimates], reach date, flow at time of estimate, area sampled and method of estimate (M-R = mark-recapture, 2-catch = two-catch) by electrofishing in selected tributaries to the upper Flathead River in 1980 to 1982.

						Cutthroat trout				Bull trout			
	Reach	Date	Flow (cfs)	Area (m^2)	Method	$\hat{N}$	95% CI	$\hat{p}$	Density No/100m^2	$\hat{N}$	95% CI	$\hat{p}$	Density No/100m^2
North Fork													
Langford	1	7/16/82	4.4	350	2-Catch	88	± 9	.73	25.1	--	---	--	---
	1	8/8/81	--	297	2-Catch	91	±16	.64	30.6	--	---	--	---
Cyclone	1	7/19/82	11.5	720	2-Catch	131	± 3	.90	18.2	5	± 3	.67	0.7
	1	7/23/81	--	590	2-Catch	177	±21	.65	30.0	--	---	--	---
Red Meadow	2	7/21/82	48.6	1330	2-Catch	129	±45	.48	9.7	61	±22	.18	4.6
	2	8/6/81	--	1648	2-Catch	172	±21	.65	10.4	15	± 2	.83	0.9
Whale	2	8/11/82	51.8	1620	2-Catch	2	± 0	1.0	0.1	No Estimate Possible			
	2	8/10/81	--	1623	2-Catch	17	±21	.43	1.0	76	±31	.50	4.7
Coal	2	8/5/82	58.8	1740	M-R	12	± 9	(+2)1/	0.7	130	±36	(+2)1/	7.4
Middle Fork													
Challenge	1	7/15/82	4.9	990	2-Catch	78	± 5	.83	7.9	1	± 0	1.0	0.1
	1	7/14/80	4.6	627	2-Catch	47	± 1	.95	7.5	--	---	--	---
Ole	2	9/13/82	--	1200	2-Catch	25	±61	.29	2.1	25	±12	.57	2.1
Morrison	4	9/1/82	3.6	600	2-Catch	--	---	---	---	93	± 5	0.83	15.5
	4	9/23/80	--	673	M-R	--	---	---	---	91	±48	(-) 1/	13.5

1/ These numbers are the number of mortalities between marking and recapture fishings.

by species as he pulls himself upstream. Age classes can be determined by segregating fish into size classes by noting the locations of the fish's nose and caudal fin over reference points on the substrate. Measure the distance between these reference points after frightening the fish downstream. Measurements can be done with a wet suit glove marked into intervals recommended below. Age class distinctions for westslope cutthroat trout were maximums of 40, 65 and 110 mm for ages 0, I and II, respectively. Cutthroat trout larger than 130 mm should be classed as age III+. Bull trout maximum sizes for age classes 0, I and II were 50, 90 and 140 mm, respectively. Bull trout larger than 140 mm should be classed as age III+ (Fraley et al. 1981). An aide walking the streambank downstream from the snorkeler, should record each fish as the snorkeler describes them on Form FMD-B (Appendix E). The aide can also measure the section's length and a minimum of 10 widths for estimating total surface area. Habitat features within a sample section can be segregated and measured separately during the count.

Sample two sections, each approximately 3.0 km long, to assess fish abundance in the Middle Fork of the Flathead River using snorkel techniques (see Appendix C for sample site locations). Census every pool, 50% of the runs, and two or three representative riffles and/or pocketwaters within each section. Divers should count each fish by species and age class using techniques described above. Estimate surface areas of all areas snorkeled by measuring the length and several widths. Count every feature in the sample section, and estimate their surface areas by measuring lengths and widths.

Snorkel Estimates

Compute fish densities (the number of fish per 100 m^2 of the wetted surface area) by species and age class. For the river sections, compute fish densities by feature. No precision of these estimates can be calculated. Total estimates of fish populations in Middle Fork of the Flathead River sample sections can be computed by multiplying the average fish density for each feature type by the total estimated area of that feature in the section.

Report Format

Report fish density estimates for tributaries in a format similar to that shown for snorkeling estimates done in 1979-1981 (Table 4). Report estimates of fish density for the Middle Fork of the Flathead River sections by feature, and estimates of total number of fish for the entire 3.0 km section (Tables 5 and 6).

Table 4. Summary of fish densities observed in upper Flathead tributaries from snorkel counts during 1980 to 1982. Total includes fish age I and older.

				Fish per 100 m² surface area									
				Cutthroat trout					Bull trout				
Stream	Reach no.	Date	Area (m²)	Age 0	Age I	Age II	Age III+	Total	Age 0	Age I	Age II	Age III+	Total
Akokala Creek	001	8-19-80	1577.0	0.6	0.4	0.1	1.3	1.80	---	---	---	---	---
	001	8-19-81	1261.0	30.1	3.9	2.7	2.8	9.40	---	---	---	---	---
	001	9-02-82	1239.2	5.6	1.6	1.3	0.7	3.60	---	---	---	---	---
Schafer Creek	003	7-13-80	357.6	---	---	0.8	3.1	3.90	---	---	---	---	---
Trail Creek	001	8-8-80	1126.9	---	---	---	0.3	0.30	0.7	0.4	0.7	0.5	1.60
	001	8-24-82	1097.8	0.2	0.5	0.8	2.2	3.50	2.9	0.5	0.4	---	.90

Table 5. Summary of fish densities observed in the Middle Fork of the Flathead River from snorkel counts in 1979, 1980 and 1982. Total does not include age 0 fish.

			Fish per 100 m² surface area									
			Cutthroat trout					Bull trout				
	Date	Area	0	I	II	III+	Total	0	I	II	III+	Total
Schafer Section (3 km)	8-27-82											
Riffle (3)	&	1836.8	-	--	---	---	---	---	-	--	---	---
Run (8)	8-28-82	5901.8	-	--	---	.05	.05	.01	-	--	---	---
Pool (6)		2937.7	-	--	.10	.41	.51	---	-	--	---	---
Pocketwater (2)		771.9	-	--	---	---	---	---	-	--	---	---
Combined (19)		11448.2	-	--	T 1/	.13	.13	.01	-	--	---	---
Schafer Section	8-5-80											
Pools (8)		3295.0	-	--	.03	1.10	1.13	---	-	--	---	---
Schafer Section	7-29-80											
Pools (6)		1544.0	-	--	.45	.51	.96	---	-	--	.06	.06
Schafer Section	9-4-79											
Pools (3)		630.0	-	--	---	.63	.63	---	-	--	---	---
Gooseberry Section (3km)	8-25-82											
Riffle (3)		1879.5	-	--	.05	---	.05	---	-	--	---	---
Run (12)		7020.4	-	--	---	1.30	1.30	.01	-	--	---	---
Pool (7)		3272.9	-	--	---	1.30	1.30	---	-	--	---	---
Combined (22)		12172.8	-	--	.01	.43	.44	.01	-	--	---	---
Gooseberry Section	8-22-80											
Pool (4)		1960.0	-	.05	---	.41	.46	---	-	--	.05	.05
Gooseberry Section	7-24-80											
Pool (6)		4291.0	-	--	.47	.21	.68	---	-	--	---	---

1/ T = trace (less than .005).

Table 6. Estimates of the number of cutthroat trout, bull trout and mountain whitefish per 3 km in the Middle Fork of the Flathead River during 1982.

River section	Year	Cutthroat Age I	Cutthroat Age II	Cutthroat Age III+	Bull Trout Age I	Bull Trout Age II	Bull Trout Age III+	Bull Trout Mature[1/]	Mountain whitefish <152mm	Mountain whitefish >152mm
Schafer Meadows	1982	<1	4	25	<1	<1	<1	0	157	253
Gooseberry Park	1982	<1	8	63	<1	<1	<1	1	140	151

1/ Mature bull trout numbers were based on actual counts of bull trout in sampled areas and were not expanded over the entire section.

AGE AND GROWTH

Age and growth characteristics can be used to monitor the health and age structure of trout populations. Relative year class strengths and incremental growth for each year can be used as indicators of habitat quality. Dramatic changes in population structure or declining incremental growth rates could indicate degradation of aquatic habitats, excessive harvest or overpopulation.

Scales should be used for age determination and back-calculating fish lengths at previous annuli. Based on comparisons between otoliths and scales, readers generally preferred scales because: 1) very few scales were considered unreadable relative to the number of unreadable otoliths, 2) ages assigned using scales were made with more confidence than ages assigned using otoliths, 3) scales can be collected without sacrificing the fish, and 4) ages assigned to scales corresponded closely to ages assigned to otoliths from the same fish (Fraley et al. 1981, Leathe and Graham 1982). Collect scales from an area just above the lateral line between the dorsal and adipose fins. Place each scale sample in a scale envelope on which the fish species, fish length, fish weight, collection location, date and other information has been recorded (Appendix E, Form FMD-C).

Assign each scale sample a unique identification number. Make cellulose acetate impressions of scales at 101 to 107°C (215 to 224°F) using 9072 kg (20,000 lbs.) of pressure for 30 seconds. Scratch the identification number on each acetate. Examine these acetate impressions at 43 to 72X magnification and record the distance from the focus to each annulus and the scale's edge in mm using a transparent rule. Measure these distances along a line approximately 20-30° from the longest axis of each scale. These various magnifications can be standardized to a 67X magnification when these data are analyzed using FIRE I (Hesse 1977) and AGEMAT (Montana Department Fish, Wildlife and Parks) computer programs (Appendix F). These computer programs back-calculate fish lengths at previous annuli. Back-calculated lengths can be upwardly biased and should be used only if scale sample sizes at each age class are small.

Scales should be read only by trained and experienced personnel. The slow growth rates and small size of scales from juvenile westslope cutthroat and bull trout make interpretation difficult for untrained scale readers. The first annulus was found to be missing from approximately 60 to 70% of the westslope cutthroat scales examined from fish captured in the Middle and North Fork drainages attributed to their late emergence and slow growth (Fraley et al. 1981, Graham et al. 1980), and from 43 to 29% of the westslope cutthroat scales examined from fish captured in Flathead Lake and the mainstem Flathead River above Flathead Lake, respectively (Leathe and Graham 1982, McMullin and Graham 1981). Johnson (1963) suggested the presence of seven or more circuli inside the first annulus indicated a missing annulus. Five circuli inside the first annulus of westslope cutthroat trout scales is reason to suspect a missing annulus. These scales should be further examined for abnormally thick or broken circuli, indicating a missing annulus. Scale collections made during the course of this study are on file at the MDFWP Regional Headquarters, Kalispell, Montana, and should be referenced to standardize scale reading techniques and missing annulus designations. Enter data associated with each scale on IBM computer forms (Appendix E, Form FMD-D) following the proper format.

The following Monastyrsky logrithmic equations were computed for 2953 westslope cutthroat trout ($r = .95$, $p < .001$) and 1397 bull trout ($r = .97$, $p < .001$) collected from Flathead Lake, the North and Middle Forks of the Flathead River, tributaries to the North and Middle Forks of the Flathead River, and the mainstem Flathead River (Leathe and Graham 1982):

Westslope Cutthroat Trout:

$$\text{Log TL} = .747 \log \text{SR} + 1.09$$

Bull Trout:

$$\text{Log TL} = 1.020 \log \text{SR} + .751$$

TL = total fish length

SR = scale radius.

For monitoring purposes, the above equations should be used to standardize back-calculations from scale measurements to compare present fish growth to future growth. Back-calculate growth using FIRE I (Hesse 1977) and AGEMAT (Montana Department Fish, Wildlife and Parks) computer programs. Report the back-calculated lengths at each annulus and growth increments between each age.

Future investigators may want to develop body length-scale length relationships for individual creeks where adequate sample sizes are available. Different growing conditions may result in slightly different body length-scale length relationships and it may be advantageous to develop relationships for individual creeks to more accurately reflect changes in those creeks. We collected scales from a sufficient number of westslope cutthroat from Coal, Red Meadow, Langford, Hay, Moose, Trail, Moran, and Cyclone creeks in the North Fork drainage to develop individual Monastyrsky scale length-body-length equations for these creeks. We also collected scales from a sufficient number of bull trout from Trail, Red Meadow, Coal and Whale creeks in the North Fork drainage and Geifer and Ole creeks in the Middle Fork drainage. The data from these fish and their scales are on file and/or computer tape and could be reanalyzed to compare body-length-scale length relationships for potential changes due to changes in habitat.

Future investigators must use caution when comparing incremental growth between years because: 1) salmonid growth rates may vary within age classes. even within a single species from the same water, 2) salmonid growth rates are affected by water temperatures, and 3) westslope cutthroat trout growth increments are difficult to compare because of the potential seasonal mixture of fish with three different life-histories (tributary resident, river migrants and lake migrants).

Weight-length relationships and condition factors $\left(\frac{W\ X\ 10^5}{L}\right)$ were calculated for westslope cutthroat and bull trout from the North and Middle Fork rivers and their tributaries (Fraley et al. 1981). Condition factors and the relationship between condition factor and fish length were reported by Leathe and Graham (1982) and 928 bull trout collected from Flathead Lake. Condition factors can also be used to monitor the relative health of fish populations (Everhart et al. 1975).

BULL TROUT REDD SURVEY

Survey Section Sites

Portions of Big, Coal, Whale and Trail creeks consistently contained the majority of bull trout redds enumerated in the North Fork of the Flathead River drainage during redd surveys conducted between 1979 and 1982. Portions of Ole, Morrison, Lodgepole, Granite, Schafer, Dolly Varden, Trail and Strawberry creeks were identified as important bull trout spawning areas in the Middle Fork of the Flathead River drainage. Recommended bull trout redd survey sections, identified by beginning and ending landmarks, are shown and described on maps (Appendix C). Priorities were selected for suggested sample sites (Table 7). Complete (basinwide) redd surveys should be conducted at least every five years. For descriptions of all survey sections in the basin consult the two Montana Department of Fish, Wildlife and Parks reports:

1) Fish and habitat inventory of streams in the North Fork drainage of the Flathead River (1983a Montana Department of Fish, Wildlife and Parks, Kalispell, Montana).

2) Fish and habitat inventory of streams in the Middle Fork drainage of the Flathead River (1983b Montana Department of Fish, Wildlife and Parks, Kalispell, Montana).

Equipment Needed

A list of the equipment needed is in Appendix D.

Assumptions

1) Accurate counts of bull trout spawning sites (redds) can be obtained by visual inventories.

Assumption 1 can be satisfied by conducting ground surveys with experienced field personnel at the proper time. Redds are large (1 m X 2 m) and easily identified by experienced personnel because gravels in redds generally has a "cleaned" appearance and is loosely compacted so that it can be easily worked by foot or hand. Timing of the surveys is critical and surveys must be done immediately after spawning is completed.

2) Redd inventories of selected (known) bull trout spawning areas will provide a reliable index of yearly trends in bull trout redd numbers throughout the basin and also can be used to assess adult bull trout escapement.

Assumption 2 is based on the fact that bull trout use the same spawning areas annually, and that the relative use of each area remains consistent year after year. Graham et al. (1982) discussed the habitat characteristics of spawning areas selected by bull trout adults and illustrated that bull trout consistently utilize specific spawning sites on an annual basis. Four years of

Table 7. Summary of recommended creeks to inventory for bull trout redds for monitoring adult bull escapement into upper Flathead River tributaries, including time of survey, estimated field man-days, estimated man-days for data analysis and priorities.

			Man-days 1/		
Drainage	Creek	Timing	Field	Data Analysis	Priority
North Fork	Coal	Mid-September	6	1	1
	Whale	to	6	1	1
	Trail	mid-October	2	1	1
	Big		3	1	2
Middle Fork	Ole 2/	Mid-September	3	1	1
	Morrison	to	6	1	1
	Lodgepole 3/	mid-October	2	1	1
	Granite		3	1	1
	Dolly Varden 3/		4	1	2
	Schafer 3/		2	1	2
	Trail 4/		6 5/	1	3
	Strawberry 4/		2 5/	1	3

1/ Man-days in the field were based on traveling to a particular drainage and surveying all creeks from a base camp.

2/ Ole Creek is within Glacier National Park and would provide "control" information.

3/ Creeks with the Great Bear Wilderness Area would provide "control" information.

4/ Creeks within the Bob Marshall Wilderness Area would provide "control" information.

5/ Trail and Strawberry creeks must be done during the same sampling period.

bull trout redd inventory data suggests that the relative number (expressed as percent of the redds enumerated in the basin) of redds remains generally consistent by creek (Table 8). We believe redd counts conducted in selected areas can be used as an index of total bull trout spawning (and adult escapement) in the upper Flathead basin. We urge continued research to further document the number of adults escaping into spawning tributaries versus the number of redds in those tributaries. Many researchers have recognized the value of using redd surveys as an index of adult escapement (see the review by Neilson and Green 1981).

Procedure

Preliminary Surveys

Actual redd counts should be conducted immediately after spawning has been completed. Because timing of redd surveys is critical, preliminary surveys should be conducted through the spawning period. Begin preliminary surveys in late August.

Maximum daily water temperatures can be used to determine when spawning activity has been initiated. Fraley et al. (1981) suggested that bull trout spawning was initiated when maximum daily water temperatures dropped to 9°C. Further research in Coal Creek produced evidence to support this hypothesis (Figure 5). Begin monitoring maximum daily water temperatures in these tributaries, as time permits, beginning around 20 August. After water temperatures drop below 9°C, begin preliminary surveys in either Big, Coal, Whale, Trail or Morrison creek. Areas recommended for preliminary survey are identified on sample site maps (Appendix C). Final spawning inventories should begin after observing numerous completed redds, few adult fish and little evidence of active spawning. During previous years of study, final inventories were done in late September or early October.

Final Redd Surveys

Conduct final redd inventories as quickly as possible to ensure redds are identified before silt covers them. If redds are "silting in" during the preliminary surveys, it may be necessary to survey these sections twice (early and late) and either use the highest count or mark early redds so they will not be recounted during subsequent counts.

Visually identifying redds generally presents little problem since redds appear as large (1 m by 2 m) "cleaned" areas of gravel with a distinct pit and associated tailspill. Each identified redd should be classified into a category based on the following criteria:

1) Definite: No doubt. The area is definitely "cleaned" and a pit and tailspill area are recognizable. Not in an area normally cleaned by stream hydraulics.

Table 8. Number of bull trout redds by creek, percent of redds in each creek for drainage (NF=North Fork, MF=Middle Fork) and percent of redds in each creek for entire upper Flathead River Basin area surveyed during 1979 to 1982 by year.

	YEAR											
	1982			1981			1980			1979		
Creek	No.	%NF	%Tot	No.	%NF	%Tot	No.	%NF	%Tot	No.	%NF	%Tot
North Fork												
Big	45	6	4	24	5	3	15	5	3	12	7	4
Hallowat	31	4	3	14	3	2	8	3	1	2	1	1
Coal	95	13	8	30	6	4	48	18	8	44	26	15
S.Fk.Coal	9	1	1	24	5	3	2	1	<1	4	2	1
Mathias	17	2	2	10	2	1	10	4	2	2	1	<1
Red Meadow	--			19	4	3	6	2	1	2	1	1
Whale	228	31	20	101	22	14	47	17	8	34	20	12
Shorty	56	8	5	17	4	2	4	1	1	33	20	11
Trail	99	13	9	82	17	12	31	11	5	35	21	12
Kishenehn	23	3	2	13	3	2	16	6	3	--	--	--
Howell	103	14	9	72	15	10	53	19	9	--	--	--
Other	35	5	3	61	13	9	34	12	6	--	--	--
NF Total	741	100		467			274			168		
Middle Fork		%MF			%MF			%MF			%MF	
Nyack	23	6	2	14	6	2	14	5	2	--	--	--
Other	--	--	--	17	7	2	17	6	3	19	15	7
Ole	51	13	5	23	10	3	19	6	3	--	--	--
Bear	23	6	2	12	5	2	9	3	2	--	--	--
Granite	34	9	3	14	6	2	34	11	6	14	10	4
Morrison	86	22	8	32	13	4.5	75	25	13	25	20	9
Lodgepole	23	6	2	18	8	2.5	14	5	2	32	26	11
Schafer	17	4	2	12	5	2	10	3	2	16	13	5
Dolly Varden	36	9	3	31	13	4	21	7	4	20	16	7
Clack	7	2	1	7	3	1	10	3	2	--	--	--
Bowl	19	5	2	10	4	1	29	10	5	--	--	--
Strawberry	39	10	3	21	9	3	17	6	3	--	--	--
Trail	30	8	3	26	11	4	31	10	5	--	--	--
MF Total	388			237			300			124		
Grand Total	1129			704			574			292		

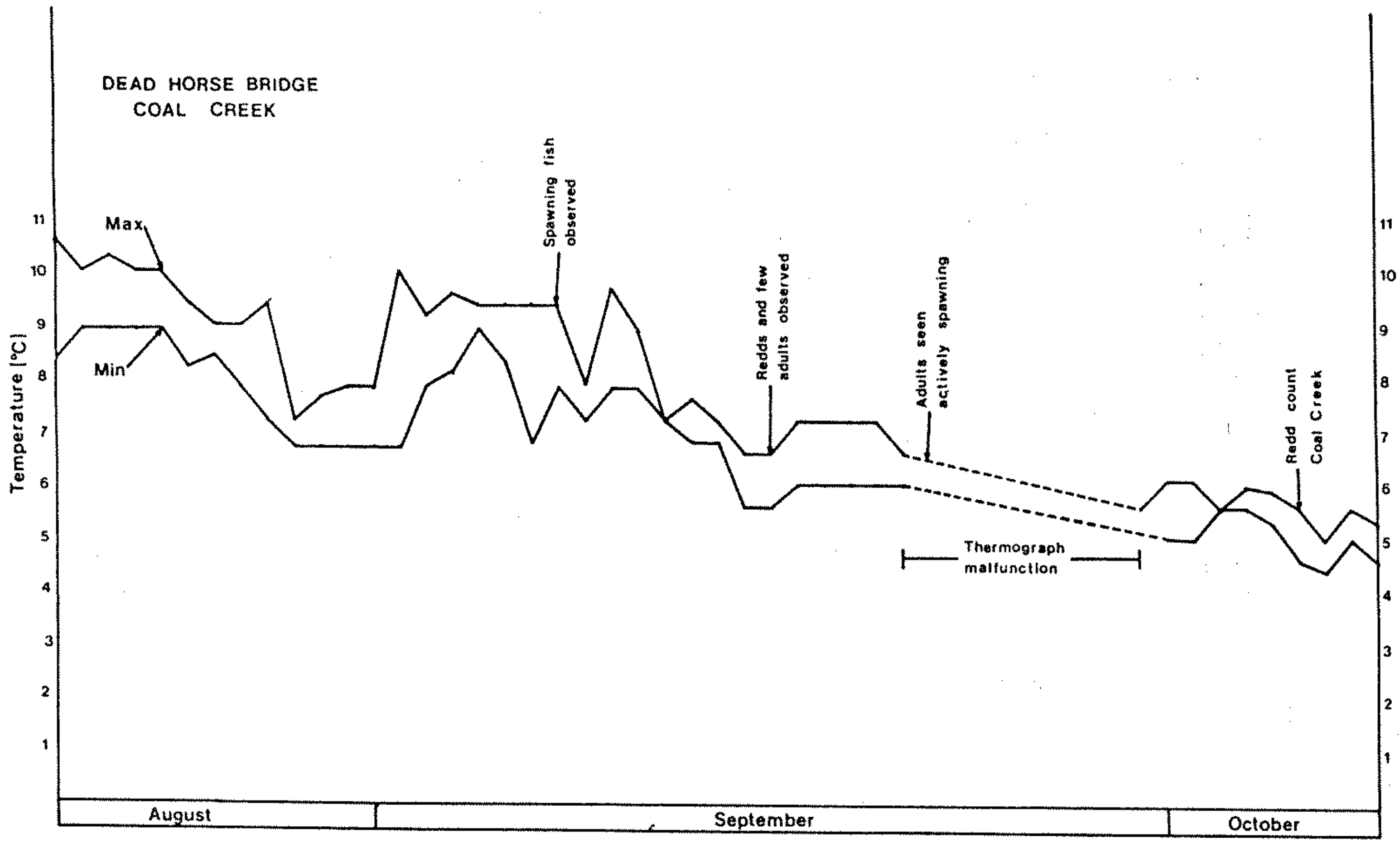

Figure 5. Minimum and maximum daily temperatures in Coal Creek near the Dead Horse Creek Road bridge during the early fall showing when bull trout spawning activity occurred.

2) Probable: An area cleaned that may possibly be due to stream hydraulics but a pit and tailspill are recognizable, or an area that does not appear clean, but has a definite pit and tailspill.

3) Possible: A cleaned area that is probably due to stream hydraulics and does not have a recognizable pit and tailspill.

For final reports only class one and two redd observations should be included. Occasionally, extremely large (up to 5 m X 10 m) areas of disturbed streambed may be encountered, and surveyors will find it difficult to determine the exact number of redds within this area. We recommend enumerating each identifiable pit as a separate redd.

Locate the upper boundary of the survey section from the map (Appendix C). Establish this point as pace "0" on data sheet (Form FMD-G, Appendix E) and begin pacing downstream, keeping track of paces walked. Record an estimate of pace length for the individual pacing the survey. When a redd is encountered, record its certainty class (sure, probable or possible) according to criteria suggested previously, along with its location in the stream (as the number of paces from the start of the survey). Water depth over the redd at the upstream edge of the depression (in centimeters) should also be recorded. Record the above information for each redd observed.

It is recommended that fieldwork be done by two surveyors to adequately cover the entire section. Surveyors should record any distinct landmarks (bridges, trail crossings, creek mouths, etc.) by noting the pace number at the location of each landmark. Water temperature, date, stage (if available) and stream discharge should all be measured during or immediately after completing the survey.

Since Schafer and Dolly Varden creeks are interconnected drainages (as are Morrison and Lodgepole creeks), it may be desirable to survey the two creeks within the same drainage during the same day. In this case, we recommend (for speed and efficiency) that Schafer and Lodgepole creeks be surveyed from their mouths upstream. These data can later be adjusted to reverse the direction of the survey for reporting purposes.

Shepard et al. (1982) compared ground versus helicopter redd survey results for eight tributaries in the Flathead basin and found that helicopter counts generally provided reliable results. The disadvantages of using helicopter surveys are:

1) higher cost;

2) timing becomes more critical since redd identification is based exclusively on the "cleaned" appearance of the streambed;

3) weather conditions must be favorable;

4) streams surveyed must be large streams with little riparian canopy hanging over the surface of the water; and

5) plotting redd distributions within each stream is more difficult.

The major advantages of using helicopter surveys are: 1) surveys can be conducted faster, and 2) only one field surveyor (plus the pilot) is needed. In most cases, the disadvantages outweigh the advantages and helicopter counts should be used only when ground surveys are not feasible.

Data Analysis

Summarize the number of redds for each creek section. Standardize the pace distances for each survey section by dividing the known length between two landmarks (measured from a map) by the number of paces between those two landmarks. Convert pace numbers to distance (in meters) and plot the frequency (number) of redds by 0.5 km increments beginning at pace "0" to the end of the survey. Note landmakrs on these plots.

Report Format

Report the number of redds by survey section as shown for 1980-1981 (Table 9). Graph the distributions of bull trout redds for each survey section and compare years as illustrated by Morrison Creek Reach I and II (Figure 6). Shepard et al. (1982) contains redd distributions for past years.

Table 9. Number of redds observed within the sections recommended for redd survey monitoring on tributaries of the North and Middle Fork of the Flathead River.

Creek	1982	1981	1980	1979
North Fork				
Big	41	18	20 1/	10 1/
Coal	60	23	34	38 2/
Whale	211	98	45 3/	35 3/
Trail	94	78	31 3/	34 3/
Middle Fork				
Ole	51	19 4/	19	--
Morrison	86	32 4/	75	25
Lodgepole	23	18 4/	14	32
Granite	34	14 4/	34	14
Schafer	17	12	10	15
Dolly Varden	36	31	21	20
Trail	30	26	31	--
Strawberry	39	21	17	--

1/ 1979 and 1980 counts may be high since redd surveys conducted during these two years began at Nicola Creek (located above Skookoleel Creek, our recommended beginning point).

2/ 1979 count may be high since this redd survey included an area below Road 909 (Cyclone Lake Cuttoff Road), our recommended lower boundary.

3/ 1979 and 1980 counts may be low since a portion of the creek we recommend surveying was not surveyed during these two years.

4/ 1981 count may be low since surface ice had formed on some portions of the creek making observation of redds difficult.

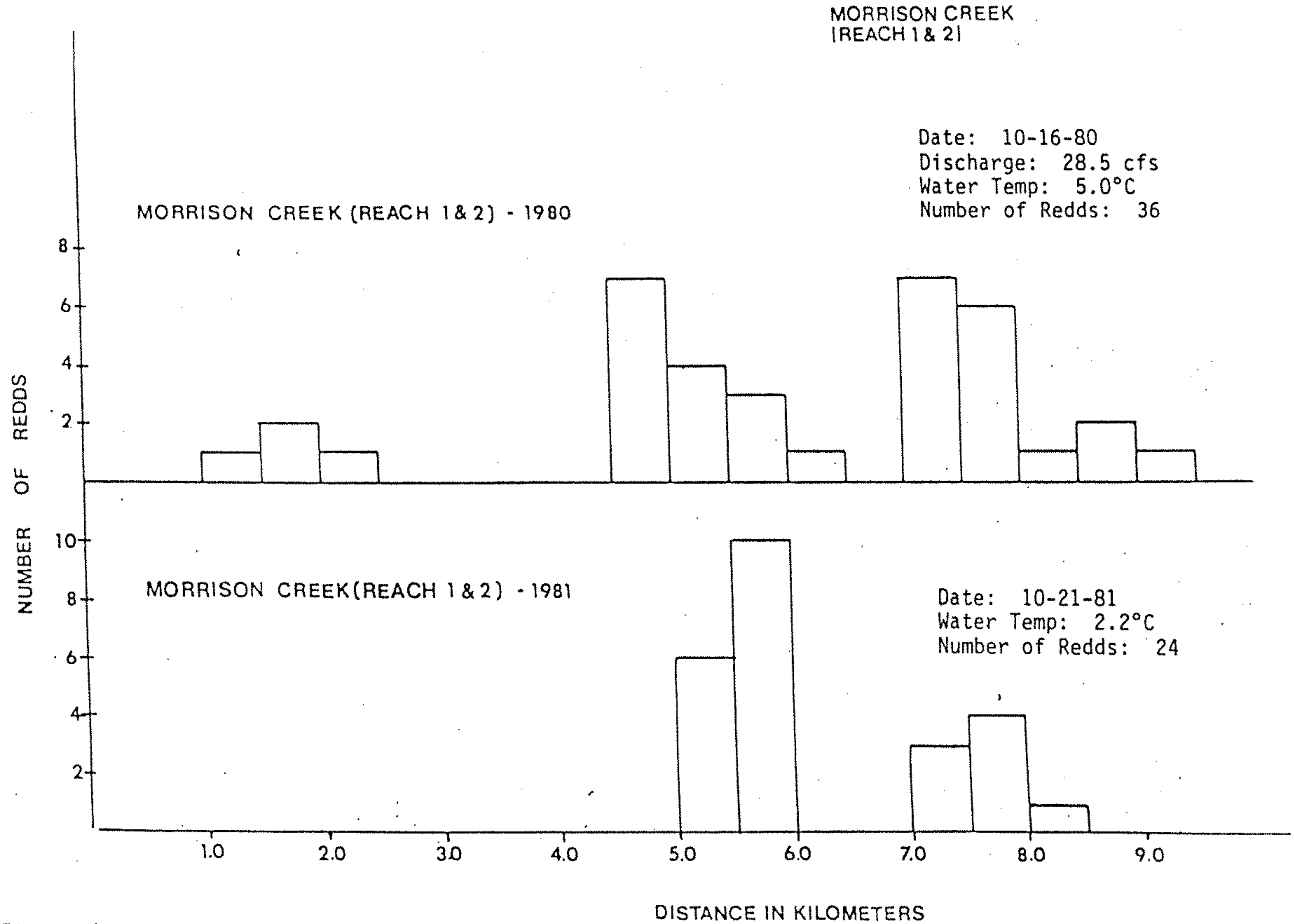

Figure 6. Bull trout redd distribution in Morrison Creek Reaches 1 and 2 surveyed in 1980 and 1981. Survey began at new trail crossing (kilometer 0.0 on figure) and ended below lower trail crossing (kilometer 8.8 on figure). Mouth of Star Creek is at kilometer 2.9 on figure, and the mouth of Lodgepole Creek is at kilometer 6.8 on figure.

FISH HABITAT

Fish habitat surveys were completed by reach (185 reaches) for 44 streams in the Middle Fork drainage and 47 streams in the North Fork drinage (Graham et al. 1980, Fraley et al. 1981, Shepard et al. 1982). This information is stored on tape in the Sigma 7 computer at Montana State University, Bozeman, Montana (Appendix F). Techniques used during these surveys produced information which could be used to detect significant changes in the physical stream habitat (Shepard et al. 1982). These habitat surveys need not be repeated on a regular basis. Surveys should be repeated prior to and following proposed major activities to document potential habitat changes in streams. Habitat surveys should also be repeated periodically to identify potential cumulative impacts of small-scale developments or natural events on the aquatic habitat. Decreasing fish abundance, degrading spawning habitat, or observed changes in habitat quality would warrant repeating habitat surveys to document habitat changes.

The surveys used during this study are generally not intensive enough to quantitatively evaluate the impacts of small-scale developments on fish habitat in a drainage. In that event, a site-specific survey should be conducted by expanding the existing survey. An example would be a study to evaluate the impacts of a salvage timber sale on the fish resources in the Coal Creek drainage, a tributary to the North Fork of the Flathead River (Shepard and Graham 1983). On a broader scale, habitat surveys were conducted on streams in the Swan River drainage to evaluate potential impacts of microhydro development in 20 sites within the drainage (Leathe and Graham 1983). These surveys were expanded to include more detailed streamflow, temperature and selected additional habitat data. The habitat surveys completed in tributary reaches of the North and Middle Fork drainages provided a broad data base which can be repeated with or without the addition of site-specific data collection to meet future needs. Hall and Knight (1981) believed that rating habitat quality could be used to minimize the effects of natural variation in fish populations when evaluating the impacts of non-point source pollutants.

Graham et al. (1980) and Fraley et al. (1981) first described the survey techniques used during this study. A document has been prepared summarizing the procedures used to survey habitat which includes a glossary of habitat terminology used to identify habitat characteristics (Habitat Evaluation Procedures, Montana Department of Fish, Wildlife and Parks 1983). Sample site locations and data summarized from the four years of this study can be found in two Montana Department of Fish, Wildlife and Parks publications:

1) Fish and habitat inventory of streams in the North Fork drainage of the Flathead River (Montana Department of Fish, Wildlife and Parks 1983), and

2) Fish and habitat inventory of streams in the Middle Fork drainage of the Flathead River (Montana Department of Fish, Wildlife and Parks 1983).

STREAMBED COMPOSITION IN BULL TROUT SPAWNING AREAS

Monitoring streambed composition in known bull trout spawning areas will allow fisheries professionals to evaluate the impacts of sediment on fry production and document trends in sediment deposition. Many management activities proposed in the upper Flathead basin (logging, mining, microhydro, oil, gas and associated roading) have the potential to increase quantities of sediment delivered to adjacent streams (Gibbons and Salo 1973, Richardson and Pratt 1980). Imawoto et al. (1978) presented an excellent review of the literature on the effects of sediment on salmonid embryo survival and emergence success.

Sample Site Location

Known spawning areas in Big, Coal, Whale and Trail creeks in the North Fork drainage and Granite Creek in the Middle Fork drainage were selected as streambed monitoring sites (see sampling site maps presented in Appendices C and G). We developed priorities for sampling based on criteria presented in the Introduction (Table 10).

Equipment Needed

Lists of the field and laboratory equipment needed are included in Appendix D.

Assumptions

1) Hollow-core samples (McNeil and Ahnell 1964) across permanent transects (perpendicular to streamflow) in known bull trout spawning habitat can accurately reflect streambed composition.

This assumption will be met if: 1) an adequate number of samples are collected from each site, and 2) each sample contains large enough volumes of streambed material. Shirazi and Seim (1979) stated that as few as three samples may be adequate, but they combined visual assessments with core sampling. They further stated that if the streambed is reasonably homogeneous, sample sizes may be adjusted to reflect the variability within the site of interest. By sampling 8 to 12 sites per spawning area, information should be detailed enough for evaluating compositional changes through time. Shirazi and Seim (1979) reported that sample sizes of 5 to 10 kg per sample generally produced accuracy of within 10% when using a hollow core sampler. Shirazi and Seim discussed the advantages and disadvantages of manual (hollow core) sampling and concluded manual core samples provided adequate information when used properly. They stressed that to minimize operator bias, sample sizes should be standardized by sampling to a predetermined depth.

2) Relationships between streambed composition and bull trout embryo survival to emergence can be developed, or relationships between streambed composition and emergence success developed for chinook salmon (also a large fall spawning species) will apply to bull trout.

Table 10. Summary of recommended streambed monitoring program for the upper Flathead River Basin including sampling sites, time of sampling, estimated man-days and priorities. All sampling should be done during mid to late October after bull trout adults have completed spawning.

Drainage	Creek	Site	Man-days: Field	Man-days: Laboratory and data analysis	Priority
North Fork	Big	Hallowat Creek Road Bridge	4	4	1
	Coal(DH)	Dead Horse Creek Road Bridge	4	4	1
	Whale	Whale Buttes Road Bridge	4	4	1
	Trail(JC)	Junk car site	4	4	1
	Coal (CL)	Cyclone Lake Road cutoff	2	2	2
	Trail(RS)	Rock slide site	2	2	2
Middle Fork	Granite	Below trail crossing	4	4	1

Further research is needed to document the relationship between bull trout embryo survival and emergence success relative to the percent of fine material in the redd. At this time, data derived using another large, fall spawning species (chinook salmon) was used to predict the impacts of fine sediment on bull trout fry recruitment (Shepard and Graham 1982).

3) Maintaining the relative health of bull trout spawning habitat should insure the relative health of westslope cutthroat spawning habitat.

Assumption 3 has not been empirically demonstrated, but can be intuitively deduced. Both species select small to medium sized gravels for spawning (Shepard et al. 1982). Fine materials would logically accumulate at similar rates in spawning areas used by both species because those areas are subject to the same hydrologic conditions which deposited spawning gravels. However, the timing of sediment deposition over spawning areas used by each species is likely to be different. Consequently, the effects of fine sediment may impact early survival of one species differently than another. For example, cutthroat embryos are deposited in the gravel in the early spring, incubate for two to four months, and emerge in mid- to late summer. Their embryos would be primarily influenced by sediments carried and deposited during the runoff and post runoff periods. Bull trout embryos (which are deposited in the autumn, incubate during the winter and emerge during the early spring) would be influenced primarily by sediment input over the winter period. Another potential problem in meeting this assumption would occur if the spawning areas of the two species were differentially impacted by fine sediment because of a dissimilar distribution in a stream or drainage. There is presently insufficient information on the distribution of cutthroat spawning areas to assess this problem.

Procedure

Field

Locate sampling sites in known bull trout spawning areas (rebar defining transect) using maps in Appendix G and replace any missing rebar by measuring distance from rebar remaining in place (Table 1 in Appendix G). Stretch a measuring tape from the left bank rebar (looking downstream) across the stream and tie it off on the right bank rebar. Locate core sample site at predetermined point below the measuring tape. Exact sample points may be within 1.0 m on either side of the predetermined point on the measuring tape.

Push the hollow-core sampler (McNeil and Ahnell 1964) into the streambed with a circular motion until the flanged end is flush with the surface of the substrate (Figure 7). Remove streambed material within the cylinder and place it in a bucket lined with a sample bag. After removing approximately 5 to 7 kg of material, stir the water within the corer and fill an Imhoff cone with 1 liter of silt-laden water from within the corer. Place the Imhoff cone in an upright supported position and let it stand for 20 to 25 minutes. Measure

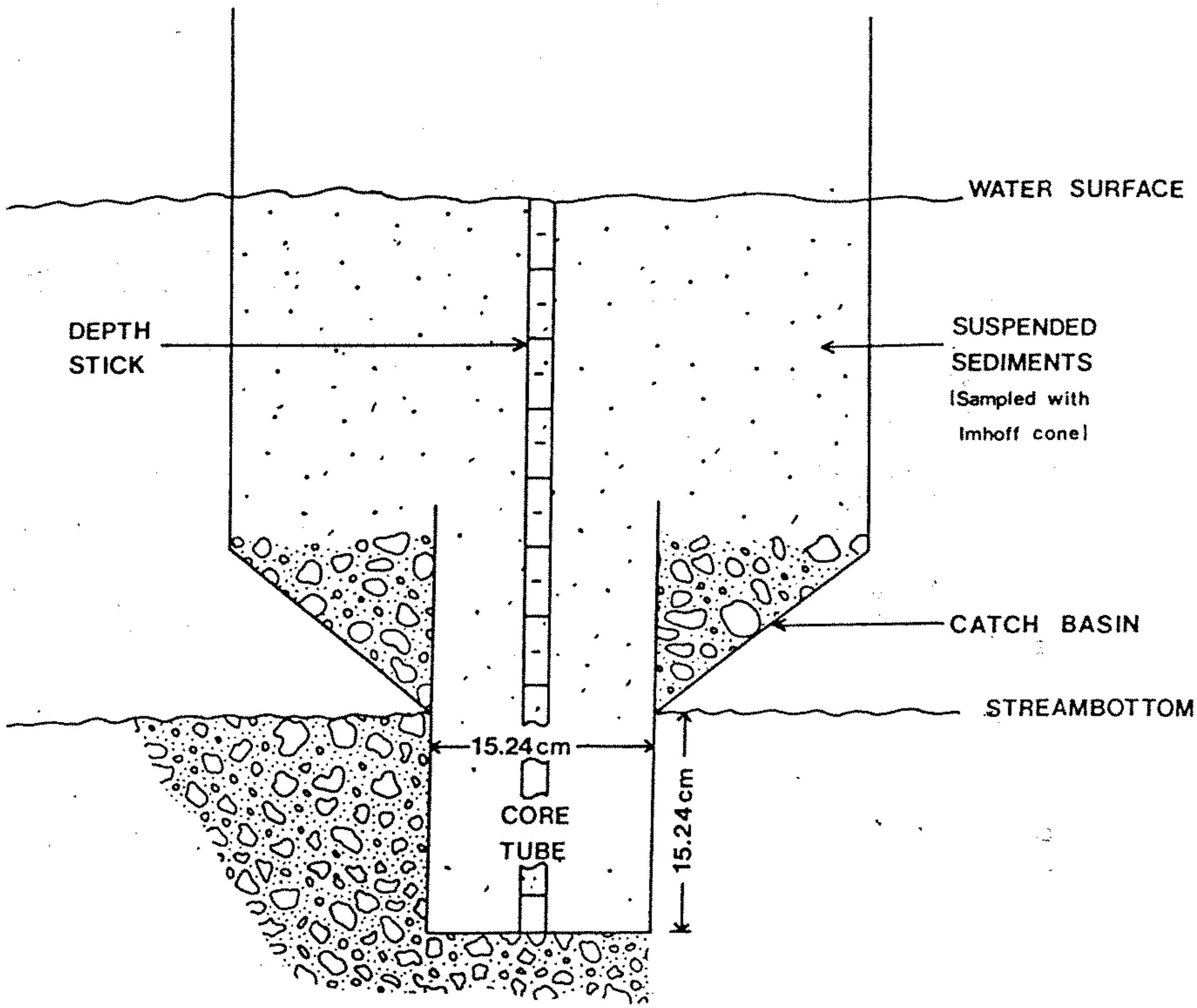

Figure 7. Cut-away side view of hollow core sampler inserted properly into streambed. Note position of depth stick to measure water depth within the corer.

the depth of water within the corer (to the nearest cm) with a meter stick. Be sure to measure from the bottom of the cylinder. Record the water depth (in cm) and the amount of settled material in the Imhoff cone after 20-25 minutes (in ml/l).

Remove the remaining streambed material from within the cylinder until the jagged teeth at the bottom of the cylinder can be felt. Place all this material into the sample bag. Place a "Rite-in-the-Rain" label in the sample bag with the transect core number, creek name, site description and date. Tie a similar label on the sample bag's exterior after sealing the sample bag by tying a knot in the opening.

Take a water sample from the creek above the core site with the Imhoff cone to determine the background level of settleable material (tare) in creek. Let this sample stand 20-25 minutes and record the amount of settled material (in ml/l) (Form FMD-E, Appendix E). Normally, this creek water will have an undetectable amount of settleable material. Transport all bagged streambed samples to the laboratory in plastic buckets to prevent damage to the sample bags and subsequent loss of sampled material.

Laboratory

Transfer each sample from the bag into a separate drying tray. Wash all material out of the bag into the tray. Place whichever field label is most legible into the drying tray and record the sample number (transect number-core number) and tray number on data paper (Form FMD-F, Appendix E). Dry the samples in an oven at 45°C until completely dry (approximately 8 to 12 hours).

After drying, shake each sample through the sieve series stacked as follows (from top to bottom):

76.1 mm
50.8 mm
16.0 mm
6.35 mm
2.0 mm (#10)
.063 mm (#230)
pan.

After shaking for 12 minutes, place the material retained on each sieve in a separate small tray (of known tare weight) and weigh the material (total weight - tare weight of tray = weight of material). For smaller mesh sieves and the pan, use a camel hair brush to transfer all material from the sieves (or pan) to the trays.

Composition Estimators

Calculate the volume of water that was present in the corer during sampling (when the Imhoff cone sample was removed) by converting water depth to water volume (Table 11). Multiply the volume of settled material in the Imhoff cone (ml/l) times the volume of water within the corer (in liters - l) to obtain the total volume of sediment which remained in suspension. Multiply the volume of wet sediment times a conversion factor of 0.27 (Shepard and Graham 1982) to obtain the dry weight of material in suspension and add this value to the weight of material in the pan (less than 0.063 mm). Compute the percent of material by size class. A computer program was developed to do the above computations (Appendix F).

Report Format

Graph the percent of each size class for each individual sample and composites of samples by site to compare streambed composition changes (see Figure 8 as an example). Compute percent of material finer than 6.35 mm and 2.00 mm and locate points on a graph similar to Figure 9 (developed from Tappel 1981).

Table 11. Volume of water (liters) related to depth of water (cm) within the McNeil-Ahnell (1964) hollow core sampler.

Depth of Water (cm)	Volume of Water (l)	Depth of Water (cm)	Volume of Water (l)
25.5	7.88	43	25.18
26	8.48	44	26.18
27	9.43	45	27.08
28	10.48	46	28.03
29	11.58	47	28.88
30	12.48	48	29.73
31	13.58	49	30.63
32	14.38	50	31 58
33	15.38	51	32.53
34	16.38	52	33.38
35	17.38	53	34.38
36	18.38	54	35.38
37	19.38	55	36.33
38	20.33	56	37.33
39	21.33	57	38.33
40	22.28	58	39.43
41	23.38	59	40.43
42	24.38	60[1]	41.13

[1] Top of corer

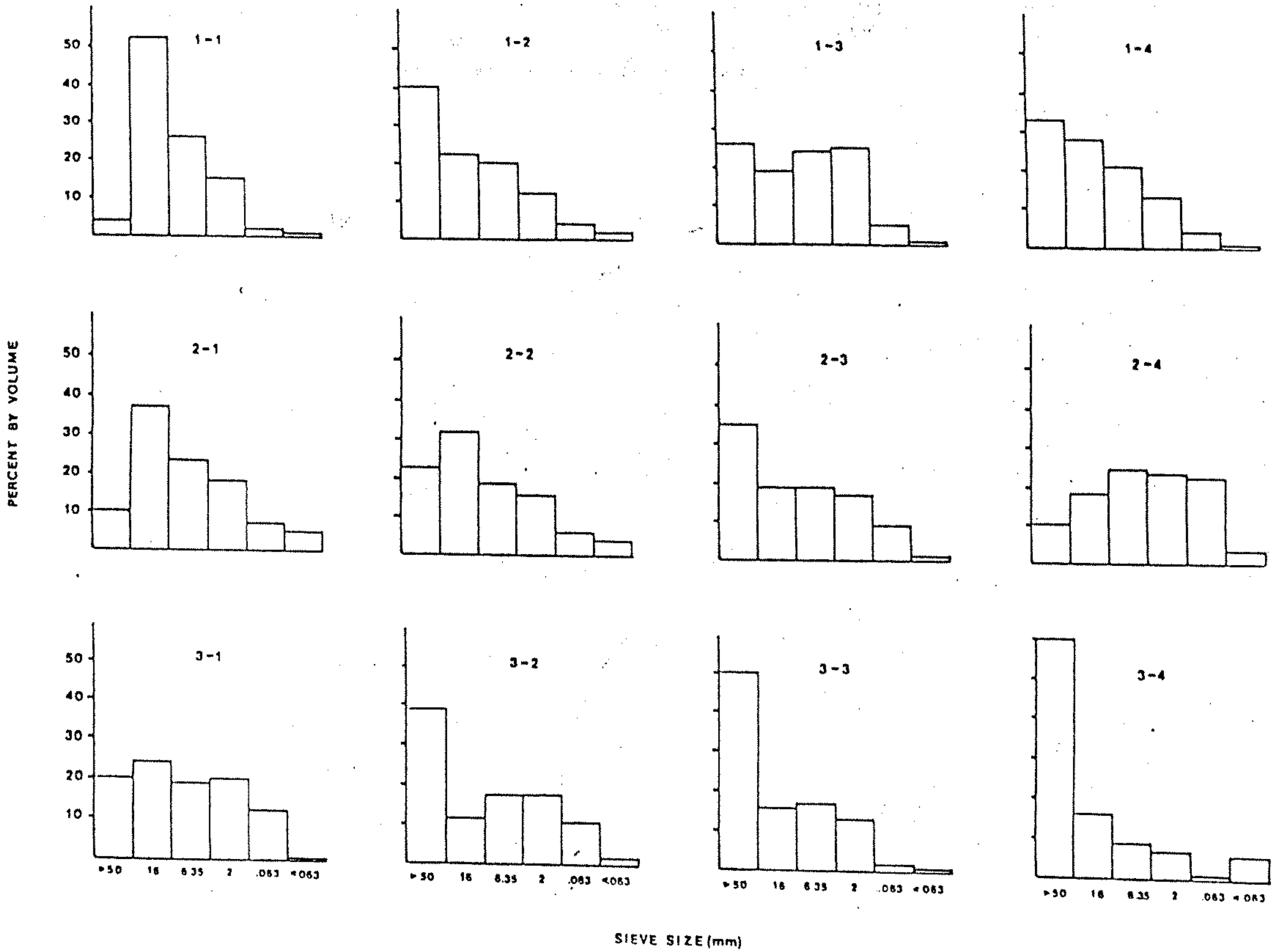

Figure 8. Substrate compositions by dry volume from transects #1, 2 and 3 in Whale Creek sampled during October, 1981.

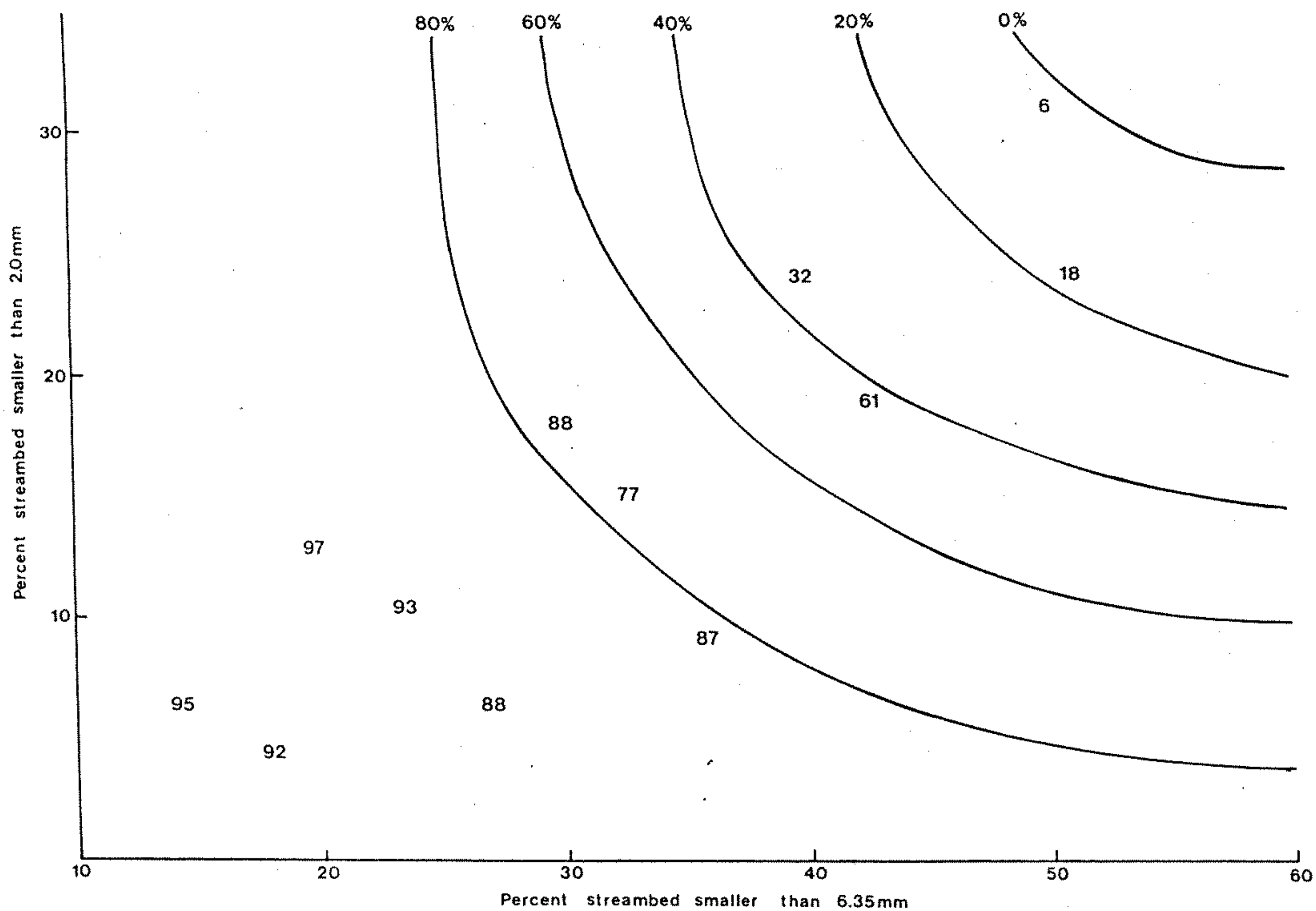

Figure 9. Bands adapted for bull trout from chinook embryo survival data from Tappel (1981) overlying the range of natural spawning gravel in the upper Flathead. Scattered numbers indicate actual percent survival values from chinook embryo laboratory incubation experiments. Tappel (1981).

FLATHEAD LAKE

Implementation of any monitoring program to document temporal changes in the status of the fish resource in the upper Flathead basin must include monitoring of Flathead Lake. Flathead Lake provides the environment for favorable growth which allows the fish species present in the upper Flathead basin to attain the large sizes for which they are known. Temporal trends in Flathead Lake's fish resource and associated food resource must be documented by monitoring to allow future managers to assess the status of the resource and potential negative impacts of development in the upper basin.

The recommended monitoring program presented in this report does not include monitoring of kokanee because other studies are presently being conducted on this species in Flathead Lake and the Flathead River system above the lake. Monitoring recommendations for assessing kokanee abundance will result from those studies upon their completion. Recommendations for monitoring Flathead Lake were drawn from Leathe and Graham (1982).

PHYSICAL LIMNOLOGY

Temperature profiles should be measured in gill netting and plankton sampling areas at the time of sampling. We designed the gill netting series to be done during the early spring when the lake is isothermal (4-5°C), and temperature profile information will document this condition. If the lake is found to be isothermal at areas 1 and 2 and weather conditions remain stable, no temperature data needs to be collected at the other three gill netting sample areas. Water temperature profiles must be measured at all plankton sampling sites.

Temperature should be measured to the nearest 0.5°C at one meter intervals using an Applied Research FT3 hydrographic thermometer or equivalent. Water transparency should be estimated to the nearest 0.5 m using a 20 cm diameter Secchi disc in all sampling areas.

RELATIVE FISH ABUNDANCE

Sample Sites

Relative fish abundance sampling should be conducted in five major areas of the lake during the spring (Figure 10). In each area, three sample sites will be netted. All five areas were assigned as top priority, but sampling can be modified to gather relative fish abundance data primarily for adult westslope cutthroat trout by using only floating gill nets or primarily subadult and adult bull trout by using sinking gill nets exclusively (Table 12).

Equipment Needed

Lists of equipment needed are in Appendix D.

Assumptions

1) Catches from standard gill net sets conducted at a specified time of year can be used to index long-term trends in the abundance of westslope cutthroat and bull trout in Flathead Lake.

Assumption 1 is based on catch per unit effort, where effort is held constant with respect to number and type of gear, duration fished, and time of year fished. We are assuming that equal netting effort at a specific time each year will identify changes in fish abundance. We recognize that populations of mature adfluvial cutthroat may not be fully monitored due to entry of a portion of this group of fish into the Flathead River during the winter months.

2) Gonadal condition of westslope cutthroat trout can be used to determine reproductive status.

Assumption 2 is easily met by recognizing the state of maturity from gonadal development for westslope cutthroat (Appendix H).

Procedure

Gill netting should be done in five areas of the lake each spring before runoff when the lake is isothermal at 4 to 5°C, so that year-to-year variations in limnological conditions are minimized. We recommend that gill netting begin in the upper two areas (1 and 2 on Figure 10) to avoid changing limnological conditions caused by the formation of a turbidity plume from the mouth of the Flathead River associated with spring runoff.

Nets should be set at three sites within each netting area for a total of 15 sites being netted each spring (Figure 10). A combination of multistrand nylon gill nets are to be used at each netting site. Two standard (1.83 m X 38.1 m; equivalent to 6' X 125') floating nets should be tied end to end and set at each site by tying them off to the shoreline and stretching them perpen-

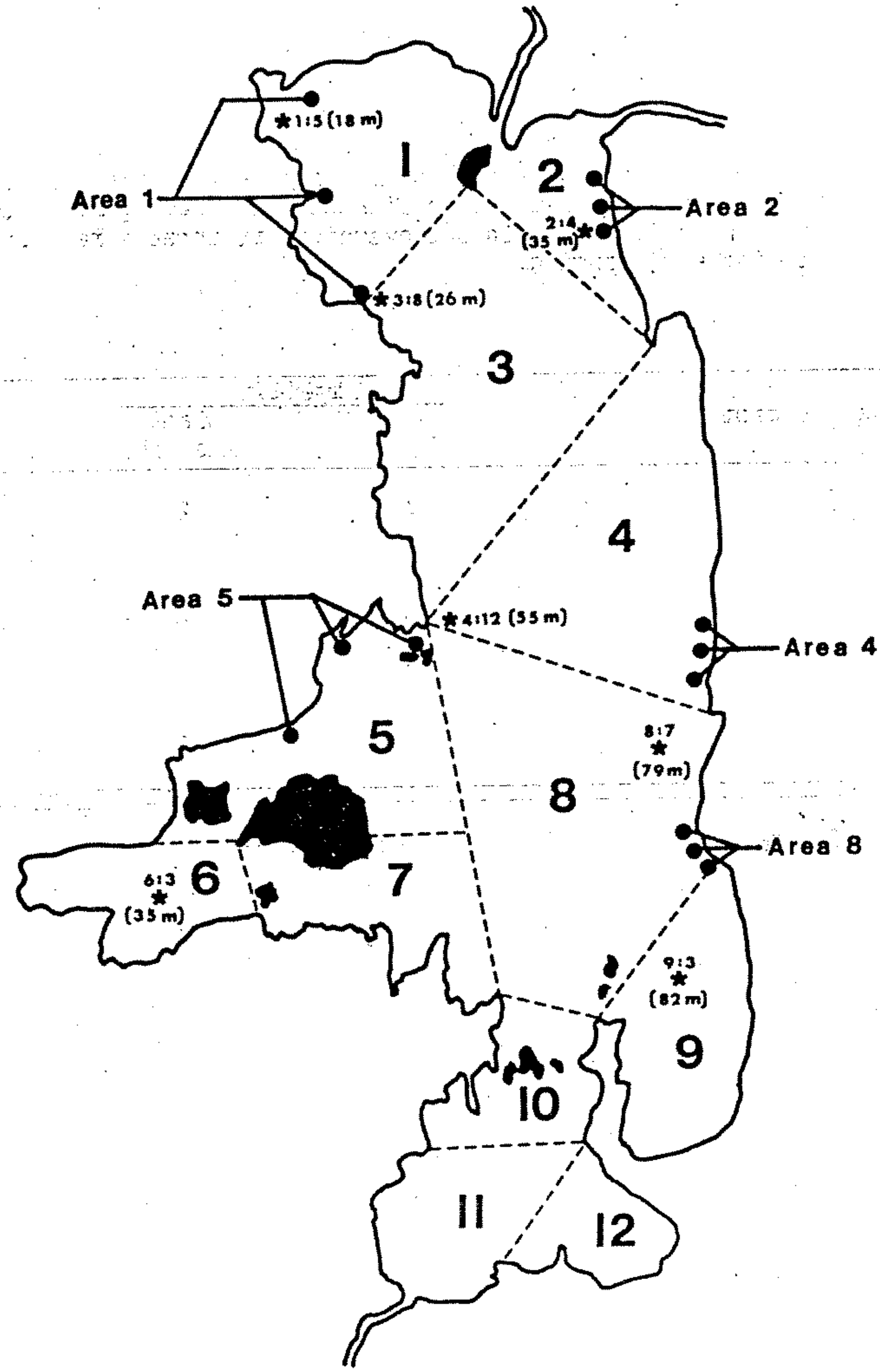

Figure 10. Map of Flathead Lake, Montana depicting major lake areas (1-12), seven zooplankton sampling stations (indicated by asterisks) with associated average depths (meters), and five gill-netting areas.

Table 12. Netting locations, estimated man-days and priorities for a gill netting series, consisting of a double floating and a double sinking gill net, each set overnight at three sites per area during early spring.

Netting Location Area[1/]	Man-Days Field	Man-Days Data Analysis	Priority
1	4	2	1
2	4	2	1
4	4	2	1
5	4	2	1
8	4	2	1

1/ See map (Figure 8) for area locations.

dicular to the shoreline. Two standard sinking gill nets tied end to end should also be set at each site. Sinking nets should be set perpendicular to the shoreline along sloping lake bottoms at depths ranging between 10 and 35 meters. Sinking net sample locations should be identified using a chart recording echo sounder. All gill nets should be constructed of five equal length panels of 19, 25, 32, 38 and 51 mm mesh (bar measure). Montana Department of Fish, Wildlife and Parks records should be consulted to determine specific netting locations and depths fished.

Net sets should be made in the evening and retrieved the next morning. After removing the fish from the nets, record (by species for gamefish) total length (the nearest mm), weight (to the nearest g for fish less than 500 g and to the nearest 5 g for fish larger than 500 g), check gonad development on westslope cutthroat after cutting open the body cavity, and take scales from just above the lateral line between the dorsal and adipose fins. Measure the total lengths of all nongamefish.

Long-term Relative Fish Abundance Estimators

Calculate the number of fish (by species) per single standard net by type of net (sinking or floating) and area. Compute the number of mature westslope cutthroat (those expected to spawn during the upcoming season), the sex ratio and the percent of fish expected to spawn. Determine the size composition and condition factors of the gamefish captured. Determine the species composition for the entire catch.

Report Format

Report the number of fish (by species) per single standard net by type of net (floating or sinking) and area. Report percent composition by species and net type (as shown in Table 13). Compare the results to results as shown in previous years (Figure 11). Tabulate the sex composition and percent of westslope cutthroat expected to spawn (Table 14), and the size composition of bull trout (Table 15).

Table 13. Percent composition by species and net type of combined spring, summer, fall and winter gill net catch on Flathead Lake 1980-81.

Species	Abbreviation	Percent of catch		Total catch
		Sinking nets	Floating nets	
Cutthroat	(WCT)	0.1 (0.8)[a/]	12.8	219
Bull trout	(DV)	10.3 (14.8)	3.4	469
Lake trout	(LT)	1.5 (1.5)	0.2	63
Kokanee	(KOK)	2.3 (10.9)	23.0	479
Lake whitefish	(LWF)	27.0 (44.8)	1.3	1,105
Mountain whitefish	(MWF)	5.9 (1.4)	1.5	260
Suckers	(SU)	4.8 (2.2)	0.4	197
Northern squawfish	(NSQ)	18.2 (10.4)	20.3	1,072
Peamouth	(PM)	28.9 (5.0)	36.5	1,771
Yellow perch	(YP)	0.7 (1.0)	0.4	34
Rainbow trout	(RB)	0 (0)	0.1	1
Northern squawfish X Peamouth	(NSQXPM)	0.5 (-)	0.1	22
Eastern brook trout	(EB)	0 (-)	0.1	1
TOTAL CATCH		4,011	1,682	5,693

a/ Catch composition during the period November 1967 through August 1969 (from Hanzel 1970).

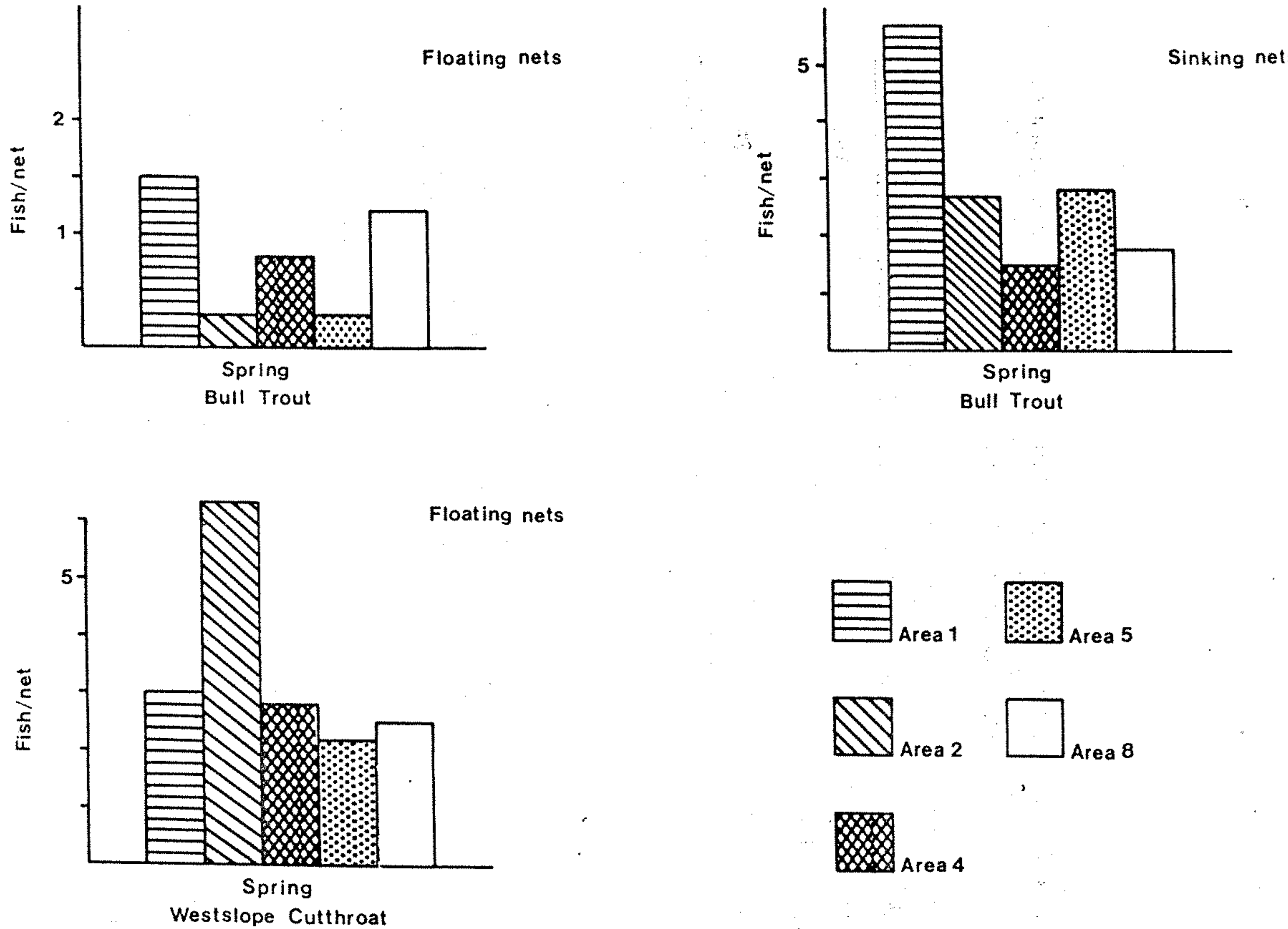

Figure 11. Catch rates for westslope cutthroat trout in floating gill nets and bull trout in floating and sinking gill nets by area for five areas of Flathead Lake during 1981.

Table 14. Sex composition and percentage of fish expected to spawn for westslope cutthroat trout captured in floating gill nets in Flathead Lake during 1980 and 1981.

Season	No. fish sexed	Ratio ♂:♀	Percent of fish expected to spawn
Fall 1980 & 1981	71	1:1.7	15%
Winter (Jan 1981)	40	1:2.5	3%
Spring 1981	102	1:2.5	2%

Table 15. Size composition of the 1980-81 Flathead Lake bull trout gill net catch as compared to previous gill netting conducted by Montana Department of Fish, Wildlife and Parks personnel during the years 1967 through 1970.

Timespan	No. fish	Mean length(mm)	Length range	Percent >457 mm (18 inches)	Percent >634 mm (25 inches)
1967-1970	842	388	165-869	26%	5%
1980-1981	588	412	177-764	42%	4%

ZOOPLANKTON

Crustacean zooplankton were found to be important food items in the diets of many fish species in Flathead Lake (Leathe and Graham 1982). Potential changes in the water quality of Flathead Lake resulting from upper basin or lakeshore development could alter the species composition and/or abundance of crustacean zooplankton populations in the Lake. Significant changes in zooplankton populations would probably impact fish populations using the Lake. Since the presence of opossum shrimp (*Mysis relicta*) has been documented in Flathead Lake (Leathe and Graham 1982), monitoring of zooplankton populations becomes more important (see Leathe and Graham 1982 for a discussion of possible future ramifications of the establishment of *Mysis* in Flathead Lake).

Sample Sites

We recommend sampling relative zooplankton population densities and species composition in at least one area of Flathead Lake. Leathe and Graham (1982) suggested any deep water (30 m or deeper) location should be selected for monitoring zooplankton. They recommended the Bigfork (Station 2:4) or Yellow Bay (Station 8:7) due to the existence of previous data (Figure 10). We recommend using the station at Bigfork, since previous data has been collected and a popular summer kokanee fishery exists there. Stomach samples from kokanee could be collected from this area during a summer creel census. Priorities were determined for various zooplankton sampling frequencies at the Big Fork or Yellow Bay stations (Table 16). Station 6:3 (Big Arm) could be added to the monitoring program if budgetary constraints allowed, since significant differences were observed for *Cyclops* in 1980 and *Daphnia longiremis* in 1981 between this station and other sampling stations (Leathe and Graham 1982).

Equipment Needed

A list of equipment is contained in Appendix D.

Assumptions

1) Shallow vertical surface plankton tows (0-15 m) will adequately represent populations of crustacean zooplankton in Flathead Lake.

Leathe and Graham (1982) found that all of the important summer food organisms in the diets of planktivorous gamefish concentrated in these surface waters (0-15 m) during the summer months. Leathe and Graham (1982) also evaluated the reliability of using vertical plankton tows with a metered Wisconsin net by comparing results obtained using this method with results using a Schindler plexiglass plankton trap, believed to be one of the most efficient zooplankton sampling devices (Schindler 1969, Prepas and Rigler 1978). Differences between the two samplers were found to be nonsignificant using a paired t-test ($0.25 \leq p \leq 0.74$) for all species except *Daphnia thorata*. A somewhat significant ($p<.07$)

Table 16. Recommended sample stations, sampling frequencies, field man-days, laboratory man-days and priorities for sampling crustacean zooplankton in Flathead Lake using duplicate shallow (0 to 15 m) vertical plankton tows.

Station[1/]	Frequency	Time Period	Man-days: Field	Man-days: Lab and data	Priority
2:4 or 8:7	Biweekly Monthly	mid-April through mid-October November through March	12 5	10 5	1 1
2:4 or 8:7	Biweekly	mid-April through mid-October	12	10	2
2:4 or 8:7	Monthly	April through October	7	5	3

1/ See map (Figure) for area locations. Station 6:3 may be added to sampling program if possible interstation differences are of interest.

difference was found for this species leading Leathe and Graham (1982) to conclude density estimates based on metered Wisconsin tows may underestimate "correct" densities of *Daphnia thorata* by approximately 22%. We believe these findings permit acceptance of assumption 1.

Procedure

Field

Locate the sampling site in the field using a recording echo sounder (such as the Honda Si-Tex model HE-256) to find the proper depth (~30 m). Lower the Wisconsin-type net equipped with the flow meter to a depth of 15 m and retrieve the net by hand at the rate of 0.8 to 0.9 m/sec. This can be accomplished by pulling the entire 15 m tow in 12 to 13 seconds. Generally, if the net is pulled in as fast as possible, the time of the tow will result in the proper tow rate. Maintain the boat's position using oars to insure the net is oriented vertically during the net's descent and tow. Duplicate tows should be conducted at each site.

Wash contents of the net down into the bucket at the cod end of the net, first by dipping the net in the lake and then by squirt bottle. Dewater sample as much as possible before washing with preservative (see Appendix D, p. 6, for formula) into sample jar. This will minimize sample decomposition which can occur during long-term storage. Combine both duplicate samples into a single sample bottle, preserve by topping off with plankton preservative, and label with the site sampled, the date, the length of the tow, and the time of the tow.

Laboratory

Dilute the samples to known volumes of preservative allowing plankton concentrations to be expanded to total number of plankters in the sample. Agitate the same and remove three to five 1 ml subsamples from the diluted sample using a Hensen-Stempel pipette. Place each one ml subsample into a Sedgewick-Rafter cell.

Count the number of plankton by species (excluding *Leptodora* and *Epischura*) present in each 1 ml subsample using either a 40X binocular compound or a 45X dissecting microscope with graduated mechanical stage.

Leptodora and adult *Epischura* should be counted separately by examining 7 to 10% of each combined sample under a dissecting microscope at low power. Pooled replicate samples from Big Fork or Yellow Bay should be saved for historical purposes. These samples could be stored at Montana Department of Fish, Wildlife and Parks Regional Headquarters in Kalispell or at the University of Montana Biological Station at Yellow Bay.

Population Density Estimators

Compute the density, in number per liter of water sampled, for each species, excluding *Leptodora* and adult *Epischura*. Compute the density for *Leptodora* and adult *Epischura* as the number of organisms per cubic meter of water sampled.

Report Format

Report the mean densities and range of densities for each species by station for the period April to October (Table 17, for example).

Mysis Sampling

Leathe and Graham (1982) documented the presence of *Mysis relicta* in Flathead Lake and discussed the implications of their find. Mysid abundance should be monitored in Flathead Lake by conducting 30 m vertical tows, using 0.5 to 1.0 m diameter coarse mesh fry nets (1 to 2 mm mesh opening), monthly at night during the dark phase of the moon in May and June at the Big Fork plankton station (2:4) and optionally at the Yellow Bay site (8:7) (Figure 10). Analyze the samples using the same techniques as described for *Leptodora* and *Epischura*.

Table 17. Mean density (No./L) and range of density (in parenthesis) of the principal crustacean zooplankton species in 0-30 m tows collected monthly from seven stations on Flathead Lake during the period June through December 1980. *Epischura* and *Leptodora* densities are No/m³.

	Station						
	1:5	2:4	3:8	4:12	6:3	8:7	9:3
Daphnia thorata	0.8 (0.1-1.6)	1.0 (0.1-2.4)	0.9 (0-1.6)	1.0 (0-2.3)	1.2 (0.1-3.3)	1.2 (0.1-2.3)	1.0 (0.1-2.1)
Daphnia longiremis	0.4 (0-1.2)	0.2 (0-0.6)	0.4 (0-1.3)	0.5 (0-2.5)	0.9 (0-5.0)	0.9 (0-5.4)	1.1 (0-4.5)
Bosmina	0.9 (0.1-2.5)	0.6 (0.1-1.4)	0.6 (0.1-1.0)	0.4 (0-0.9)	1.1 (0.3-2.4)	0.6 (0.1-1.0)	0.5 (0.1-0.9)
Diaptomus	8.8 (0.9-39.5)	3.8 (1.0-9.5)	6.3 (0.4-18.0)	8.8 (0.9-39.3)	9.3 (1.0-35.2)	8.1 (1.2-36.2)	8.6 (1.2-35.3)
Cyclops	2.7 (0.8-5.0)	2.9 (0.6-5.4)	3.0 (1.7-4.5)	3.0 (2.0-5.0)	4.4 (2.3-6.3)	3.7 (1.5-4.6)	3.8 (2.7-4.9)
Adult *Epischura*	16.6 (7.3-33.4)	21.2 (4.0-53.6)	18.7 (7.5-36.6)	45.6 (4.8-211.0)	26.8 (1.7-123.2)	15.6 (1.8-34.6)	25.8 (4.8-58.2)
Leptodora	3.3 (0.-15.2)	15.5 (0-73.4)	6.9 (0-16.3)	3.4 (0-14.0)	4.4 (0-20.5)	11.2 (0-34.4)	4.2 (0-17.7)

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APPENDIX A

Estimated budgets (based on 1982 dollar values) for recommended long term monitoring of the fish resource in the upper Flathead Basin.

Table 1. Estimated budgets (1982 dollar values) for estimating fish abundance in tributaries to the North and Middle forks of the Flathead River. Budget estimates by creek (or river) include field data collection, data summarization, per diem and travel costs. Report costs are estimated in Table 6.

		Man-days		Salaries 1/		Travel 3/		
Drainage	Creek	Field	Data analysis	and benefits	Per diem 2/	(miles)	cost	Total
North Fork	Akokala	2	1 4/	219	20	(100)	30	269 4/
	Coal	8	2 4/	730	80	(80)	24	834 4/
	Red Meadow	8	2 4/	730	80	(120)	36	846 4/
	Whale	8	2 4/	730	80	(180)	54	864 4/
	Trail	8	2 4/	730	80	(200)	60	870 4/
	Cyclone	3	1 4/	292	30	(80)	24	346 4/
	Langford	2	1 4/	219	20	(70)	21	260 4/
Middle Fork	Ole	3	2 4/	365	30	(150)	45	440 4/
	River(Schafer)	3	1	292	30		250 5/	572
	Morrison	2	1 4/	219	20	(180)	54	293 4/
	Challenge	2	1 4/	219	20	(170)	51	290 4/
	Schafer	2	1	219	20	----	5/	239
	River (Gooseberry)	6	1	511	60	----	5/	571
	Trail	2	1	219	20	----	5/	239

Biologist to supervise: 15 days at $92/man day = 1380

1/ Salaries and benefits for Grade 10, Step 5 at $73/man day.
2/ Per diem based on a rate of $10/field man day.
3/ Travel costs based on approximate distance from Kalispell at $0.30/mile.
4/ Does not include age-growth analysis. Add $365 for each creek if age-growth included.
5/ Air flight into Schafer Meadows to sample all designated creeks.

Table 2. Estimated budgets (1983 dollar values) for bull trout redd inventories in tributaries to the North and Middle forks of the Flathead River. Budget estimates by creek include data collection in the field, data summarization, mileage costs and per diem. Report preparation costs are found in Table 6.

Drainage	Creek	Man-days Field	Man-days Data analysis	Salaries and benefits 1/	Per Diem 2/	Travel 3/ (mileage)	Travel 3/ cost	Total
North Fork	Coal	6	1	511	60	(100)	30	601
	Whale	6	1	511	60	(200)	60	631
	Trail	2	1	219	20	(220)	66	305
	Big	3	1	293	30	(90)	27	350
Middle Fork	Ole	3	1	293	30	(180)	54	377
	Morrison	6	1	511	60	(200)	60	631
	Lodgepole	2	1	219	20	(200)	60	299
	Granite	3	1	293	30	(200)	60	383
	Dolly Varden	4	1	365	40		250 4/	655
	Schafer	2	1	219	20	---	--- 4/	239
	Trail	6	1	511	60	---	--- 4/	571
	Strawberry	2	1	219	20	---	--- 4/	239

Biologist to supervise: 10 man-days at $92/man-day = 920

1/ Salaries and benefits for Grade 10, Step 5 ($73/day).
2/ Per diem based on a rate of $10/day for each man-day in the field.
3/ Mileage based on approximate distance from Kalispell at $0.30/mile.
4/ A round trip flight into Schafer Meadows at $250/flight. Assumes all these creek to be surveyed in a single sampling trip.

Table 3. Estimated budgets (1982 dollar values) for streambed monitoring program in tributaries to the North and Middle forks of the Flathead River. Budget estimates by creek and sample site include data collection in the field, laboratory analysis, data summarization, per diem and travel costs. Report preparation costs are found in Table 6.

		Man-days		Salaries		Travel		
Drainage	Creek (site)	Field	Laboratory and data analysis	and benefits	Per Diem	(mileage)	costs	Total
North Fork	Big	4	4	584	40	(160)	48	672
	Coal (DH)	4	4	584	40	(200)	60	684
	Whale	4	4	584	40	(280)	84	708
	Trail (JC)	4	4	584	40	(340)	102	726
	Coal (CL)	2	2	292	20	(90)	27	339
	Trail (RS)	2	2	292	20	(170)	51	363
Middle Fork	Granite	4	4	584	40	(280)	84	708

Biologist to Supervise: 5 man-days at $92/man-day = 460

Table 4. Estimated budgets (1982 dollar values) for fish abundance assessment in Flathead Lake during the early spring. Budget estimates by area include data collection in the field, data summarization, equipment upkeep, mileage costs and per diem. Age-growth analysis is included as an optional item. Report preparation costs are found in Table 6.

	Man Days			Salaries[1/]		Travel[3/]			
Area	Field	Data analysis	Age-Growth (optional)	and benefits	Per diem[2/]	(miles)	cost	Equipment[4/]	Total[5/]
1	4	2	5	438	40	(120)	36	60	574
2	4	2	5	438	40	(120)	36	60	574
4	4	2	5	438	40	(140)	42	60	580
5	4	2	5	438	40	(140)	42	60	580
8	4	2	5	438	40	(160)	48	60	586

Biologist to supervise: 5 man-days at $92/man-day = 460

1/ Salaries and benefits for Grade 10, Step 5 (@ $73/man-day). An additional $365 must be added to each if age-growth analysis is done.
2/ Mileage based on estimated distance from Kalispell at a rate of $0.30/mile.
3/ Per diem based on a rate of $10/field man-day.
4/ Equipment costs include boat use and gill net replacement (@ 2 nets/year at $200/net).
5/ Add $365 to each total if age-growth analysis is included.

Table 5. Estimated budgets (1982 dollar values) for plankton sampling in Flathead Lake by priority level (see Table 16, main text). Budget estimates include data collection, data summarization, laboratory analysis, mileage costs and per diem. Report preparation costs are found in Table 6.

Priority level	Man-days		Salaries and benefits 1/	Per diem 2/	Travel 3/		Total
	Field	Laboratory and data analysis			(miles)	cost	
1	17	15	2,336	170	(950)	285	2,791
2	12	10	1,606	120	(600)	180	1,906
3	7	5	876	70	(350)	105	1,051

Biologist to supervise: 15 man-days at $92/man-day = 1,380

1/ Salaries and benefits for Grade 10, Step 5 (@ $73/man-day).
2/ Per diem based on a rate of $10/field man-day.
3/ Mileage based on estimated distance from Kalispell at $0.30/mile.

Table 6. Estimated budgets (1982 dollar values) for reporting information collected during one year of monitoring the upper Flathead River basin and Flathead Lake. Estimates are based on having data summaries completed.

Area of drainage	Type of information	Man-days			Salaries and benefits	Report costs	Total
		Biologist G-13, S-5	Technician G-10, S-5	Secretary G-8, S-5			
Upper Flathead River	Fish Abundance	5	5	3	1,014	25	1,039
	Streambed Monitoring	3	5	2	641	50	691
	Bull Trout Redd Counts	3	5	2	641	50	691
Flathead Lake	Fish Abundance	5	3	3	868	50	918
	Zooplankton Abundance	5	5	3	1,014	50	1,064

APPENDIX B

Evaluation of mark-recapture, two-catch and multiple-catch estimators and underwater counts to estimate fish abundance in mountain streams.

The reliability of any method to estimate fish abundance is an important consideration when conducting research or designing a monitoring program. Ricker (1975) presents a brief history on the origins of recorded demographic statistics. Otis et al. (1978) present an excellent historical overview of the more recent works on the development of statistical techniques to describe closed animal populations. White et al. (1982) explain the underlying assumptions and statistics for sampling closed populations and discuss four models to test specific assumptions about capture probabilities using field data. We urge readers who are interested in exploring the background history of demographic statistics and the theory of statistical inference to consult the above works. When applying the above estimators to assess salmonid populations in streams, electrofishing has been the most common technique used to capture fish. The use of direct underwater observation to assess fish abundance has been a relatively recent phenomena. Ellis (1961) and Keenleyside (1962) first reported using diving to observe and photograph lotic salmonids.

Little definitive research has been conducted to evaluate the relative efficiency of underwater counts compared to more conventional electrofishing estimators (mark-recapture, two-catch or removal). Northcote and Wilkie (1963), Reed (1967), Whitworth and Schmidt (1980), and Griffith (1981) assessed the reproducibility and replicability of underwater counts versus electrofishing or seining techniques and found underwater counts provided reasonable estimates. Washington State Game Department (1977) evaluated underwater counts versus mark-recapture and removal electrofishing estimates and found that underwater counts produced unsatisfactory results. These apparent conflicting studies can be attributed to the fact that these two estimation techniques (underwater counts and electrofishing) are often mutually exclusive. When water conductivities are high enough for electrofishing to be efficient, water clarity is usually so poor that underwater observation of fish is not possible. When water clarity permits underwater observers to count fish, low water conductivities generally limit electrofishing.

Collection of fish resource baseline information in tributaries within the the upper Flathead River basin provided a unique opportunity to evaluate several methods for estimating fish abundance. Water clarity in streams of the area was such that divers could observe fish from a distance of 2.0 to 4.0 m, and conductivities ranged from 82 to 340 μohms (Fraley et al. 1981, Shepard et al. 1982). This combination of conditions allowed reasonable comparisons to be made between various electrofishing estimators and between an electrofishing estimator (two-catch) and underwater counts. The following reports on results of these investigations and reviews the pertinent literature. This document contains two parts:

Part I. Electrofishing estimators - where various electrofishing estimators are evaluated; and

Part II. Underwater observation - where underwater counts are compared to two-catch estimates.

PART I. ELECTROFISHING ESTIMATORS

A review of the literature disclosed that there are three population estimation techniques well suited to electrofishing in streams (Zippin 1958, Seber and LeCren 1967, Vincent 1971, Ricker 1975). Two of the three methods are based on removal or depletion-type estimators and are referred to by multi-catch (Zippin 1958) and two-catch (Seber and LeCren 1967) in this report. Both are special cases of catch per unit effort (CPUE) estimation techniques reviewed by Ricker (1975), where the effort is held constant. The third technique is the mark-recapture method or modified Peterson (1892, 1896, 1922).

Previous investigators have questioned the reliability of two-catch and multi-catch estimators because a basic underlying assumption, constant probability of capture during all fishings, is frequently violated (Zippin 1958, Seber and LeCren 1967, Gooch 1967, Mahon 1980). When probability of capture decreases during subsequent fishings, an underestimate usually results (Zippin 1958, Gooch 1967, Mahon 1980). The advantage of completing a fish population estimate in a single day warranted further investigation into these depletion methods. Junge and Libovarsky (1965) demonstrated that the bias in the estimate of population size due to gear selectivity will be small if $\hat{p}$ (probability of capture) is large. White et al. (1982) stated two-capture estimates will provide reliable estimates even if capture probability is not constant, as long as $\hat{p}$ is greater than 0.8. Cross and Stott (1975) reached a similar conclusion and believed that the two-catch method was applicable in "fairly small streams."

We tested the reliability of two-catch, multi-catch and mark-recapture estimators using electrofishing techniques for estimating numbers of westslope cutthroat and bull trout larger than 75 mm in tributaries within the Flathead Basin (Table 1). Seber and LeCren (1967) warned that it cannot be assumed that an equal probability of capture exists for all species present, or all size classes or sexes within each species. We believed fish less than 75 mm were inefficiently sampled due to the mesh size of our block nets (12.7 mm) and inherent selection of electrofishing for larger fish. We also assumed little differential probability of capture existed for each species in the range of sizes sampled (75 to 250 mm). Estimates were conducted separately for each species.

We concluded that two-catch electrofishing estimators provided reliable estimates of the number of fish 75 mm and longer in streams flowing 10 cfs or smaller. In streams flowing 10 to 20 cfs, two-catch estimators may be applied only if $\hat{p}$ values are larger than 0.6 (Table 1). In streams larger than 20 cfs, mark-recapture estimates were generally higher and more precise than two-catch estimates (Table 1). We also recommend using bank shocking techniques where possible; however, a backpack mounted generator-Variable Voltage Pulsator combination (Coffelt or equivalent) was found to be reasonably effective in streams flowing less than 10 cfs.

Table 1. Comparison between mark-recapture, two-catch and multiple catch fish population estimates for cutthroat and bull trout (≥75 mm) in the upper Flathead River Basin tributaries during 1981 and 1982 and Swan River Basin in 1982.

Creek	Flow (cfs)	Date	Mark-recapture[1/] $\hat{N}$	95% CI	(Mortalities)	Two-catch[2/] $\hat{N}$	95% CI	$\hat{p}$	Multiple catch[3/] $\hat{N}$	90% CI	$\hat{p}$
Cutthroat Trout											
Flathead											
Stannard	5.0	5/29/81	29	± 8	(+2)	25	± 6	0.72	29	± 4	0.59
Dodge	6.6	6/28/81	70	±19	(+7)	48	± 6	0.75	89	±13	0.34
Challenge	5.5	7/14/81	59	±14	(+3)	47	± 1	0.96	53	± 1	0.80
Geifer	4.5	7/29/81	16	± 3	(+7)	21	± 3	0.82	22	--	0.79
Essex	---	8/4/81	71	±14	(+11)	72	±16	0.61	81	±40	0.58
Coal-Cyclone	64.6	4/20/82	42	± 9	(+1)	31	± 4	0.79	35	± 5	0.65
Coal-Cyclone	75.9	8/10/82	84	±47	(+9)	41	±18	0.55	53	± 5	0.41
Coal-Dead Horse	28.1	4/14/82	15	± 4	(+1)	12	± 1	0.90	13	± 2	0.77
Coal-Dead Horse	58.8	8/5/82	12	± 9	(+2)	7	± 2	0.80	12	± 6	0.30
Coal-South Fork	100.4	5/11/82	--	--	(--)	18	± 2	0.87	--	--	--
Coal-South Fork	31.2	8/4/82	44	±14	(+1)	32	± 6	0.74	52	±46	0.20
Swan											
Groom	5.6	8/31/82	53	± 4	(+4)	51	± 1	0.91	42	± 4	0.67
Soup	6.9	8/25/82	71	± 5	(+5)	69	± 5	0.78	77	± 5	0.67
S.F. Lost	13.3	8/31/82	13	± 1	(--)	12	± 2	0.80	10	± 1	0.73
Bull Trout											
Flathead											
Dodge	6.6	6/28/81	3	--	(--)	2	--	1.00	2	--	0
Geifer	4.5	7/29/81	7	± 3	(--)	6	± 2	0.80	6	--	0.81
Coal-Cyclone	64.6	4/20/82	93	±55	(+2)	30	± 6	0.71	48	±19	0.37
Coal-Cyclone	75.9	8/10/82	90	±63	(+1)	50	±43	0.40	59	±15	0.31
Coal-Dead Horse	28.1	4/14/82	84	±27	(--)	65	±34	0.47	61	±13	0.50
Coal-Dead Horse	58.8	8/5/82	130	±36	(+2)	102	±51	0.43	102	±32	0.46
Coal-South Fork	31.2	8/4/82	32	±20	(+1)	17	± 9	0.60	37	±10	0.48
Swan											
S.F. Lost	13.3	8/31/82	39	±10	(--)	24	± 5	0.71	18	±18	0.34
Bethal	6.7	8/25/82	22	± 1	(--)	21	± 1	0.95	22	± 1	0.88

1/ Chapman's modification of Peterson's mark-recapture estimate (Ricker 1975).
2/ Seber-LeCren's method (Seber and LeCren 1967).
3/ Zippin's modification of Leslie's method (Ricker 1975, Zippin 1958).

The statistical model used to estimate fish numbers from a two-catch electrofishing effort is:

$$\hat{N} = \frac{C_1^2}{C_1 - C_2} \qquad \text{(Seber and LeCren 1969)}$$

Where:

$\hat{N}$ = population size at time of first catch

C_1 = number of fish captured during first catch

C_2 = number of fish captured during second catch.

Variance of the estimate:

$$V(\hat{N}) = \frac{C_1^2 \, C_2^2 \, (C_1 + C_2)}{(C_1 - C_2)^4}$$

Probability of capture:

$$\hat{p} = \frac{C_1 - C_2}{C_1}$$

Where:

C_1 = number of fish ≥75 mm captured during the first catch

C_2 = number of fish ≥75 mm captured during the second catch.

Probability of capture ($\hat{p}$) must be 0.6 or higher to provide a reliable two-catch estimate. It may be necessary to shift from a two-catch estimate to a mark-recapture estimate for any census site where the computed $\hat{p}$ (calculation done in the field) is less than the desired level (0.6). If $\hat{p} < 0.6$, field personnel must be flexible and mark all fish captured (C_1 and C_2) to allow for a recapture fishing two or three days later.

The statistical model used to estimate fish numbers from a mark-recapture electrofishing catch is:

$$\hat{N} = \frac{(M + 1)(C + 1)}{(R + 1)} \qquad \text{(Ricker 1975)}$$

Where: $\hat{N}$ = estimate of population size at the time of marking

M = number of fish marked

C = catch or sample taken and examined for marks (catch of recapture fishing)

R = number of marked fish captured during recapture fishing

Variance of estimate (Chapman's [1951] formula presented on page 78 of Ricker [1975]):

$$V(\hat{N}) = \frac{N^2(C - R)}{(C + 1)\ (R + 2)}$$

Chapman's original formula for computing $\hat{N}$ was:

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

Ricker (1975) stated the "-1" was of no practical significance and we agree. The above formula to estimate $\hat{N}$ is based on a hypergeometric distribution. Bailey (1951) computed a formula based on a binomial distribution of:

$\hat{N} = \frac{M\ (C + 1)}{(R + 1)}$. Ricker (1975) recognizes this as practically indistinguishable from the Chapman's formula, and we believe at the level of sampling precision normally encountered during electrofishing the slight difference between the two formulas as meaningless. The number of mortalities found during the marking fishing and between the two fishings must be added to the estimate (separated by parentheses).

Confidence limits for $\hat{N}$ follow an asymetrical distribution because of the sampling design. This asymetricl distribution is skewed such that the lower confidence limit is narrower than the upper confidence limit. Statistically, it is best to approximate this asymetric normal distribution by using the inverse ($1/\hat{N}$) because this is more symetrically distributed and more nearly normal than $\hat{N}$ (Cormack 1968). The associated variance can be estimated by:

$Var\ (1/\hat{N}) = \frac{Var\ (\hat{N})}{(\hat{N})^4}$, then converted back to the reciprocal which results in asymetric confidence intervals. Another alternative is to base confidence intervals on the probability distribution of the number of marked recaptures (M) which is assumed to have a hypergeometric distribution (Ricker 1975). The hypergeometric distribution is extremely difficult to calculate and is best approximated by Poisson, binomial or normal distributions. Chapman (1948) suggested the following most appropriate approximations:

$C < 500$	;	$\frac{R}{C} < 0.1$	Poisson approximation
		$\frac{R}{C} > 0.1$	Binomial approximation

$500 \leq C \leq 1000$;	$\frac{R}{C} \leq 0.075$	Poisson approximation
	$\frac{R}{C} > 0.075$	Normal approximation
$C > 1000$;	$\frac{R}{C} \leq 0.05$	Poisson approximation
or	$R < 100$	Poisson approximation
	$\frac{R}{C} > 0.05$	Normal approximation
	$R < 100$	

Statistical accuracy would require the use of inverse or binomial computation of confidence intervals in streams where C is less than 500 and $\frac{R}{C}$ is greater than 0.1 (as is the case in Flathead River tributaries). However, monitoring fish populations to meet fish management goals requires less precise information as managers generally deal with changes in population levels on an order of magnitude which makes the method used to calculate confidence intervals insignificant. For that reason and ease of computation and acceptance by management biologists, we recommend applying the normal approximation of $\pm 2\sqrt{V(\hat{N})}$ (Vincent 1971), realizing that upper confident intervals will be underestimated.

Sample sizes required for estimating fish numbers are dependent upon the level of precision desired. For two-catch estimators, the higher the value of $\hat{p}$, the more precise the estimate will be. For mark-recapture estimates, Robson and Regier (1964) prepared charts for determining the number of fish needed for various levels of precision. These charts can be used to determine the number of fish that are needed on a recapture fishing conducted after marking a known number of fish, at a level of precision desired. If equal efforts are extended during both the marking and recapture electrofishings, consult Table 2.

When increased precision is desired a Schnable-type (1938) multiple census may be the preferred alternative. For an excellent discussion of the history and options available in mark-recapture and removal methods, the reader is directed to the recent work of White et al. (1982). This document discusses the use of a computer program, CAPTURE, to statistically evaluate models (estimators) used to compute estimates.

Table 2. Number of fish to be captured during each fishing (marking and recapture) for various estimated population sizes ($\hat{N}$) and error bounds (B, recommended $B \leq 0.25\ \hat{N}$) at the 95% level of confidence. From the formula: $B = 2\sqrt{\frac{N^2(N-M)}{MC}}$, where M=C, presented by Jensen (1981).

Estimated population size ($\hat{N}$)	Error bound (B)		
	25% N 1/	50% N	100% N
25	20	14	9
50	33	22	13
100	54	33	22
150	71	42	23
200	86	50	27

1/ Recommended error bound.

PART II. UNDERWATER COUNTS

Comparing relative fish abundance between waters within the Flathead basin required using a single technique. Snorkeling was selected as the standard method because large portions of the Flathead drainage lie within Glacier National Park, Great Bear Wilderness and Bob Marshall Wilderness boundaries, where the use of motorized equipment is prohibited. Snorkeling has been shown to be an effective technique for evaluating fish populations in clear, low-conductivity waters (Northcote and Wilkie 1963, Goldstein 1978, Whitworth and Schmidt 1980, Griffith 1981).

Comparisons were made between two-catch electrofishing estimates and underwater counts in selected stream sections within the Flathead basin (Table 3). These comparisons revealed that: 1) underwater counts generally underestimated fish abundance and the magnitude of bias varied between species, 2) water temperature appeared to influence the accuracy of the count, and 3) physical characteristics of the stream (streamflow, water clarity, riparian canopy, instream debris) influenced the number of fish observed by snorkelers.

Pearson correlation coefficients computed for differences between snorkel counts and two-catch electrofishing estimates of westslope cutthroat trout illustrated that overhead (bank) cover, gradient, instream cover and temperature all may influence the relative estimate of fish abundance using underwater counts (Table 4). For juvenile bull trout, flow, temperature and to a lesser extent instream and overhead cover may influence the number of fish enumerated by underwater observers (Table 5). Juvenile bull trout abundance was more difficult to assess accurately using snorkel techniques than cutthroat trout abundance. Snorkel counts were in close agreement with electrofishing estimates for cutthroat in streams with little instream debris, little riparian canopy, low channel gradient (less than 3%) and low to moderate streamflows (5 to 20 cfs), provided the counts were conducted during the middle of the day in late summer when water temperatures were higher than 10.0°C (e.g., Cyclone and Giefer creeks, Table 3). Correction factors (the number of fish estimated using two-catch electrofishing estimators divided by the number of fish counted by underwater observers) were computed to more reliably compare snorkel counts to electrofishing estimates. Correction factors ranged from 0.86 to 1.47. A better relationship between underwater counts and electrofishing estimates needs to be developed which incorporates environmental variables. Initial attempts at developing these types of relationships indicate snorkel counts can be used to predict numbers of fish estimated using two-catch estimators.

Table 3. Comparison of snorkeling counts and two-catch population estimates for fish >75 mm conducted in tributaries to the North and Middle Forks of the Flathead River in 1981, and tributaries to the Swan River in 1982. ($\hat{N}$ = estimated number of fish, 95% CI = 95% confidence interval, p = probability of capture).

Creek	Date	Gradient (%)	Temp (°C)	Snorkel count	Two-catch est. $\hat{N}$	Two-catch est. 95% CI	Two-catch est. p	Difference ($\hat{N}$-snorkel)	% difference (difference/$\hat{N}$)	Correction factor ([$\hat{N}$]/snorkel count)
Cutthroat										
Flathead	1981									
Challenge	7/14	3.3	8.9	38	47	± 1	0.95	9	19	1.23
Cyclone 1/	7/23	1.5	15.0	253	217	±22	0.66	-36	16	0.86
Geifer	7/29	2.5	14.4	20	21	± 3	0.82	1	5	1.05
Essex	8/4	2.2	10.0	74	72	±16	0.61	- 2	3	0.97
Red Meadow	8/6	2.2	10.0	151	172	±21	0.65	21	12	1.14
Langford	8/8	1.2	9.4	62	91	±16	0.64	29	32	1.47
Whale	8/10	0.7	10.0	12	17	±21	0.43	5	29	1.42
Swan	1982									
Groom	8/31	9.5	8.3	24	51	± 1	0.91	27	53	2.12
Soup	8/25	10.6	8.9	27	69	± 5	0.78	42	61	2.56
S.F. Lost	8/31	3.6	--	8	12	± 2	0.80	4	33	1.50
Bull Trout										
Flathead	1981									
Geifer	7/29	2.5	14.4	7	6	± 2	0.80	- 1	17	0.86
Red Meadow	8/6	2.2	10.0	7	15	± 2	0.83	8	53	2.14
Whale	8/10	0.7	10.0	54	76	±31	0.50	22	29	1.41
Trail	8/20	1.2	7.8	1	85	±29	0.52	84	99	85.00
Swan	1982									
S.F. Lost	8/31	3.6	--	6	24	± 5	0.71	18	75	4.00
Bethal	8/25	10.5	9.4	10	21	± 1	0.95	10	52	2.10
Squeezer	9/8	1.8	7.2	14	27	± 6	0.68	13	48	1.93

1/ Age 1+ cutthroat were ≥ 50 mm.

Table 4. Pearson correlation coefficients for difference and percent difference between snorkel counts (SC) and two-catch electrofishing estimates (2C) of westslope cutthroat trout versus five habitat characteristics in ten stream sections.

	Difference	
	Number (SC - 2C)	Percent Difference (SC - 2C/2C)
Flow (cfs)	-.226	.043
Temperature (°C)	-.041	-.565
Gradient (%)	.494	.797
Instream cover (%)	.310	.491
Overhead cover (%)	.596	.693

Table 5. Pearson correlation coefficients for difference and percent difference between snorkel counts (SC) and two-catch electrofishing estimates (2C) versus five habitat characteristics of juvenile bull trout in seven stream sections.

	Difference (SC - 2C)	Percent Difference (SC - 2C/2C)
Flow (cfs)	.918	.689
Temperature (°C)	-.415	-.489
Gradient (%)	-.293	.003
Instream cover (%)	-.424	.012
Overhead cover (%)	-.396	.124

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APPENDIX C

Maps showing sample site locations of fish abundance sections, streambed sampling areas and bull trout redd survey sections recommended for long-term monitoring of the fish resource in the upper Flathead Basin.

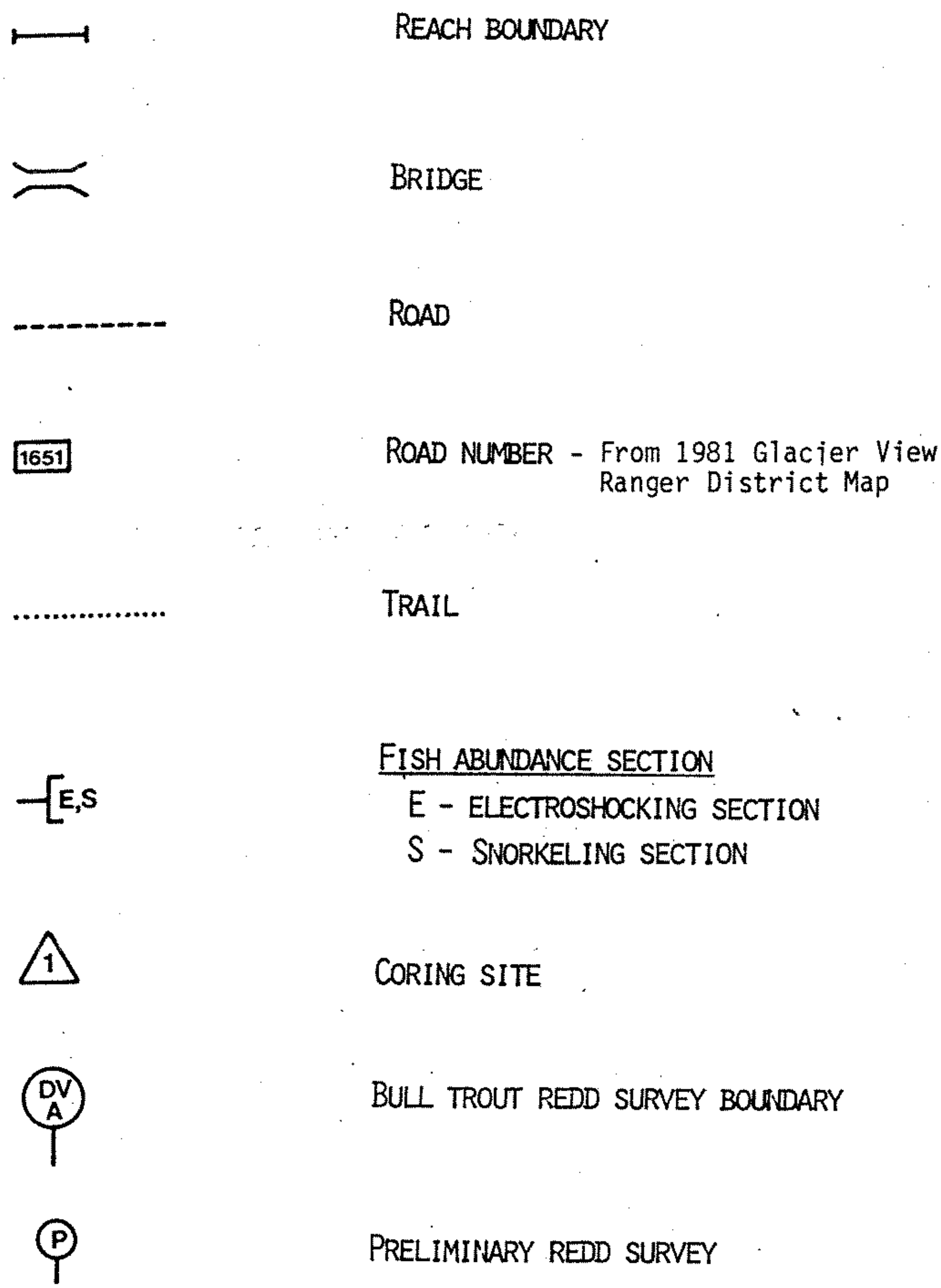


Figure 1. Legend for monitoring sample site maps.

NORTH FORK DRAINAGE

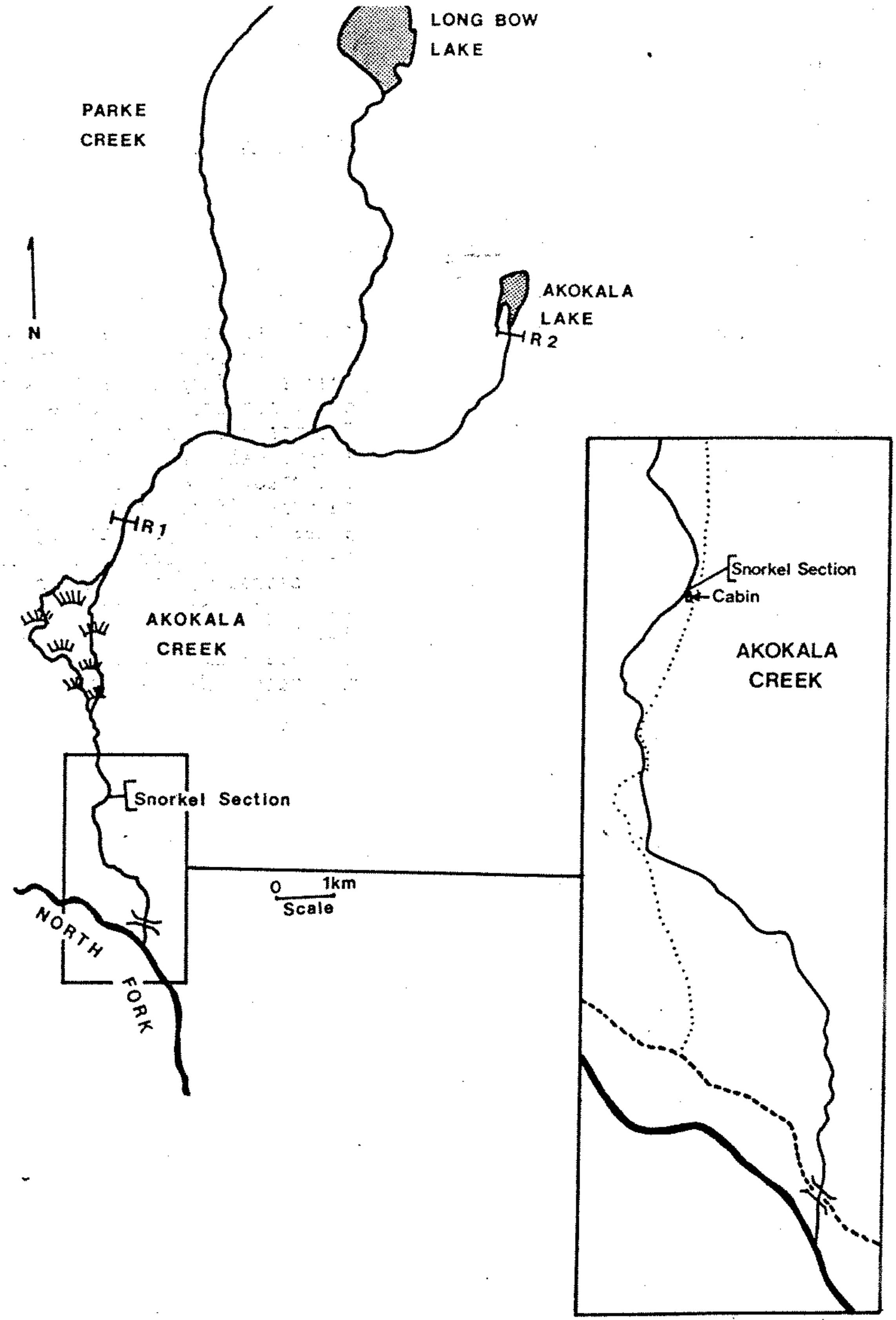
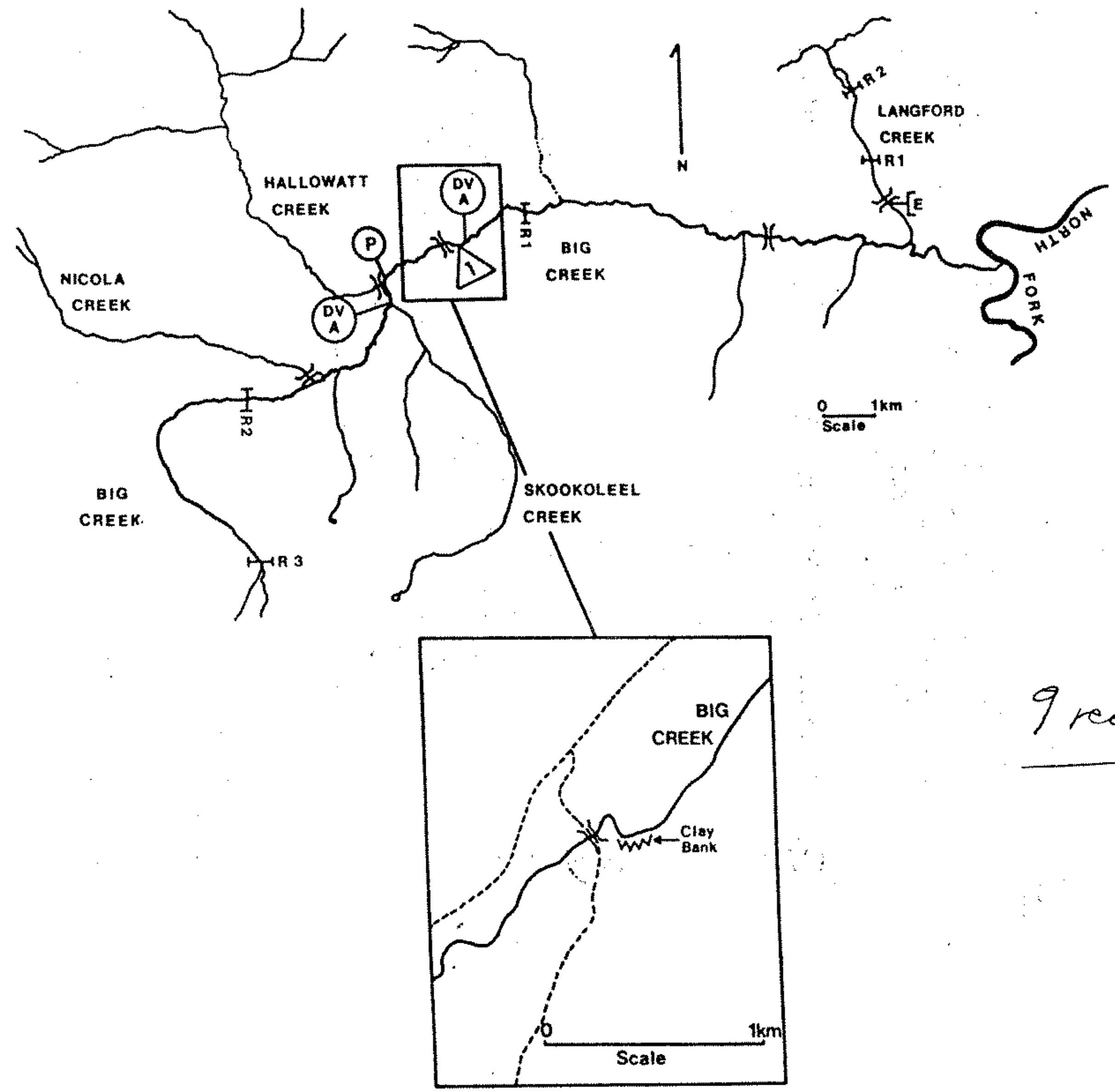


Figure 2. Location of snorkel section recommended for long-term monitoring in Akokala Creek.

Akokala Creek Drainage

S Fish Abundance:

Cross the North Fork of the Flathead River at the Polebridge Ranger Station of Glacier National Park. Proceed north, crossing Bowman and Akokala creeks. After crossing Akokala, look for a small, obscure grass covered road to the east. The road will be on the edge of the timber as you see a small meadowy spot. Walk the old road; it will become a path. The path becomes difficult to follow once it reaches a meadow. It goes through the center of the meadow. Look across the meadow and head for the depression in the land. Find the path again and proceed across the creek, up a steeper side hill, and along the flat until you see a small cabin on the north side of the path. Walk straight to the creek behind the cabin. This is the bottom of the snorkel section.



9 redds 19oct84

Figure 3. Locations of fish abundance section, streambed sampling site and bull trout redd survey section recommended for long-term monitoring in Big and Langford Creeks.

Big Creek Drainage

General Directions: Pass the Big Creek Ranger Station on the North Fork Road (FH61, 210), and turn up Big Creek Road (316); remain on 316 by taking the southwest fork (left) at the first intersection.

Fish Abundance - Langford Creek: See general directions.

Just past the intersection, look for a small bridge-culvert. The creek is small, with lots of overhang. The culvert is in the middle of a large curve in the road. The upstream end of the electrofishing section is the downstream side of the culvert.

Preliminary redd survey: See general directions.

Proceed up on Road 316 until you reach the Hallowat Creek road (315). Stay left on road 316, stopping at the bridge and walk downstream.

Redd survey: See general directions.

Proceed up Road 316, pass Hallowatt Creek and the Hallowatt Creek road (315) Park immediately past Road 315 and walk upstream to the first large stream coming in from the south (left); this is Skookoleel Creek. Begin redd survey at this confluence, walking downstream below the mouth of Hallowatt and below the next bridge (Skookoleel Creek Road 316E) approximately 500 meters. There will be several cut banks below 316E; stop at the one with an evident clay content.

Streambed monitoring: See general directions.

Continue on the Big Creek Road until road number 316E, and take a left. Park across the bridge. Coring sites are located below the bridge in the first log jam and further downstream just above the clay bank.

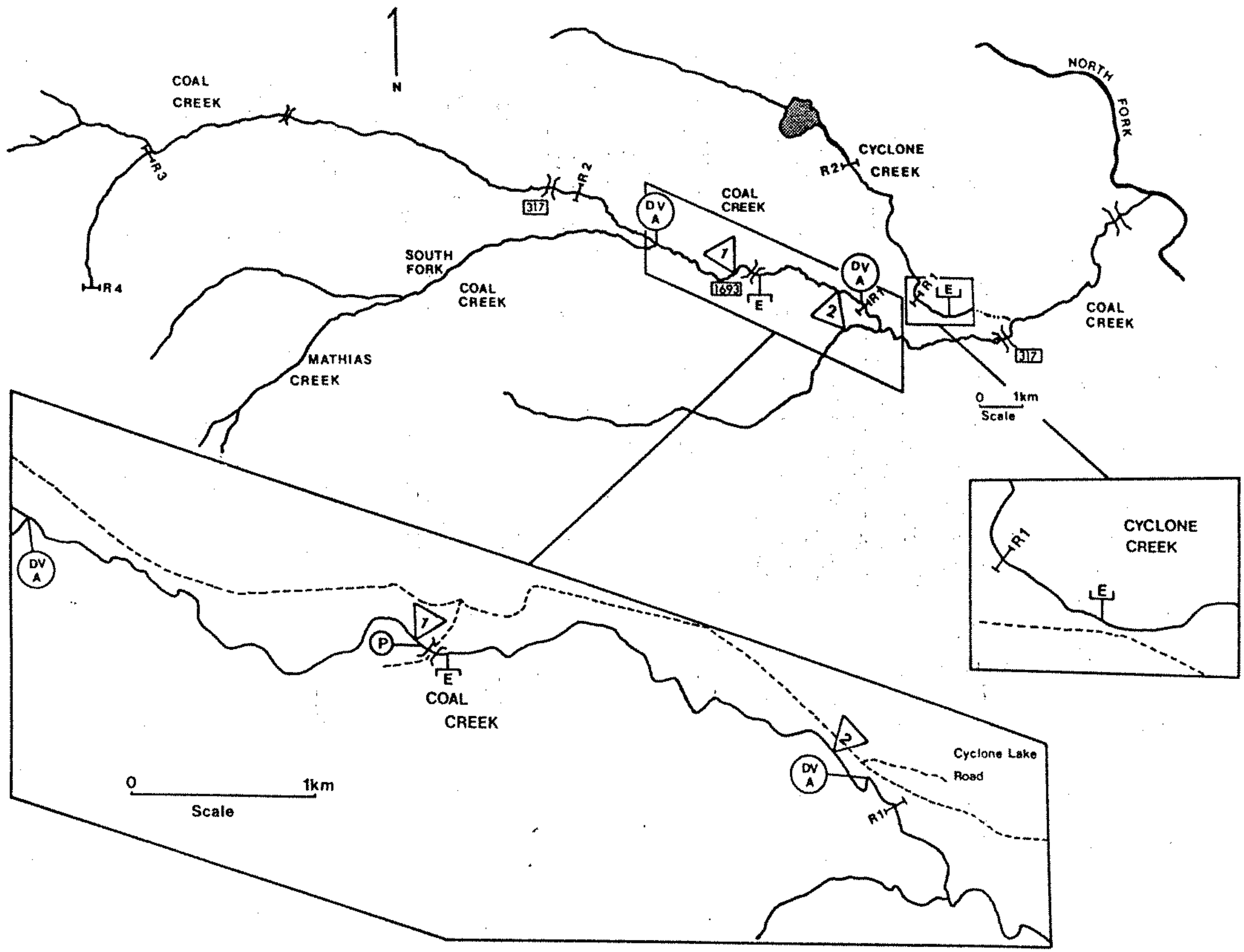


Figure 4. Locations of fish abundance sections, streambed sampling sites and bull trout redd survey sections recommended for long-term monitoring in Coal and Cyclone Creeks.

Coal Creek Drainage

General directions: Pass Big Creek Ranger Station on North Fork Road (FH61, 210), turn west onto the Big Creek Road (316). Turn right (northwest) onto the Coal Creek Road (317). Pass Mud Lake and cross Coal Creek.

E — Fish Abundance: Cyclone Creek: See general directions.

Proceed over the hill; the road will flatten and you will see a private cabin on the north-side of the road. There is a small driveway just east of the cabin. The upstream end of electrofishing section is straight into the creek from the junction of the driveway and road 317.

E — Fish Abundance: Dead Horse Bridge site: See general directions.

Proceed past the Cyclone Basin Road (909), and take the first major road south to Dead Horse Creek (1693). The upstream end of the section is the downstream side of the bridge.

P — Preliminary redd survey: See general directions.

Proceed past the Cyclone Basin Road (909) and take the first major road south toward Dead Horse Creek (1693). Walk up stream from bridge.

DV A — Redd surveys: See general directions.

Proceed past 909 and 1693. Go approximately 1.5 miles west of the Dead Horse Road (1693) passing a clearcut on the south side of the road. There are no good landmarks along the road at present. It would be better to walk into Coal Creek from the road side, and walk downstream to the confluence of Coal and the South Fork where the count begins. Consult USFS topographic map Cyclone Lake Quad.

Coal Creek Drainage cont.

(1) Streambed monitoring: Dead Horse Bridge site: See general directions.

Continue on the Coal Creek Road (317) until you reach the Dead Horse Creek Road (1693). Park at the turnout just before the bridge. The coring site is just above the bridge.

(2) Streambed monitoring: Cyclone site: See general directions.

Follow the Coal Creek Road until the creek is visible from the road. This will be at the Cyclone Basin Road (909). Enter the creek here and proceed upstream past the large debris jam. Locate rebar on upstream right gravel flat.

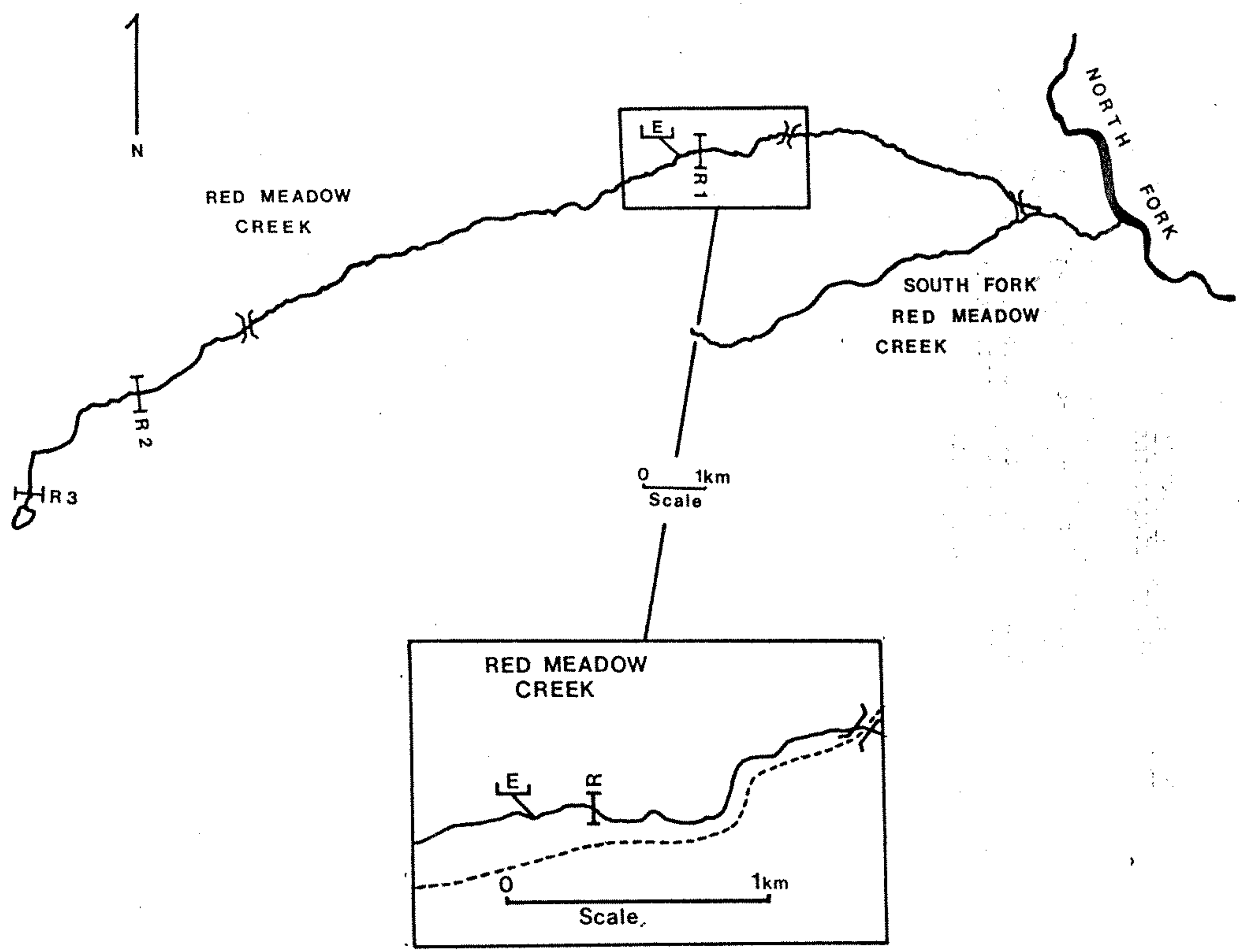


Figure 5. Location of fish abundance section recommended for long-term monitoring in Red Meadow Creek.

Red Meadow Drainage

-[E

Fish Abundance:

Cross Red Meadow Creek on the North Fork Road (FH61, 210). Turn up the Red Meadow Creek Road (115). Stay on Road 115, bearing left at the first two junctions. You will cross the creek, go approximately one more mile up road 115. Turn right on a small road (its the first right past the bridge) at the east edge of an old clearcut. There is a large turn around spot near the creek; if you walk straight into the creek there is an embedded log across the creek bottom, the downstream border of the section. From the turn around area there is a tire track to the west, it goes to an old side channel of the creek. Walk down this side channel to the creek, the upstream end of the section.

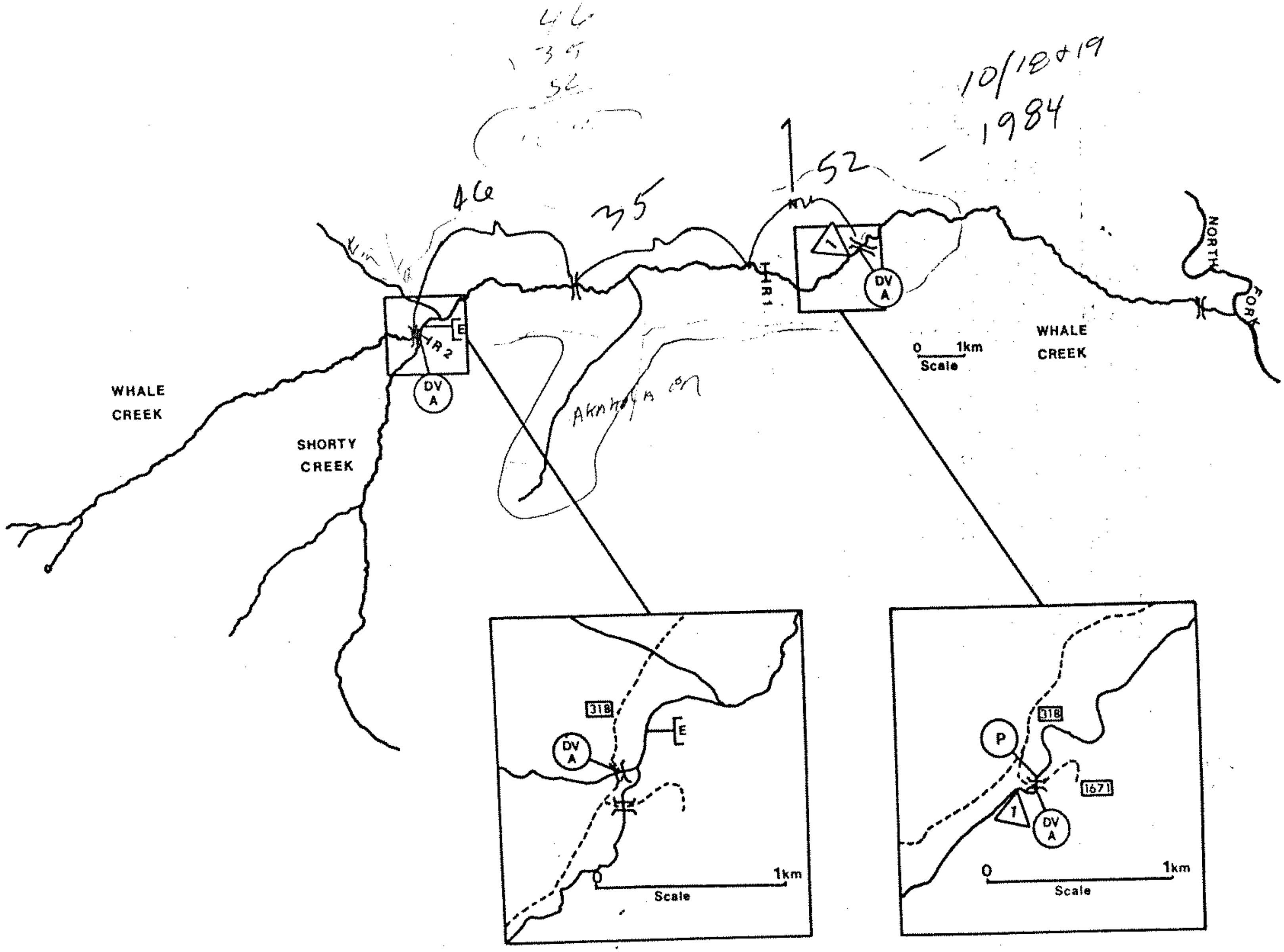


Figure 6. Location of fish abundance section, streambed sampling sites and bull trout redd survey section recommended for long-term monitoring in Whale Creek.

Whale Creek Drainage

General Directions: Proceed up North Fork Road (FH61, 210). Cross Whale Creek; turn up Whale Creek Road (318).

Fish Abundance: See general directions.

Proceed west, passing two major intersections (1671, 1672). At the next fork, go right toward Shorty Creek. You will cross Whale Creek almost immediately. Walk below the bridge to the confluence of Shorty and Whale creeks; the top of the electrofishing section is at the upstream end of the first riffle.

Preliminary redd survey: See general directions.

Proceed west, take first road south (Whale Buttes Road, lower Moose creek bridge (1671). Walk upstream from the bridge.

Redd survey: See general directions.

Proceed west, passing 2 major intersections (1671, 1672). At the next fork, go right toward Shorty Creek. You will cross Whale Creek almost immediately. Below the bridge at the confluence of Whale and Shorty creeks, begin the redd count.

Walk to the Center Mountain Road Bridge on 1672 the first day, and finish the section to the Whale Buttes Road Bridge on 1671 the second day.

Streambed monitoring: See general directions.

Continue on this road until the first major road to the left (1671). Park in the first turn out before the bridge. Walk down to the creek at this point. This will place you just upstream from the two coring sites above the bridge. The third site is just downstream of the bridge.

(.9 mile) 4 lower

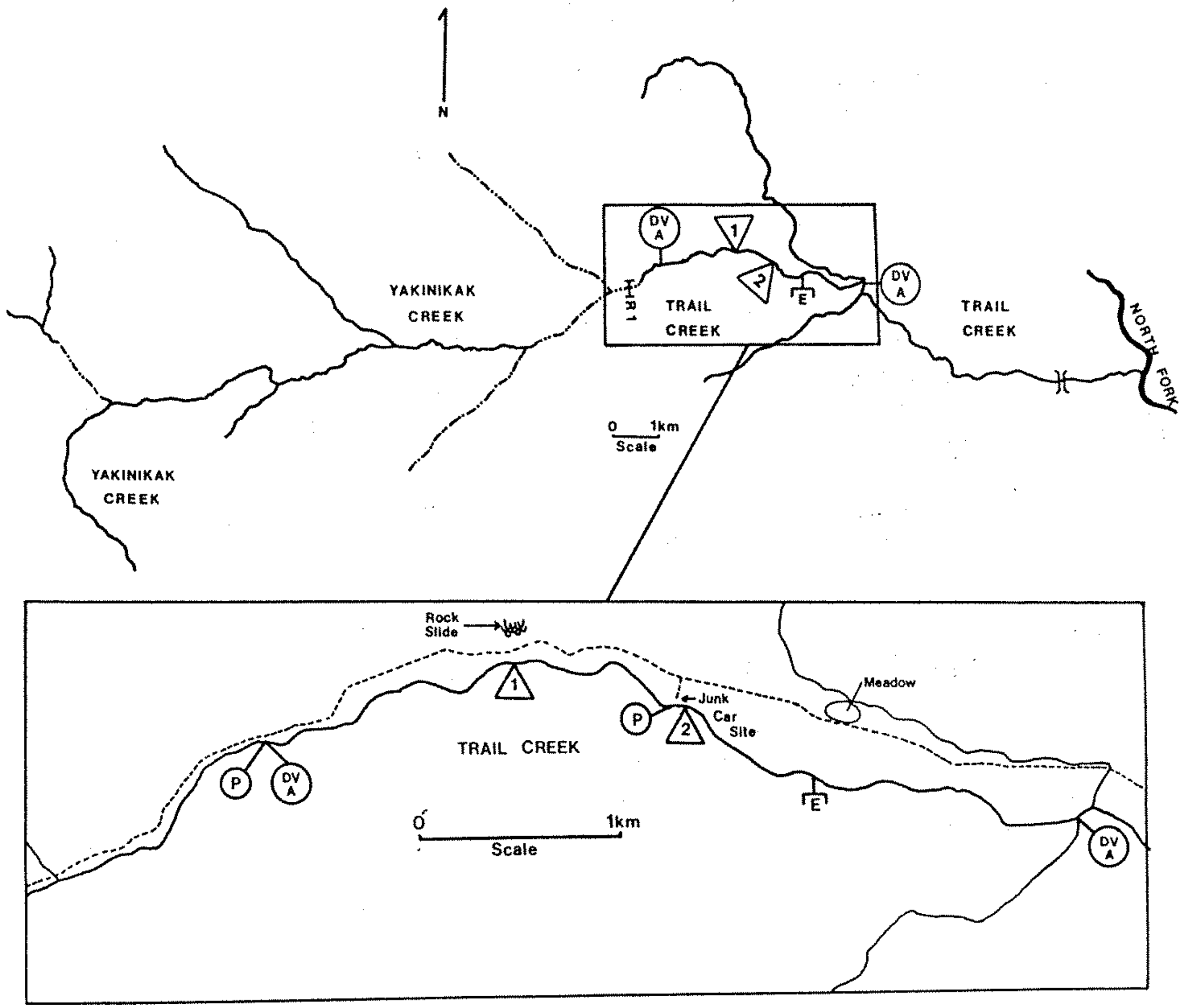


Figure 7. Location of fish abundance section, streambed sampling sites and bull trout redd survey section recommended for long-term monitoring in Trail Creek.

Trail Creek Drainage

General Directions: Cross Trail Creek along the North Fork Road (FH61, 210) and turn up Trail Creek Road (114).

Fish Abundance: See general directions.

Proceed up Road 114 and pass Cleft Creek Trail; continue west 0.75 miles more until you see a meadow on north side of the road. There is an old road on the south side of Road 114. Walk down to the creek. This is the top of the electrofishing section.

Preliminary redd surveys: See general directions.

1) Proceed up Trail Creek Road (114) past homes and tallus rock slope on north side of road. Park at next road past tallus slope and walk downstream along the rim of the canyon. The rim leads away from the creek, keep following it until you see the creek again, and a spring channel of approximately 25-30 cfs below. The spring channel is the preliminary survey site.

2) Back track from tallus slope in #1 and take first road that goes south and has a north branch as well: walk down steep dirt bank, check pool below with large rock wall on south side of creek.

Redd survey: See general directions

Stop at the Cleft Creek trail head sign, and go down the old road to the bottom of the hill; walk into the creek and look around, this is the downstream end of the section. Note the large gravel bars, and three short channels which you can see standing along the bank.

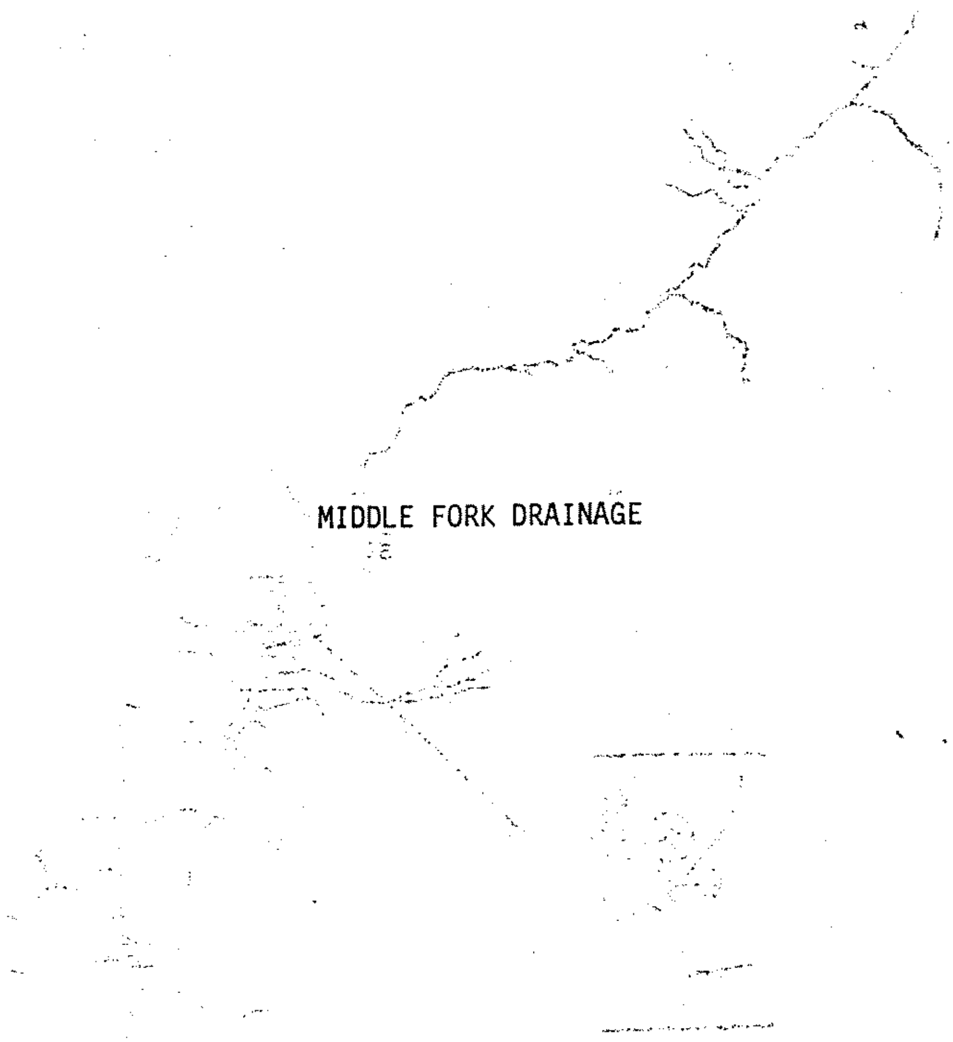
Proceed up Trail Creek Road 114 past homes and a tallus slope by the road. Park at the next road to the north after the tallus slope. You will be able to see a canyon area of the creek. Walk downstream along the rim of the canyon until the rim leads you away from the creek; at this point the valley floor widens; go down to creek and initiate redd count.

1 <u>Streambed monitoring</u>: See general directions.

Proceed up Road 114 to tallus slope along the north side of the road. You can see the creek at this point. Proceed a very short ways beyond this rock area to the next place you easily see the creek. There is a steep dirt bank. Fix a rope to a nearby tree along the road for ease of moving equipment.

2 <u>Streambed monitoring</u>: See general directions.

Proceed up Road 114 to tallus slope along north side of the road; back track to the first small road which goes south to the creek, and north as well. Take the south branch, walk past the wrecked car; go down the hill to the creek and walk downstream until you see a large pool with a rock wall along the south bank. The transects begin in the tail of this pool.


MIDDLE FORK DRAINAGE

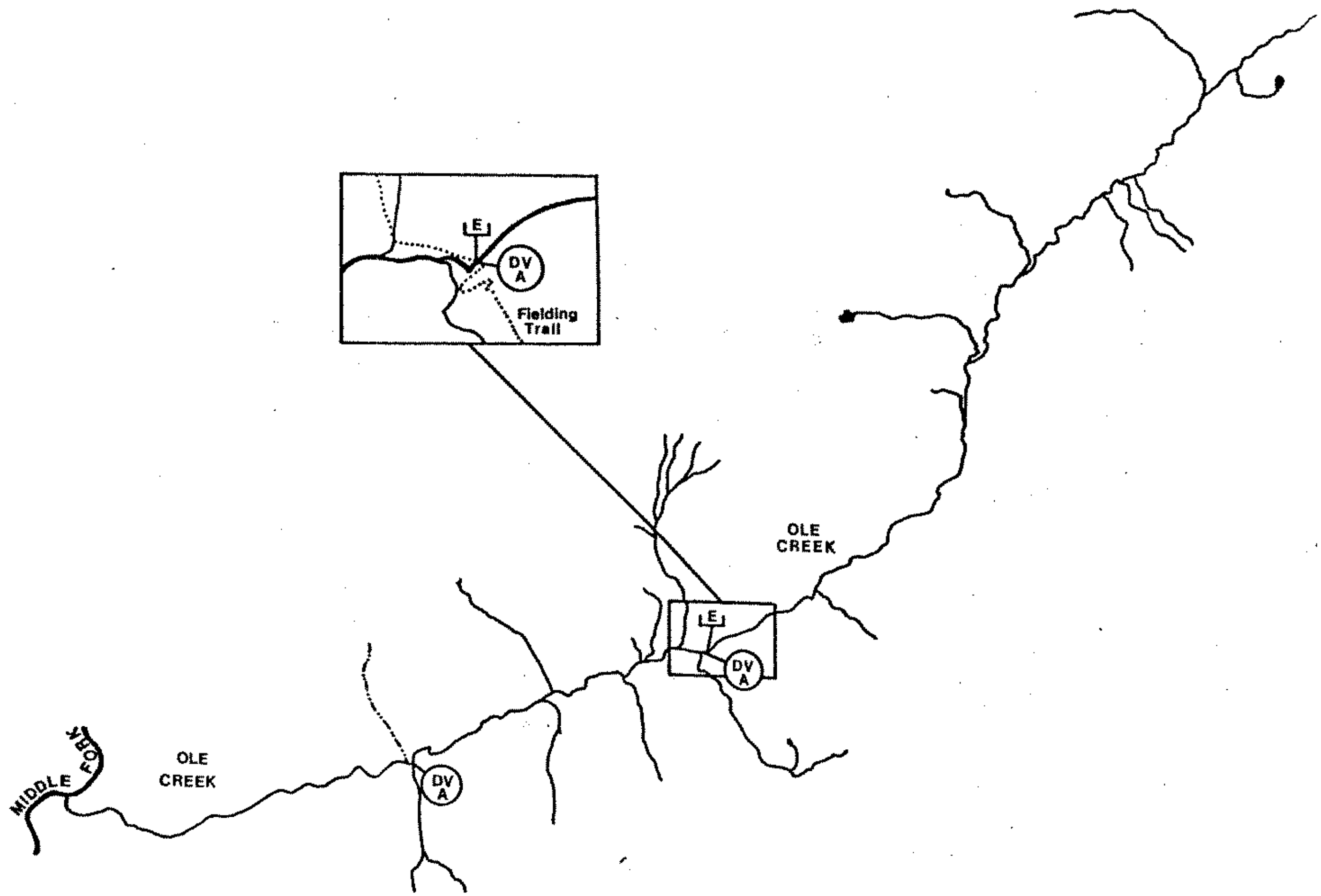


Figure 8. Location of fish abundance section and bull trout redd survey section recommended for long term monitoring in Ole Creek.

Ole Creek Drainage

Fish Abundance:

This section began at the Fielding-Coal Creek trail crossing and extended 150 m downstream. Access is by turning left off of Highway #2 approximately 100 m upstream from the Geifer Creek bridge and proceeding through a gravel pit. Stay left at the fork and cross a gated bridge below outlet of a small lake. Continue to the Burlington Northern Railroad where you turn right and follow tracks for approximately 1.2 km. The Fielding-Coal Creek trailhead was located on the point of a 165 degree bend of the railroad grade. Hike the trail past the patrol cabin and down into the Ole Creek drainage. A Glacier National Park campground was located at the crossing where the section began.

Redd survey:

Redd counts were made from the Fielding-Coal Creek trail crossing downstream to the upper end of the canyon section on lower Ole Creek. Access is the same as listed for the Ole Creek electrofishing section. The lower end of this section is located at the fifth tributary on the south below the Fielding-Coal Creek trail crossing (at stream km 6.0). (See Blacktail and Essex Quads).

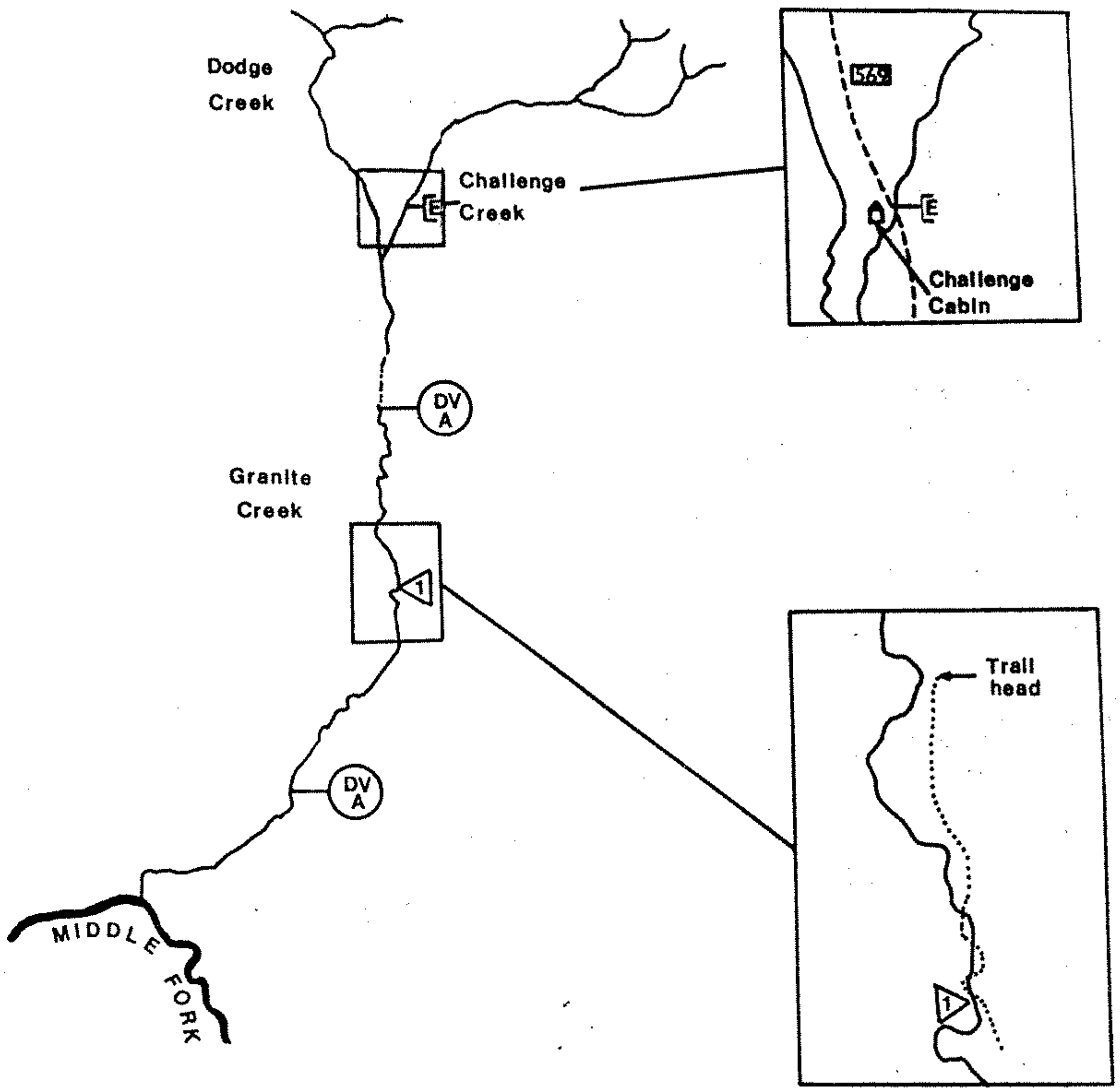


Figure 9. Location of fish abundance section, streambed sampling sites and bull trout redd survey section recommended for long-term monitoring in the Granite Creek drainage.

Granite Creek Drainage

Fish Abundance: Challenge Creek

This section began at the cattle guard across Forest Service Road 569 at Challenge Cabin and extended downstream for 150 m. Forest Service Road 569 (Skyland Road) is located off Highway #2 approximately 3.5 km west of Marias Pass.

Redd survey: Granite Creek

Redd counts were made from the lower end of the dry section down to the upper end of the canyon on lower Granite Creek. Access to this section was by Forest Service Road 569 to the Free Firewood Access Road on the right, past Challenge Cabin. Drive down the Firewood Road through the first clearcut and park just passed the corral in the second clearcut. Drop down into the creek bottom at this point and proceed down through the dry section until the stream resurfaces. The lower end of this section was at the fourth tributary on the west below the dry section (See Red Plume Quad).

Streambed Monitoring: Granite Creek

A substrate coring site was located below the dry section of Granite Creek. Access is the same as for redd counts only continue on the Firewood Road to approximately midway into the third clearcut. An unmarked trail leads down into the creek bottom near this point. Follow this trail down and walk the streambank until the rebar marking the transects is observed. Rebar on the downstream left is painted red and downstream right is painted green (See Red Plum Quad and 1982 fall coring data).

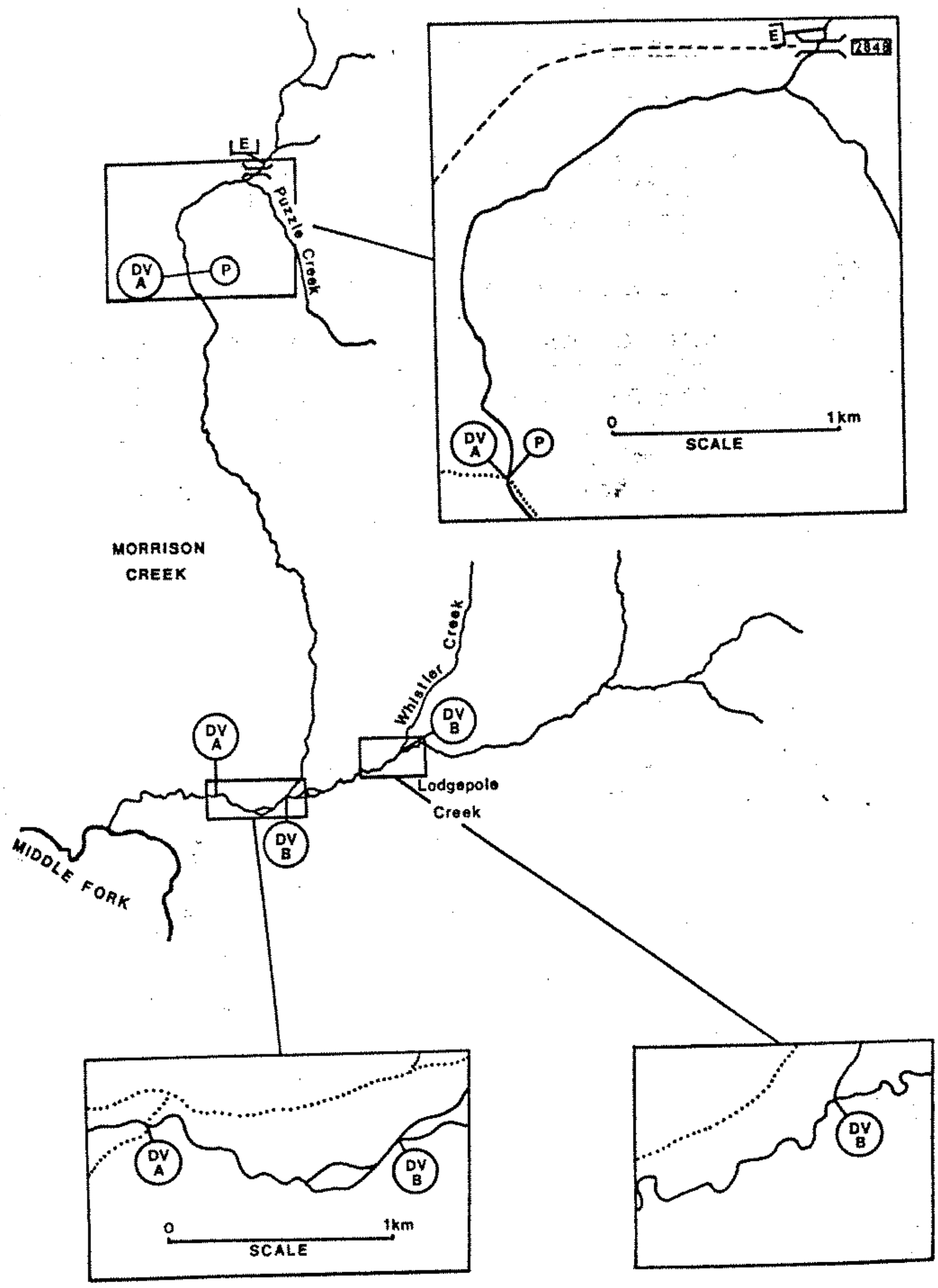


Figure 10. Location of preliminary bull trout redd survey section of Morrison Creek and the bull trout redd survey sections recommended for long-term monitoring in the Morrison Creek drainage.

Morrison Creek Drainage

E

Fish Abundance: Morrison Creek

This section began at the bridge on Forest Service Road 2848 and extended upstream 150 m. This section is best accessed by taking Forest Service Road 569 (Skyland Road) and proceeding past the Morrison Creek Trailhead approximately 1.5 km to the junction of road 2848. Pass through a locked gate and continue on until reaching the bridge crossing Morrison Creek. A large debris jam was visible in Morrison Creek above this bridge and was in the electrofishing section.

P

Preliminary bull trout redd survey: Morrison Creek

From the first crossing of the old Morrison Creek trail downstream 1 mile. Access provided by Forest Service Road 569 to the old trailhead.

DV A

Redd survey: Morrison Creek

Redd counts were made from the first crossing of the old Morrison Creek trail down to the first trail crossing below the mouth of Lodgepole Creek. Access is provided by Forest Service Road 569 to the old trailhead.

DV B

Redd survey: Lodgepole Creek

Redd counts were made from the junction of Whistler Creek down to the mouth of Lodgepole Creek. Whistler Creek is accessed from the Morrison Creek trailhead on Forest Service Road 569. Proceed down the Morrison Creek trail approximately 13 km to the junction of the Lodgepole Creek trail. Turn left onto the Lodgepole trail and cross Morrison Creek just below an old outfitters camp. Continue on the Lodgepole trail to the Whistler Creek crossing (3 km) then follow Whistler Creek down to its mouth (See Capitol Mtn. and Gable Peaks Quads).

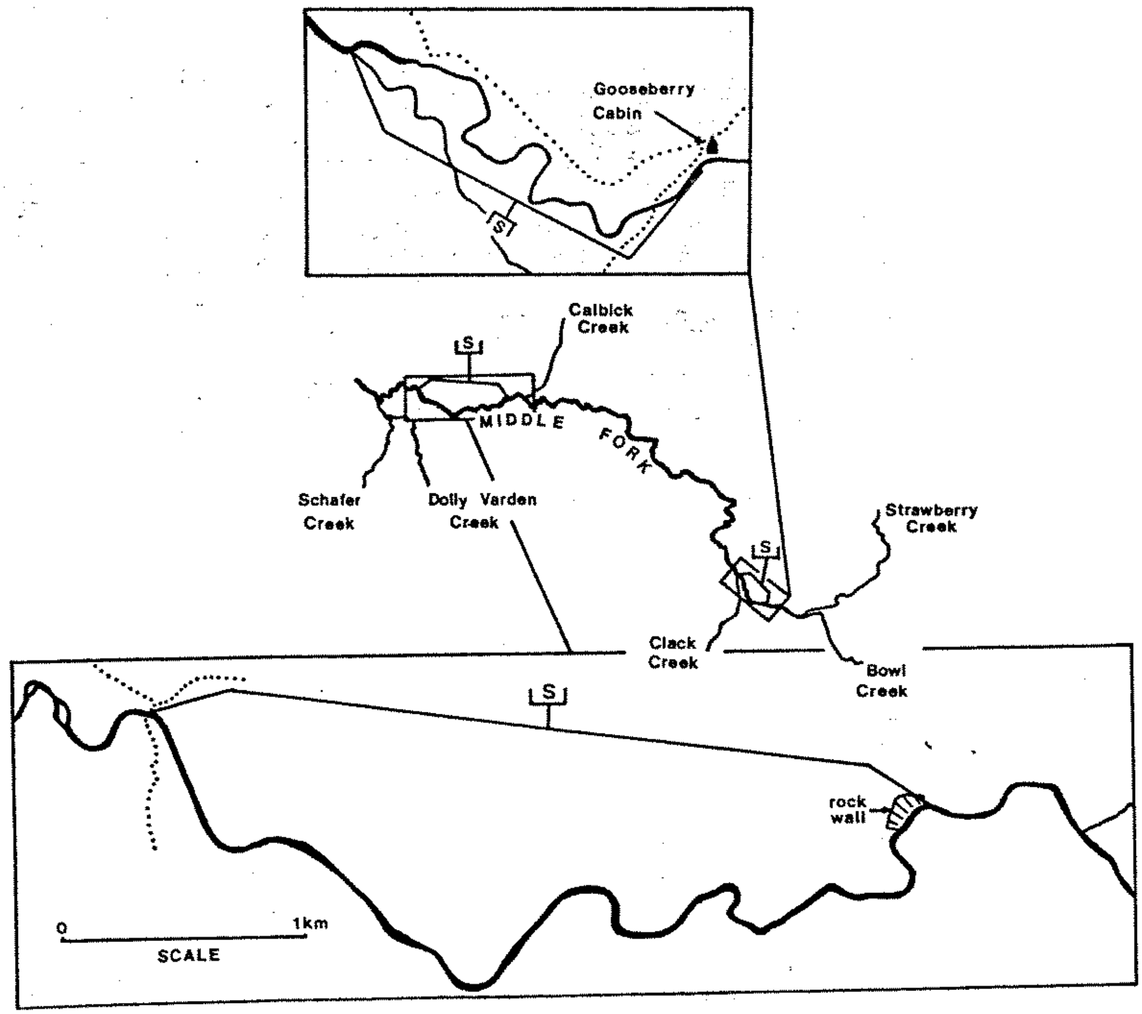


Figure 11. Location of fish abundance sections recommended for long-term monitoring in the Middle Fork of the Flathead River.

Middle Fork Flathead River

Fish Abundance: Upper River.

This section began at the first log jam pool downstream from Gooseberry Cabin (50 m) and extended down to the mouth of Clack Creek. Gooseberry Cabin is located approximately 23.5 km up the Big River Trail from Schafer Meadows Airstrip (See Gooseberry Park Quad).

Fish Abundance: Schafer River Section.

This section began at the pool located at the upper end of the rock wall above Schafer Horse Meadows and extended down to the ford at Schafer Meadows. This section is best accessed by walking the river upstream for approximately 3 km above the Schafer ford (See Gable Parks Quad).

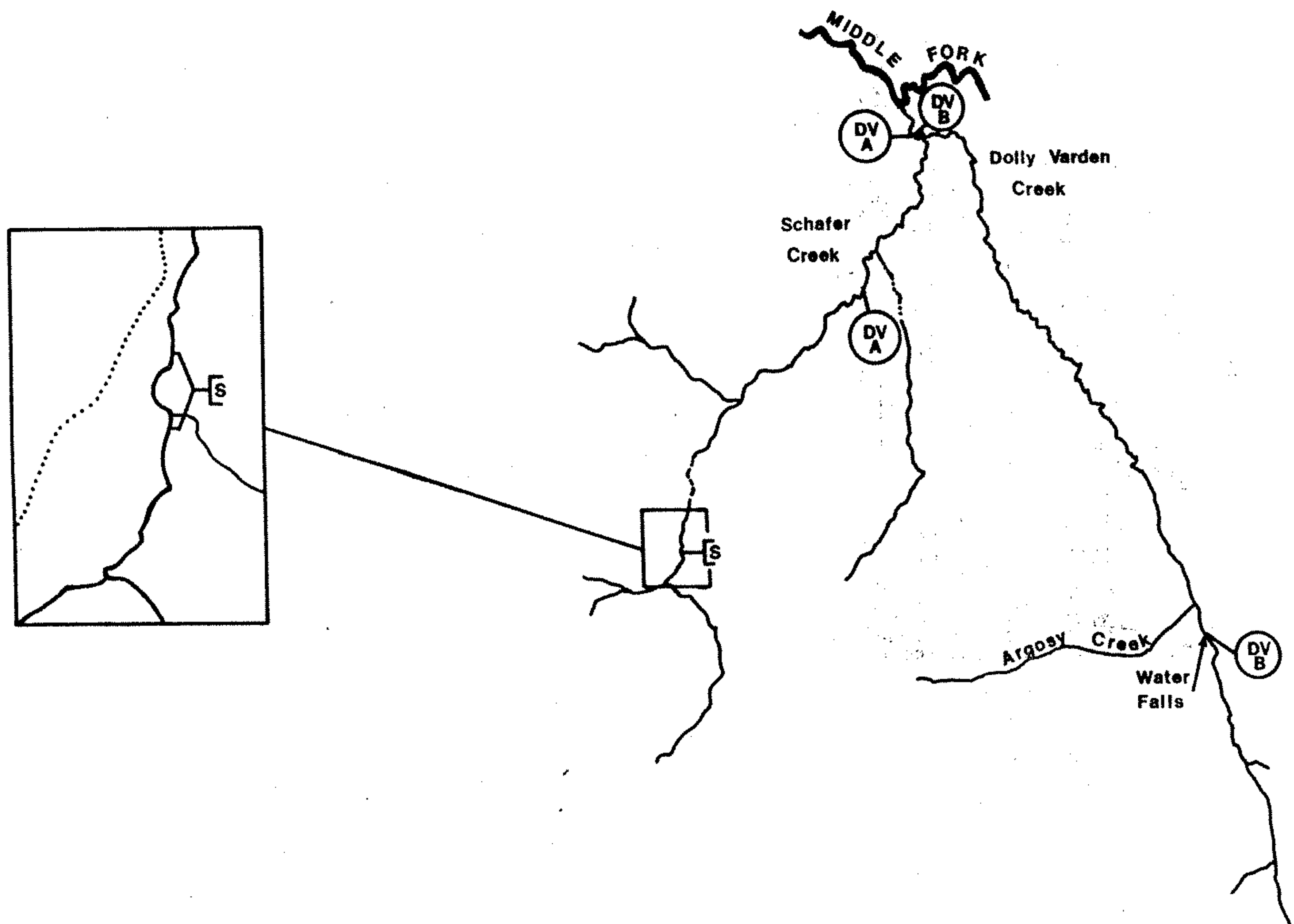


Figure 12. Location of fish abundance section and bull trout redd survey sections recommended for long-term monitoring in Schafer Creek drainage.

Schafer Creek Drainage

Fish Abundance: Schafer Creek

This section began at the third tributary on the east above the Schafer Creek-Capitol Mountain trail junction. Access by the Schafer Creek trail out of Schafer Meadows station (See Capitol Mountain Quad).

Redd survey: Schafer Creek

Redd counts were made from the large beaver dam above Roaring Creek down to the mouth of Dolly Varden Creek. This beaver dam is approximately 5 km above the mouth of Dolly Varden Creek and .75 km above the Schafer Creek trail crossing. Above this beaver dam the stream was intermittent. (See Capitol Mountain and Gable Peaks Quads).

Redd Survey: Dolly Varden Creek

Redd counts were made from the barrier falls down to the junction of Schafer Creek. Access is by the Schafer Creek trail out of Schafer Meadows. Cross the river and proceed up to the Dolly Varden crossing. Do not cross Dolly Varden Creek but continue up the trail on the upstream left bank to the Argosy Creek trail junction. Take the Argosy Creek trail down to Dolly Varden Creek then walk the stream up for approximately 1 km to the barrier falls. (See Gable Peaks and Trilobite Peak Quads).

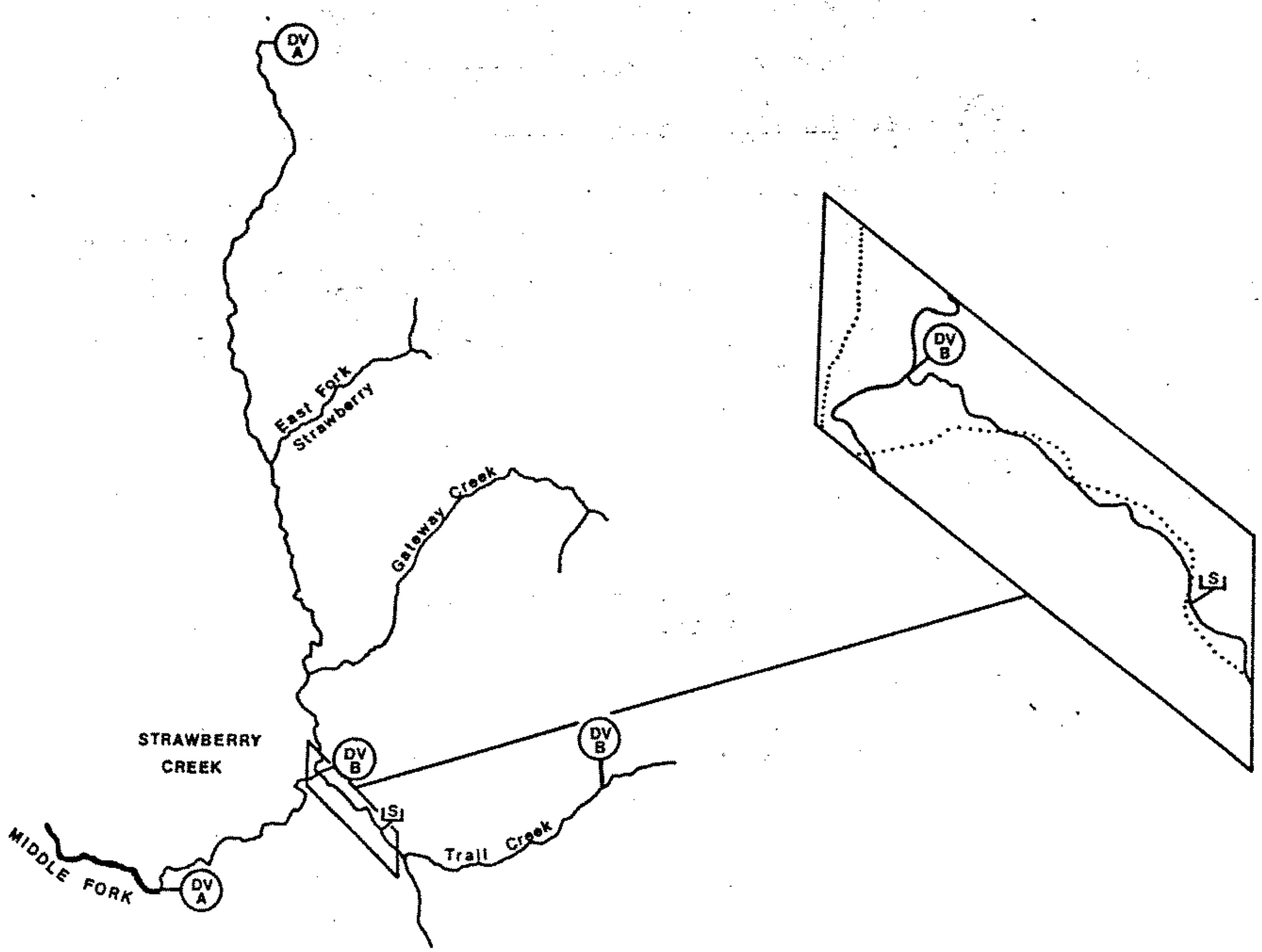


Figure 13. Location of fish abundance section and bull trout redd survey section recommended for long-term monitoring in the Strawberry Creek drainage.

Strawberry Creek Drainage

Fish Abundance: Trail Creek

This section began at the second trail crossing and extended upstream for 150 m. There was a downed tree across the pool which was the first feature in this section. Access was by the Big River trail out of Gooseberry Park to the Bowl Creek-Strawberry Creek trail fork. Take the left trail (Strawberry Creek) for approximately 4.5 km to the Trail Creek trail junction. Follow the unmaintained Trail Creek trail across Strawberry Creek and up the Trail Creek drainage to the second crossing (See 1982 Snorkel card and Gooseberry Park Quad).

Redd Survey: Strawberry Creek

Redd counts were made from the upper forks at stream km 22.5 down to the junction of Strawberry and Bowl Creeks. Access was from Gooseberry cabin up the Big River trail to the Strawberry Creek-Bowl Creek trail junction. Bear left and proceed up the Strawberry Creek trail to the upper meadows where an outfitters camp was present. The upper fork is located at the upstream end of the meadow area.

Redd Survey: Trail Creek

Redd counts were made from the junction of Jeff Creek down to the mouth of Trail Creek. Jeff Creek is located approximately 1 km above the canyon section of Trail Creek. Access is the same as for the snorkel section on Trail Creek to the second crossing. Beyond this point the unmaintained Trail Creek trail was followed up through the canyon to the mouth of Jeff Creek.

APPENDIX D

Equipment lists recommended for stream electrofishing, snorkel censuses, streambed monitoring, bull trout spawning surveys, gill netting series, and plankton sampling in the upper Flathead Basin.

Electrofishing Equipment List

Electrical equipment

generator
variable voltage pulsator (VVP)
(or a back pack unit with both)
75 m extension cord - (bank shock only)
positive hand-held electrode
negative hand-held electrode or plate
connecting electrical cords
a) positive and negative electordes to VVP
b) VVP to generator
gas and oil for generator
rubber gloves
hip boots or waders

Blocking equipment

Two-Pass
2 blocking nets (12.7 mm) mesh, 30m long with lead line and floats
small hatchet to cut sticks on site
200m rope

Mark-Recapture
2 hardware cloth (12.7 mm) mesh 30m long
10 posts (4 ft. metal)
1 post pounder
10m rebar tie wire and pliers
200m rope

Fish data collection

2 dip nets 6.35 mm mesh
a) long handle
b) short handle
2 live car 6.35 mm mesh
3 plastic buckets (5 gallon)
measuring board (metric)
scale (metric)
data paper (rite-in-rain)
fish scale cards
knife
pencils
clip board
clippers (for fins and end of dangler tag threads)
anesthetic
tags (danglers, and floy, floy gun, spare floy needles)

Electrofishing Equipment List cont.

General physical characteristics

flow meter
top setting rod
thermometer
flow cards (rite-in-rain)
meter tape (30m)
direction map with narratives to site, and ranger district map
stop watch

Repairs

spare spark plugs
VVP fuses
electrical tape
locking plugs
pliers
wire (electrical) 2 sizes
screwdriver for flow meter
screwdriver fitting locking plugs
sand and oil
wire strippers

Equipment Needed For Completing Bull Trout Redd Surveys

Hip Boots
Pencils
Rite-in-Rain field notebook (3x5) with appropriate columns labeled
Thermometer
Meter stick
Tape measure
Flow meter (+ beeper box)
Tap setting rod
Flow sheets
Stop watch
Directions and maps of survey sections, USFS ranger district maps

Snorkel Equipment List

snorkel
mask
wet suit
    (orange) jacket, pants, gloves, boots, hood, vest
wet suit cement
wet suit patching (neopreane)
measuring tape
snorkeling cards
pencils
thermometer
flow meter (+ beeper box)
top setting rod
stop watch
3 and 1 oil
maps with descriptions to sites, USFS ranger district map
defog
Flow sheets

Streambed Monitoring - Field Equipment

1 sediment corer (hollow core)
3 Imhoff cones
cup
2 pr. shoulder length rubber gloves (option: with wool liners)
100 heavy duty plastic sample bags 3.0 ml
10 five gallon bucket
data paper (rite-in-rain)
labels
  a) outside bag with string
  b) inside bag with (rite-in-rain)
pencils
indelible pen
measuring stick (cm)
tape measure (m)
rebar
spray paint
maps of sample site locations, narratives and drainage map,
  ranger district map
clip board
packs with frame
hip boots

Streambed Monitoring - Laboratory Equipment

6 shelf homemade dryer (Honeywell and G.E. controlled)
6 24" (61cm) square sample trays
Gilson screen Company - Ro-Tap testing Sieve Shaker (Model B)
7 12" (30.5cm) square lab pans
1 brass brush
1 wire brush
2 bristle brushs (4" paint brush and round paint brush)
1 16-penny galvanized nail
Mettler P11N class D balance and pan
Homemade 3" (76.1 mm) and 2 inch (50.8 mm) squares
Sieves (of the following mesh sizes)
  76.1 mm
  50. mm
  16.0 mm
  6.35 mm
  2.0 mm (#10)
  .063 mm (#230)
  pan

Gill Netting Equipment List

Netting gear

6	standard (1.83m X 38.1 m) floating gill nets
6	standard (1.83 m X 38.1 m) sinking gill nets
6	large net tubs
1	16 foot boat with 40 HP outboard motor
2 pr.	rubber gloves
2 pr.	chest waders
	data paper
	Honda Si-Tex model HE-256
	rope
	sash weights
	buckets
	pencils

Fish working gear

1	measuring board (metric)
1	scale (gram) + scale (10.0 lb.)
10	buckets
	scale envelopes
1	knife
	pencils
	data paper

Limnologic

1	Applied Research FT3 hydrographic thermometer
1	20 cm diameter secchi disk

(both on lines graduated at 0.5 m intervals)

Plankton Sampling Equipment List

Field

1	0.5 m diameter metered Wisconsin net 1.0 m long filtering cone of 80 micron Nitex netting 2 kg. lead weight sampling bucket
1	General Oceanics Model 2030 flow meter (with a low speed rotor modified to prevent back-spinning during descent)
1	16 foot boat equipped with 40 HP outboard and snatch block (be sure oars are onboard)
4	sample bottles
	Plankton preservative Recipe: 74% distilled water 15% methyl alcohol 10% formalin 1% acetic acid
	data paper, pencils rubber glove stop watch rope

Laboratory

	Plankton preservative
1	Hensen-Stempel pipette
2	Sedgewick-Rafter cells
1	Either 40X binocular compount OR 45X dissecting microscope with graduated mechanical stage
1	Microscope light
	Data paper, pencils
1	5 unit mechanical digital counter
2	watch glasses

APPENDIX E

Examples of data forms recommended for use in long term monitoring of the fish resource in the upper Flathead Basin.

ELECTROFISHING SHEET

Page __ of __

Date ____ ____ ____
Mo. Day Year

Water temp.________ @ time ________

Type fishing run ____________
1st Pass 1a
2nd pass 1b
recapture 2

Mark code (unmarked = 0, marked = 1)

Flow ____________

Creek name ____________

Section location ____________

Section length ____________

Widths a______ f______
b______ g______
c______ h______
d______ i______
e______ j______

Units of measure (English or metric)

No.	Species	Ln	Wt	Tag#	Tag type	Mark code	No.	Species	Ln	Wt	Tag#	Tag type	Mark code
1							24						
2							25						
3							26						
4							27						
5							28						
6							29						
7							30						
8							31						
9							32						
10							33						
11							34						
12							35						
13							36						
14							37						
15							38						
16							39						
17							40						
18							41						
19							42						
20							43						
21							44						
22							45						
23							46						

Form FMD-A

Form FMD-B Underwater fish census field data form. Comments can be written on the back of the form. Stream character refers to stream feature (pool, riffle, run or pocketwater). Codes are: L = length of feature (m), W = width of feature (m), C = percent instream cover (%), and D = average water depth of habitat feature (cm).

UNDERWATER FISH CENSUS

Stream ______________________________ Code No: __________ Date ___/___/___

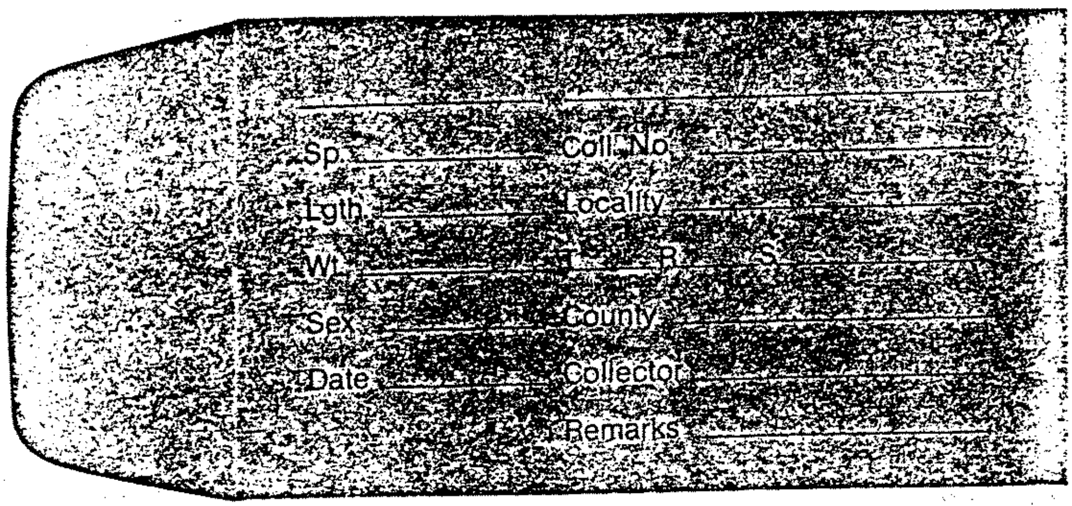
Time __________ Weather __________ Station __________ Reach __________ Air ___°C Water ___°C

Comments ______________________ Location: T___ R___ S___ T¼S___ Photo No: ______ Obs ______

Stream Character	Area				Fish Numbers															
					Cutthroat					Dolly Varden					White fish		Rain bow		Other	
	L	W	C	D	O	I	II	III+	M	O	I	II	III+	M	<6	>6	<6	>6	<6	>6

L = length of habitat unit
W = width of habitat unit
C = % cover of habitat unit (Please define cover type on the back.)
D = water depth (average for habitat unit)

Form FMD-C Scale envelope for field collection of fish scale samples.



Drainage	Water Code	Station	Month	Year	Collection Method	Day	Migration Age	Circuli to I	Missing I Annulus	Magnification	Species	Identification Number	Length	Weight	Sex	Gonad Condition	Age	Measurements (mm) I	II	III	IV	V	VI	VII	VIII	IX	X	Edge

Collection method: "1" boat shocking, "2" tow nets, "3" beach seine, "4" purse seine, "5" drift net, "6" electrofishing stream, "7" gill nets, "8" Dept. angling, "9" river trap, "10" mid-water trawl, "11" Rotenone, "12" creel census.

Age at out migration: "1"-I+, "2"-II+, "3"-III+ ...."9"-0+.

Missing annulus: "1" missing annulus, blank no missing annulus.

Sex: "1" males, "2" females.

Gonad condition: "0" undetermined, "1" egg size 1-3, "2" egg size 4-5, "3" egg size 6-7, "4" egg size 8-9, "5" egg size 10-11, "6" egg size 12-14, "7" male red, "8" male pink, "9" male white.

Age: "99" fish was not aged or no scales.

Form FMD-D

STREAMBED COMPOSITION FIELD DATA

Creek ______________________ Water Code ____________

Date ______________________

Suspended Tare ______________ (ml/l)

						Visual estimate (90)					
Transect	Core	Class	Depth in core	Sediment in cone (ml/l)	Distance to left rebar	Boulder	Cobble	Gravel	Pea Gravel	Fines	Organic

Form FMD-F

STREAMBED COMPOSITION SIEVE ANALYSIS 19__

Creek	Transect	Core	76	50	Weight in grams on Sieve size (mm) 16	6.35	2	0.063	<0.063	Cone X 0.3	Total <0.063	Total core weight	Class

Form FMD-E

BULL TROUT REDD SURVEY

Creek______________________ Water Code__________________

Section____________________ Water temperature________

Date_______________________ Discharge___________________

Pace Length________________ Surveyor____________________

Pace Number	Redd Number	Certainty class	Water depth	Landmarks

Form FMD-G

APPENDIX F

Table of computer program and data file names, location of programs and data files and function of these programs and files.

COMPUTER PROGRAMS

File Name	Purpose	Location
MSUSTAT	General package of statistical programs	CP6-INTERALMEMORY
SPSS	Same	Same
IDPHABDICT	Defines data locations in HABITAT1	CP6-TAPE 955
RETURNLM	Summarized tag return	Same
AGESUM	Age-growth summary	CP6-ACCT.NFIBM04
MONASK	Age-growth analysis	Same
FIREI	Same	Same
AGEMAT	Same	Same
ONTAPE	Transfers files to TAPE	CP6-NFIBM05
OFFTAPE	Transfers files from TAPE to ACCOUNT	Same
HABFST	Enters habitat transect data	ICIS-Kalispell
FSSED	Streambed composition summary	Same
SUMMAR	Summarizes habitat transect data	Same

Computer data files on line on the CP6 computer in Bozeman. All can be accessed through the Kalispell terminal, MDFWP.

File Name	Purpose	Location
TOTALCUTTS	All cutthroat age-growth	CP6-TAPE
TOTALBULLS	All bull trout age-growth	" - 955
SEDF81	Streambed composition Fall 1981	"
SEDS82	Streambed composition Spring 1982	"
SEDF82	Streambed composition Fall 1982	"
HABITAT1	Contains all interagency habitat data	"
FLDA2	Tag return data to 1981	"
NEWTAG	Tag return data 1981-1982	CP6-NFIBM05

APPENDIX G

Table and maps showing exact locations of bull trout redd survey sections and streambed monitoring sites recommended for long-term monitoring in the upper Flathead Basin.

Table 1. Survey sections for bull trout redd inventories to be conducted as part of a long term fish resource monitoring program.

Drainage - Stream	Upper Boundary	Lower Boundary
North Fork		
Big Creek	Mouth of Skookoleel Creek	500 m below Skookoleel Road Bridge
Coal Creek	Mouth of South Fork Coal	Cyclone Lake Road cut-off. Creek by road.
Whale Creek	Mouth of Shorty Creek	Whale Buttes bridge
Trail Creek	Bottom of rock wall canyon	Cleft Creek trail crossing
Middle Fork		
Ole Creek	Fielding trail crossing	Upstream end of canyon
Morrison Creek	Old trail crossing	Third crossing below new trailhead
Lodgepole Creek	Mouth of Whistler Creek	Junction with Morrison Creek
Granite Creek	Lower end of dry section	Junction of second order tributary at km 4.2
Schafer Creek	Lower end of dry section	Junction with Middle Fork
Dolly Varden Creek	Barrier Falls	Schafer Creek trail crossing
Trail Creek	Junction with Jeff Creek	Junction with Strawberry Creek
Strawberry Creek	Uppermost fork	Junction with Bowl Creek

Table 2. Core sample site locations and distances between rebar stakes on each transect sampled for long-term monitoring. Distance in meters from the left rebar (looking downstream).

Creek	Transect Number	1	2	3	4	Right rebar
Whale	1	4.8	5.8	8.1	11.1	18.9
	2	5.2	16.8	11.9	13.5	18.3
	3	3.7	6.3	7.7	8.8	22.5
Coal	4	9.4	10.6	11.7	13.1	15.8
	5	9.0	10.9	12.4	13.3	15.3
	6	8.4	9.3	10.8	12.4	15.0
	7	6.2	8.2	18.8	12.6	20.4
	8	6.4	7.9	10.1	11.5	20.7
Big	9	9.2	10.2	11.2	12.1	18.9
	10	5.5	6.4	7.3	8.4	14.1
	11	4.2	6.3	8.5	10.5	21.4
Trail	12	5.1	7.4	8.3	13.6	15.9
	13	5.8	7.1	9.8	12.1	18.4
	14	7.5	9.7	11.8	15.6	19.9
	15	2.3	3.4	8.9	10.7	18.9
	16	2.0	3.5	9.2	10.1	18.0

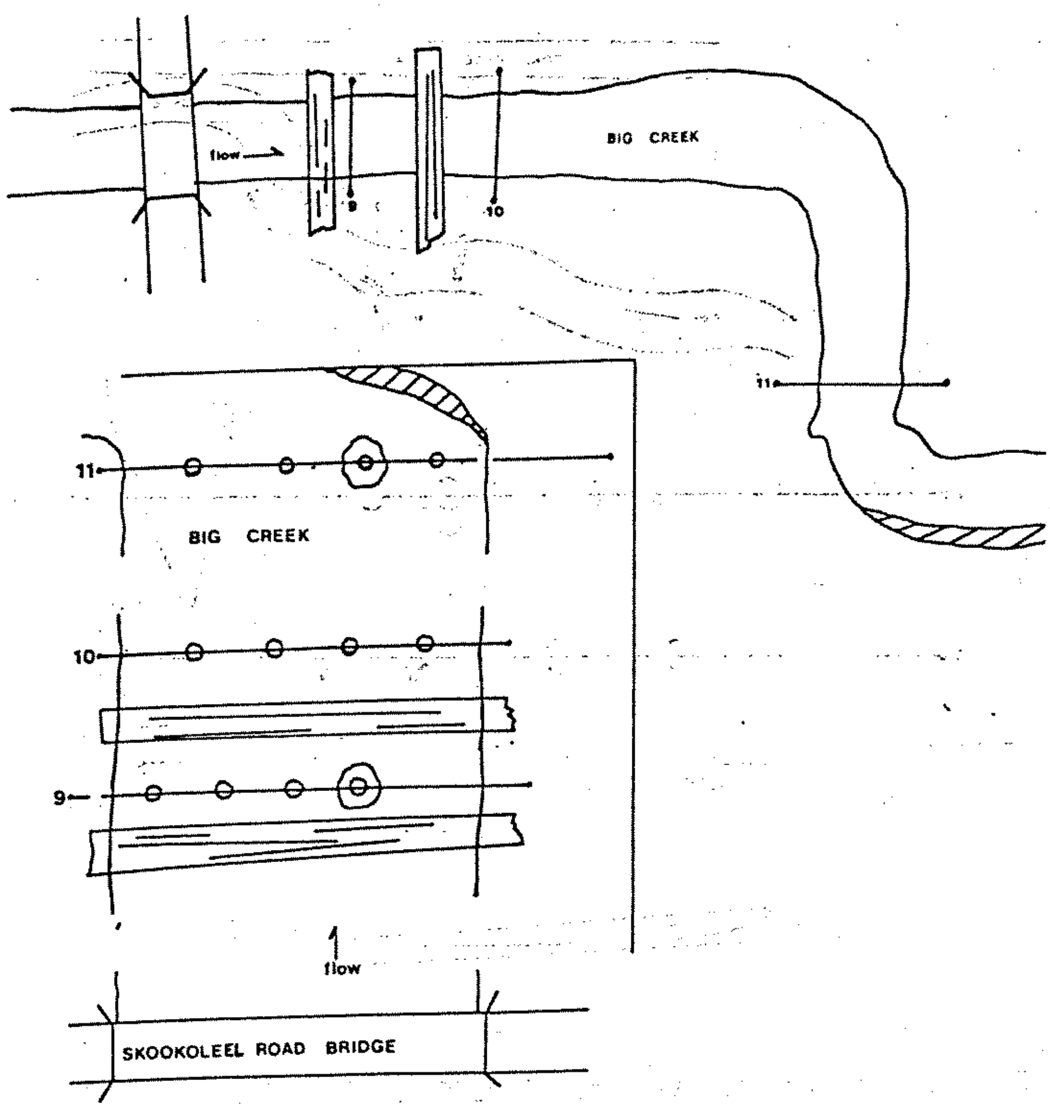


Figure 1. Map of Skookoleel Creek Road Bridge Sampling Area of Big Creek

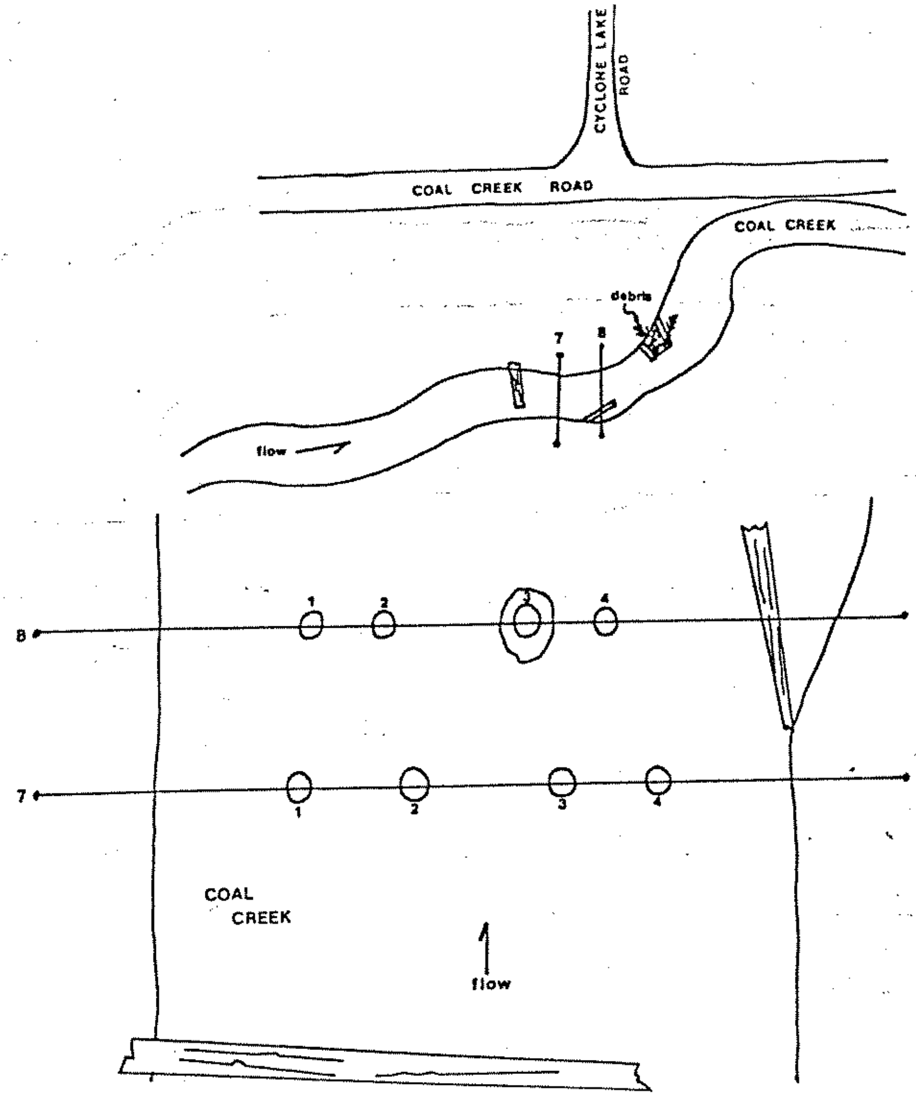


Figure 2. Map Of Cyclone Lake Road Cutoff Sampling Area Of Coal Creek.

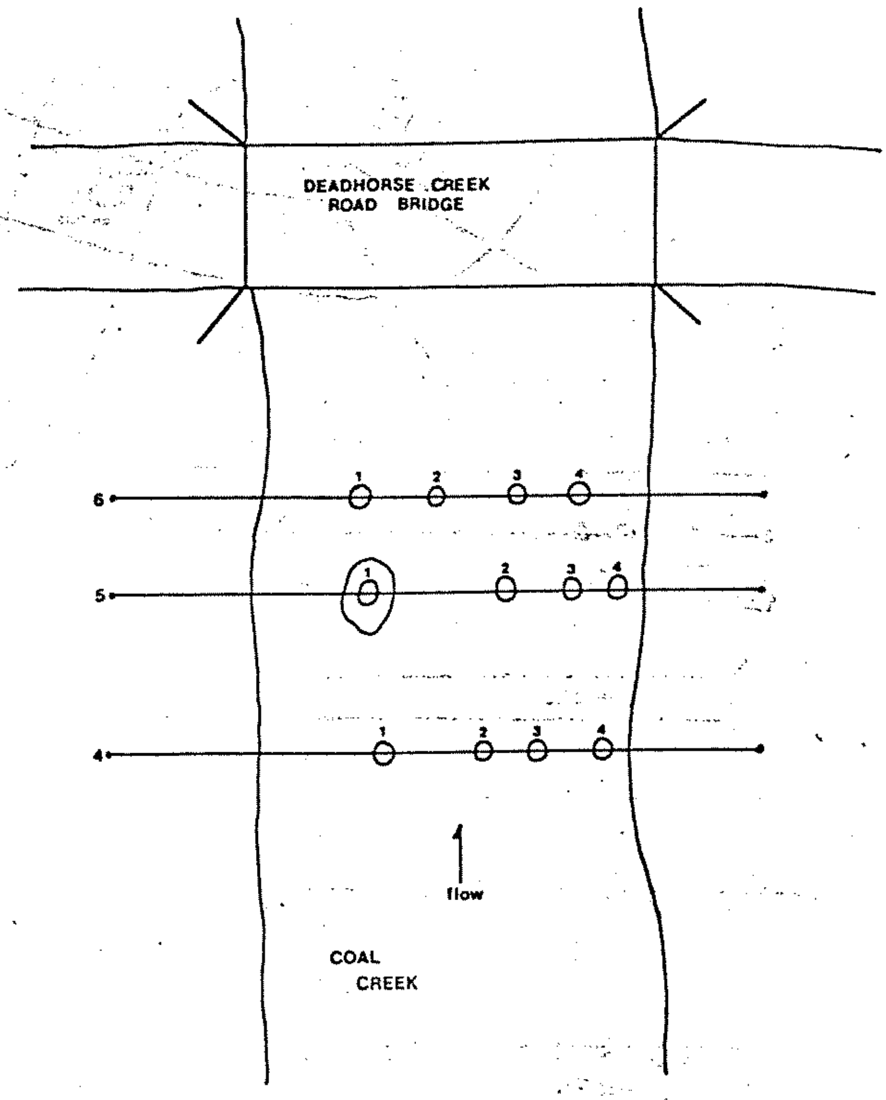


Figure 3. Map of Dead Horse Creek Road Bridge Sampling Area of Coal Creek

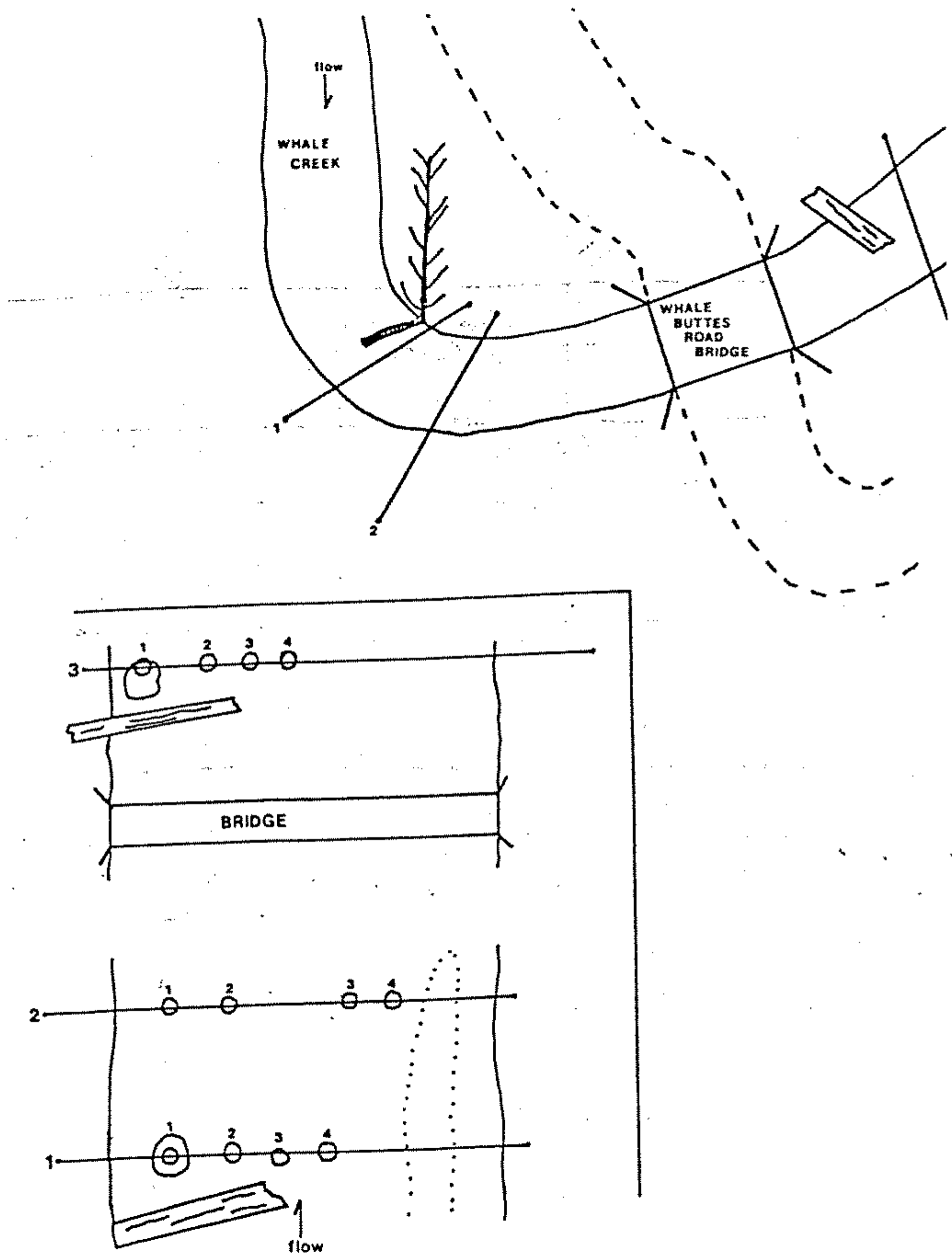


Figure 4. Map of Whale Buttes Road Bridge Sampling Area of Whale Creek

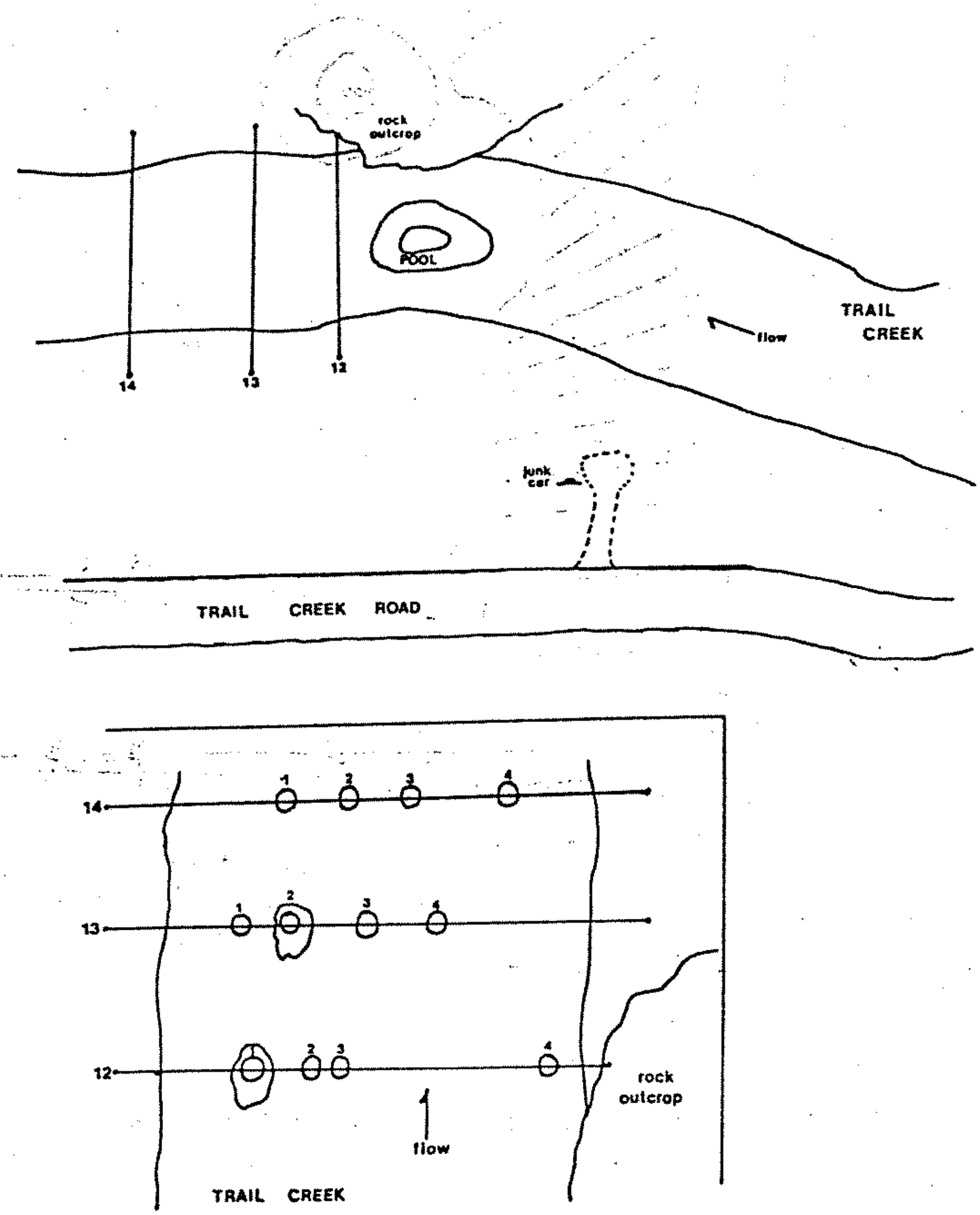


Figure 5. Map of "Junk Car" Sampling Area of Trail Creek

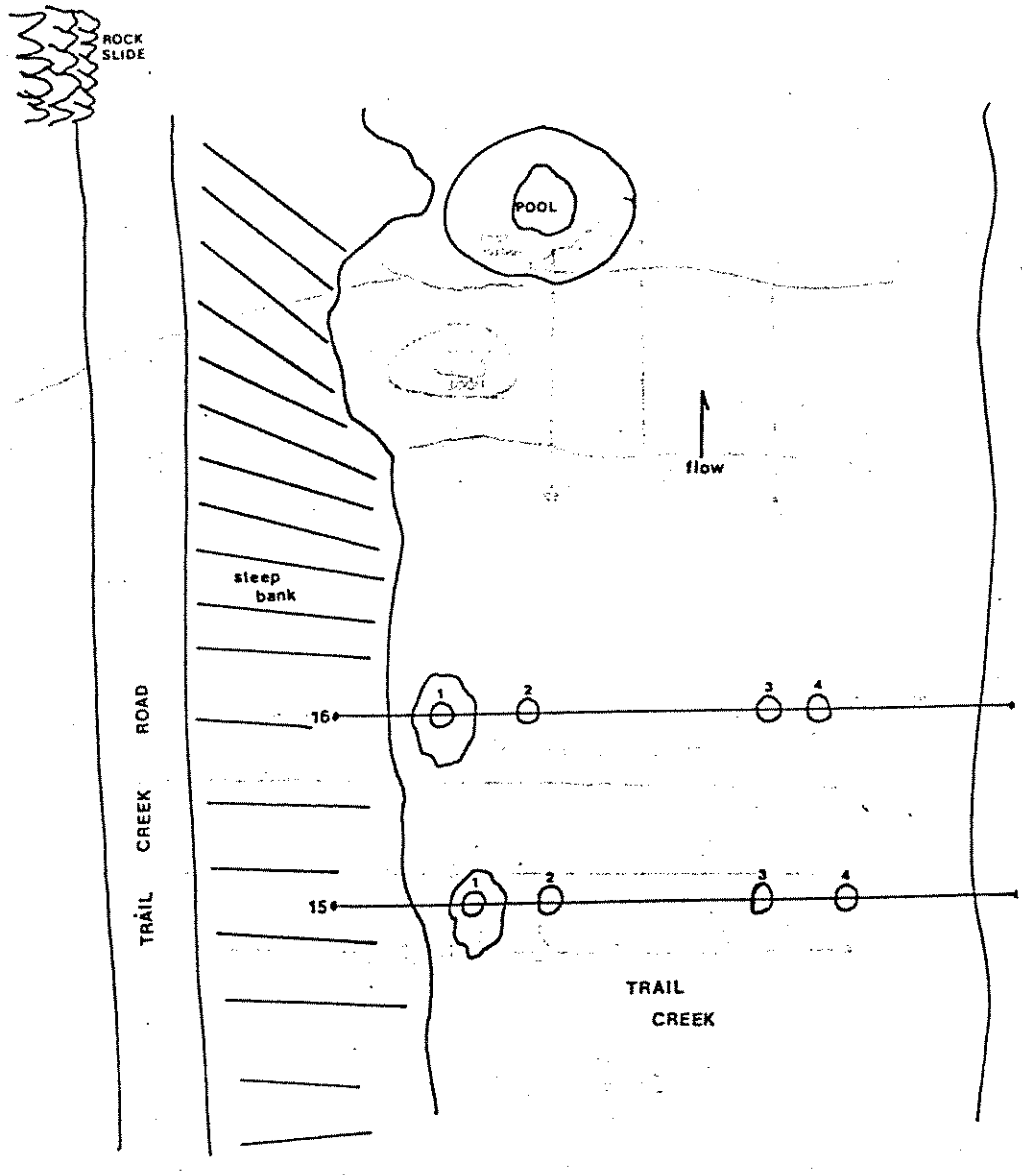


Figure 6. Map of Rock Slide Sampling Area of Trail Creek.

APPENDIX H

Egg development scale.

EGG DEVELOPMENT SCALE

(developed by Delano Hanzel)

This scale was established as a method to define the gonad development of eggs by measuring their relative size. A reference collection is available from the Montana Department of Fish, Wildlife and Parks, Regional Headquarters, Kalispell.

1. The ovary is distinguishable from testis by granular texture of the gonad. The size of the ovary generally is between 2 to 4 mm wide and 30-40 mm long. The individual egg cell cannot be seen by the naked eye. Color of gonad is orange compared to the red testis material.

2. Individual egg cells still cannot be seen by the naked eye. Ovary has increased in width and length; generally 4-8 mm wide and 50-60 mm long.

3. The individual egg cells can be seen by the naked eye. Egg diameters measure less than 1 mm. The size of this ovary ranges from 4-8 mm wide to 60-70 mm long.

4. Individual egg cells still measure less than 1 mm but the width has increased to 10 mm.

5. Egg diameter reaches 1 mm, with the size of the ovary measuring 10-15 mm wide and 70-90 mm long.

6. Egg diameter 1 mm or slightly larger.

7. Egg diameter more than 1 mm but less than 2 mm.

8. Egg diameter 2 mm.

9. ------

10. Egg diameter more than 2 mm but less than 3 mm.

11. Egg diameter 3 mm.

12. Egg diameter 4 mm.

13. Egg diameter 5 mm.

14. Egg diameter 6 mm.