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PEND OREILLE TROUT AND CHAR LIFE HISTORY STUDY

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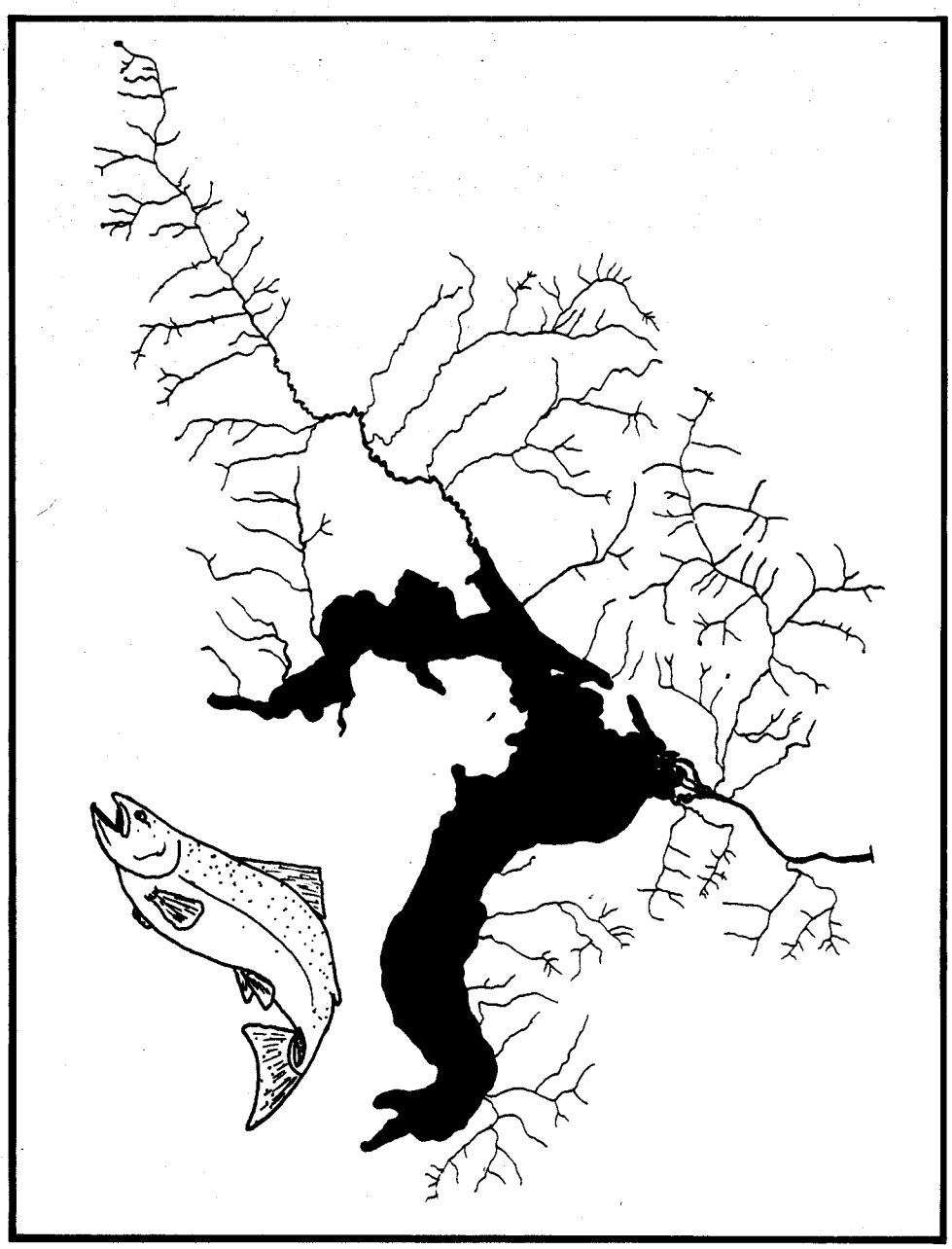

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ACKNOWLEDGMENTS

I would like to thank the sportsmen and resort owners around Pend Oreille Lake for all their help during the 1983 and 1984 field seasons. Members of both the Lake Pend Oreille Idaho Club and Trout Unlimited contributed their time for special projects which could not have been attempted without them. I would also like to thank John Scott, Gene McPherson, Bruce Thompson, Ned Horner, and Bruce Rieman for their assistance throughout the project.

During 1984, several sportsmen made outstanding contributions of time and energy. A very special thanks to Tom Mehler, Sandra Morris, George and Maxine Congelton, Dave Suttleff, and Barry Kendall.

ABSTRACT

A project to evaluate the status of adfluvial trout and their populations in the Pend Oreille system was continued in 1984. The project was conducted as a cooperative effort with salary money provided by the Lake Pend Oreille Idaho Club. The relative abundance and distribution of juvenile fish in tributaries was described by snorkeling. Redd surveys were also used to describe the distribution and numbers of bull trout in the spawning escapement. Sediment coring was conducted in a cooperative effort with the U.S. Forest Service to describe quality of spawning habitat in selected streams and to provide a basis for monitoring the impact of forest development on fisheries. An angler participation program was used to collect lengths and scales from the catch and to provide samples for age analysis. The data was used to describe growth and life history patterns, mortal ity and genetic integrity of the rainbow stock.

Juvenile trout and char were distributed throughout the Pend Oreille basin. Cutthroat were most widely distributed but also typically occurred at low densities. Rainbow were found at densities up to 120/100m^2 in localized areas and were most abundant in the mid reaches of the Pack River, Grouse Creek, and Lightning Creek drainages. Rainbow spawning distribution was inferred from fry distribution.

Bull trout were most local ized in their distribution and only used 23 percent of available stream habitat. Bull trout spawning escapement was estimated at 3,436 fish in 1984. The escapement estimate was similar to that observed in 1983, but distribution of spawning varied considerably. No bull trout redds were observed in the Cabinet Gorge spawning channel where escapements of up to 100 fish have been estimated in the past.

Estimated growth of rainbow trout was similar to that observed in earlier years and to that reported for Kootenay Lake. Age at first spawning was found to be related to age of Juvenile migration from the tributaries. Age of first maturity also appears to be declining from that observed in earlier years and is less than that described for Kootenay Lake stocks. Electrophoretic analysis indicates that the genetic material in the Pend Oreille rainbow population is predominantly (70-80%) of Gerrard stock origin but introgression has occurred from domestic rainbow (16-20%) and westslope cutthroat (4%).

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INTRODUCTION

Pend Oreille Lake is well known for both its salmon and trophy trout fisheries. Al though kokanee (Oncorhynchus nerka) provide more than 90% of the catch, nearly half (46%) of the fishermen in 1980 were seeking trout (Ellis and Bowler, 1981). The Gerrard strain of Kamloops rainbow trout (Salmo gairdneri) and the native bull trout (Salvelinus confluentus) attain trophy size on a - diet of kokanee. The record rainbow of 37 pounds and bull trout of 32 pounds were caught in Pend Oreille Lake during the late 1940s. The largest trout caught in 1983 was a 31.5-pound (14.3 kg) rainbow trout. Other salmonid species in the fishery include westslope cutthroat trout (Salmo clarki lewisii), brown trout (Salmo trutta), lake whitefish (Coregonus cluDeaformis), and lake trout (Salvelinus namaycush).

The sport fishery has been important to the residents around Pend Oreille Lake for many years. Resorts along the lake provide facilities to weigh and display trophy-size trout. Local fishermen have organized into several clubs, including Lake Pend Oreille Idaho Club, Trout Unlimited, Ponderay Sportsmen, and the Clark Fork Rod and Gun Club. Since 1945, an annual spring trophy fishing derby has-been conducted on the lake. I n 1979, a fall derby was also initiated. Over 1,800 people were registered for the spring and 672 for the fall fishing derby of 1983.

In 1982, local sportsmen expressed interest in assisting directly with management of the Pend Oreille Lake fishery. The Lake Pend Oreille Idaho Club provided funding during 1983 and 1984, in cooperation with the Idaho Department of Fish and Game, for this evaluation of trout populations in the Pend Oreille basin.

Pend Oreille is the largest, natural lake in Idaho with surface area of 383 square km, mean depth of 164 m, and maximum depth of 351 m. The Clark Fork River is the largest tributary to the lake and drains 96% of the 59,311 square km Pend Oreille watershed (Rieman, 1976).

Historically, cutthroat, bull trout, and mountain whitefish were present in Pend Oreille Lake. Rainbow trout were introduced in 1942. Rainbow, cutthroat, and bull trout are adfluvial in their native range. Tributaries to the lake, including the Clark Fork River, provide spawning and rearing habitat for adfluvial fishes (Fig. 1). Since the construction of Cabinet Gorge Dam in 1951, only 16 km of the Clark Fork River are available for the spawning and rearing of adfluvial fish. The remaining spawning and rearing habitat available to adfluvial trout and char consists of smaller tributaries to the lake and lower Clark Fork River. A total of 173 km of streams support the trout fishery in the lake today.

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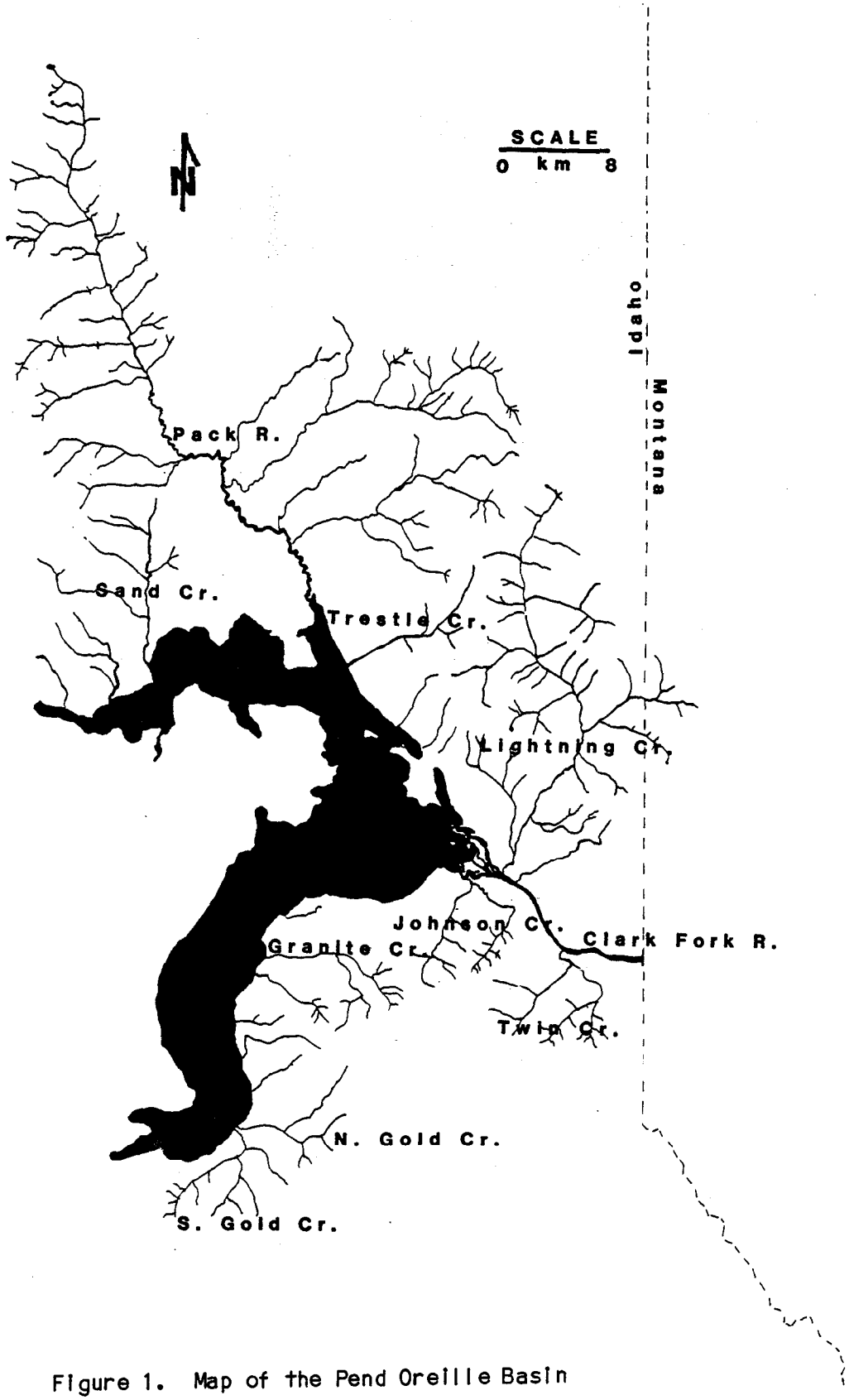

Figure 1. Map of the Pend Oreille Basin

The number of rainbow in the catch increased steadily from 1951 to 1960, while the catch of native cutthroat and bull trout declined (Irizarry, 1973). The number of cutthroat in the catch continued to decline and remains low today (Fig. 2). The bull trout catch seems to have stabilized at a low level (Fig. 3). Rainbow remain the predominant trout fishery in the lake today (Fig. 4). Although numbers declined for a period in the 1960s and early 1970s, the rainbow catch has recently increased (Ellis and Bowler, 1981; Pratt, 1984).

The other trout and char species in the lake have not contributed to the trout fishery.

OBJECTIVES

1. Continue the evaluation of Juvenile trout and char distribution and relative abundance in the tributaries to Pend Oreille Lake.

2. Monitor bull trout spawning escapement.

3. Evaluate the qual ity of trout and char spawning habitat in selected tributaries to Pend Oreille Lake.

4. Refine current data concerning trout and char age, growth, and mortality in Pend Oreille Lake.

5. Assess genetic purity of the rainbow trout population in Pend Oreille Lake.

RECOMMENDATIONS

Pend Oreille Lake

1. Evaluate historic data for indications of the potential trophy fishery in Pend Oreille Lake.

2. Conduct a creel census or partial creel census to assess trout and char harvest, catch rates, angler preference and contribution of artificial enhancement to the fishery.

3. Monitor age, growth, and mortality of rainbow trout in Pend Oreille Lake.

4. Compare estimates of mortal ity based on data collected by sportsmen and IDFG personnel.

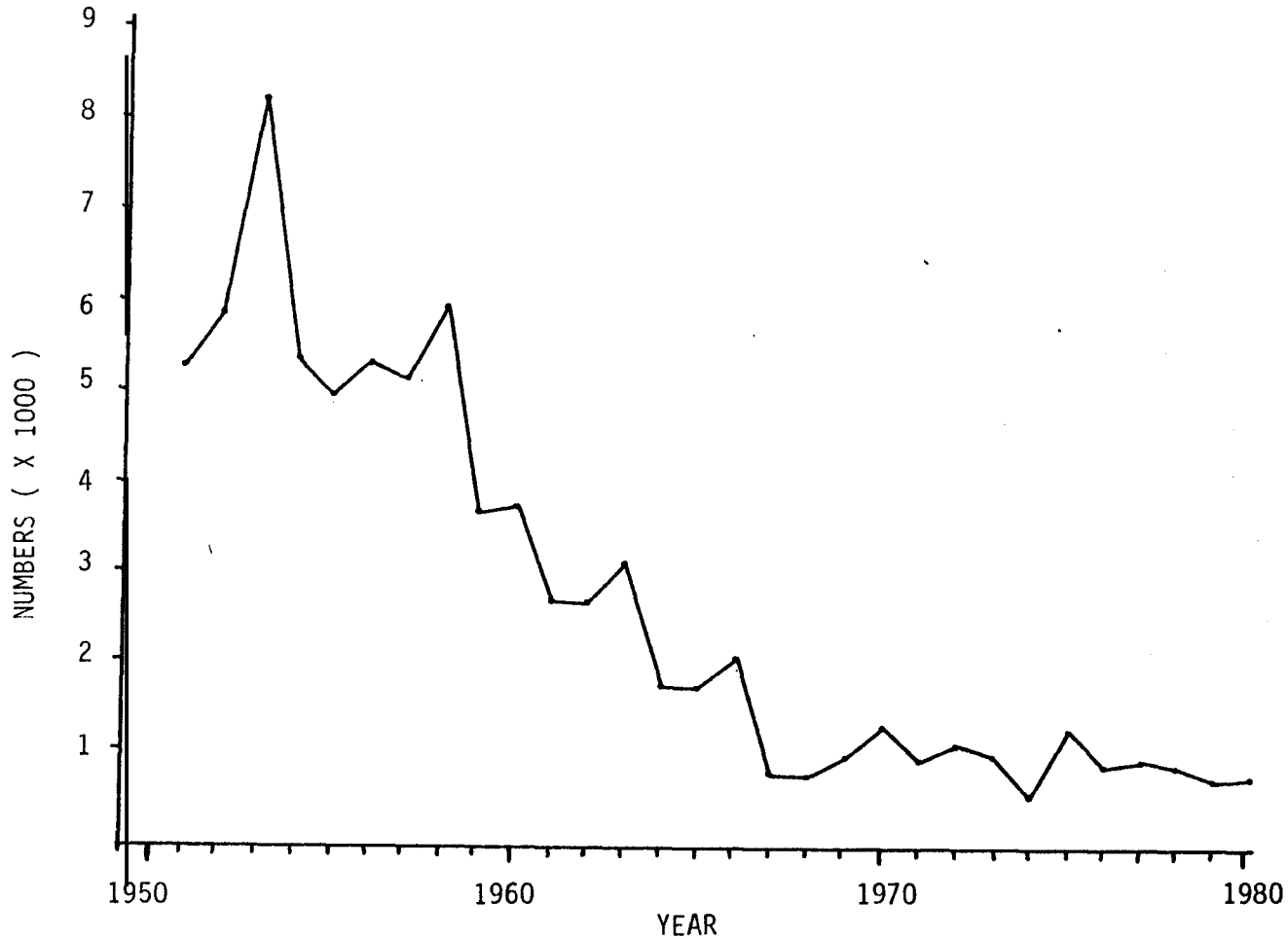

Figure 2. Estimated harvest of cutthroat trout in Lake Pend Oreille, Idaho, 1950- 1980 (from Ellis and Bowler 1981).

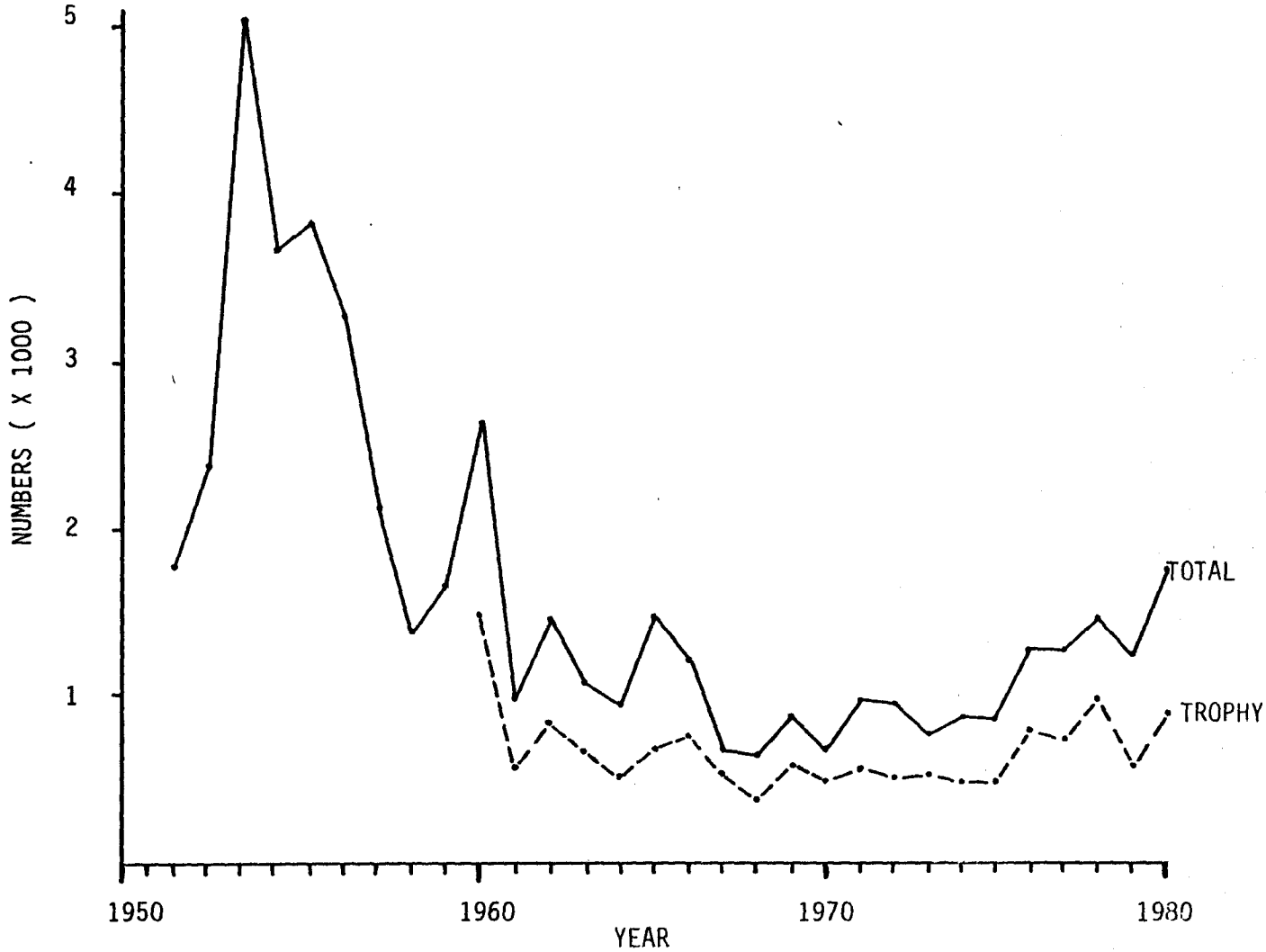

Figure 3. Estimated harvest of bull trout and trophy bull trout from Lake Pend Oreille Idaho, 1950-1980, (from Ellis and Bowler 1981).

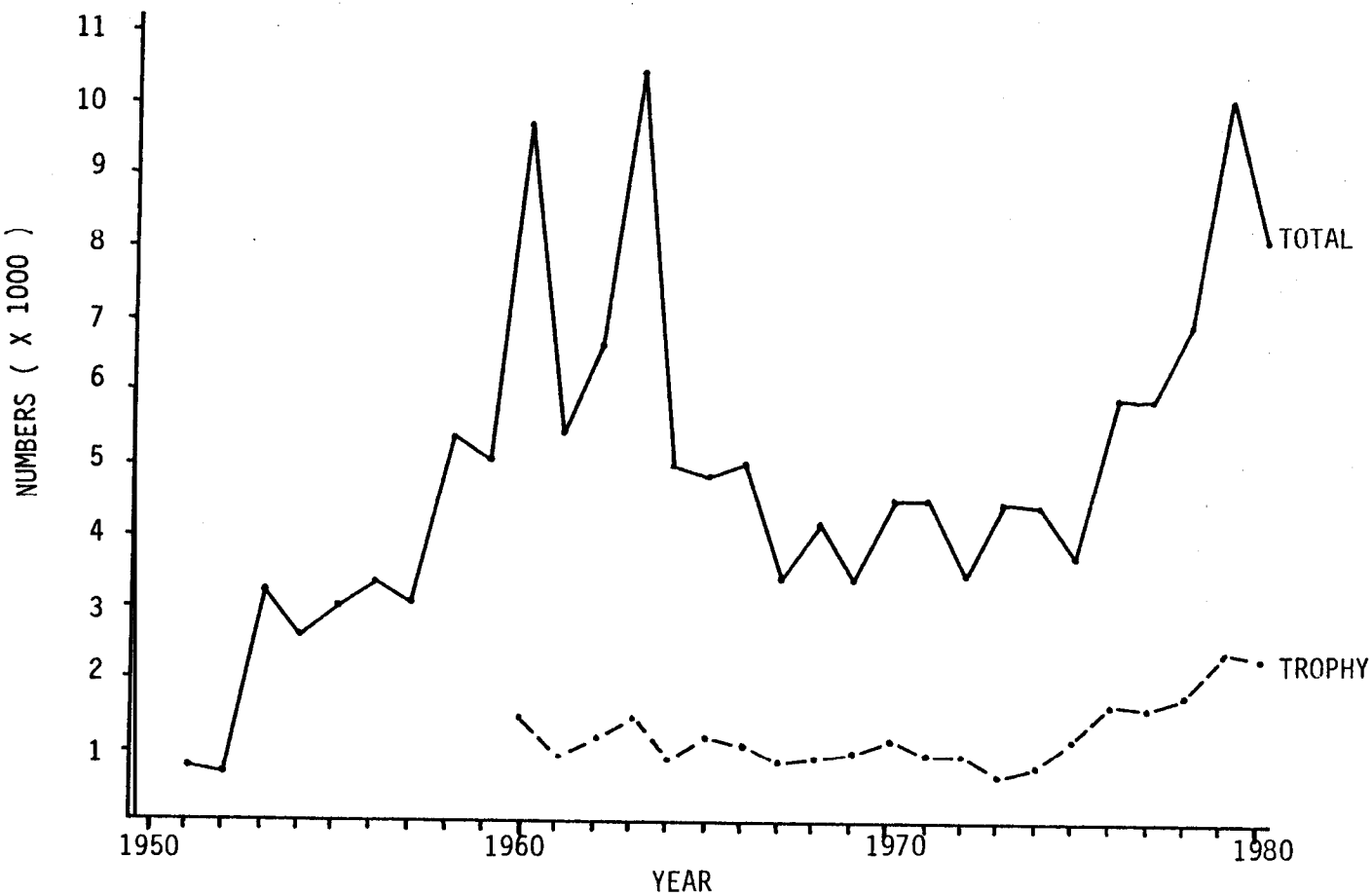

Figure 4. Estimated harvest of rainbow and trophy rainbow trout from Lake Pend Oreille Idaho, 1950-1980 (from Ellis and Bowler 1981).

Streams

1. Assess age, growth, and mortality of Juvenile trout and char in tributaries to Pend Oreille Lake.

2. Assess the harvest of Juvenile trout and char in tributaries to Pend Oreille Lake.

3. Assess angler interest in stream fishing along tributaries to Pend Oreille Lake.

4. Assess the genetic composition of trout and char populations in tributaries to Pend Oreille Lake.

5. Monitor bull trout spawning escapement.

6. Confirm rainbow trout spawning distribution.

7. Conduct a drainage-wide habitat inventory using methods which are comparable to both the Montana Department of Fish, Wildlife, and Parks (1983) and the Idaho Panhandle National Forests habitat inventory.

8. Continue to develop programs of angler support for the restoration and protection of trout and char nursery streams.

9. Establ ish minimum flow reservations for all tributaries to Pend Oreille used by adfluvial trout and char.

10. Summarize historic data on the land use practices, stream discharge patterns, and major discharge events occurring in the Lightning drainage.

Clark Fork River

1. Conduct a preliminary investigation of the trout and char distribution and relative abundance in the Clark Fork River below Cabinet Gorge Dam.

2. Describe habitat available in the Clark Fork River and the delta of the river.

3. Compare the present species composition, harvest, habitat quality, and discharge patterns to historic data.

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Public Concerns

1. Develop angler education programs to assist sportsmen in the identification of their catch.

2. Provide angler education concerning the life history patterns of trophy species in Pend Oreille Lake.

3. Conduct an economic analysis of the salmonid fisheries in Pend Oreille Lake comparing net worth of harvested species and the cash flow within local communities attributable to the Pend Oreille fishery.

METHODS

Lake Populations

Age and Growth

Length, weight and scales were collected from rainbow, cutthroat, and bull trout by cooperative sportsmen and resort personnel around Pend Oreille Lake from mid-June to the end of November. Fish were measured to the nearest 1/4 inch. Weights were measured to the nearest 1/8 pound, usually at resort locations. Fish scales were collected from the caudal peduncle region where they first form below the adipose fin and above the lateral line (Brown and Bailey, 1952).

Impressions of rainbow, bull trout, and cutthroat trout scales were made using plastic laminate pressed at 20,000 lbs pressure similar to methods described by Dery (1983).

Fish scale impressions were read at 41x magnification using an Eberback scale reader. The distance from the focus to each annulus (or year mark) and the edge of the scale were measured at a 30^{0} angle from the longest axis of the scale. Regenerate or eroded scales were not used for the growth analysis.

Annuli were determined by the observation of incomplete circuli and compaction (narrow spacing between circul I) followed by widely spaced circuli (Ricker, 1968). All criteria were met before an annulus was identified to prevent overestimation of trout ages. Summer checks, or false year marks formed in August, have been reported for rainbow in Pend Oreille Lake (Anderson, 1978).

Development of accurate body-scale relationships was difficult due to the lack of small fish in the samples. Therefore, the length of each species at scale formation was determined from the I iterature for rainbow and cutthroat trout. Rainbow trout form scales at approximately

34.4 mm (Anderson, 1978; Smith, 1955). The smallest westslope cutthroat trout observed with scales in the Flathead River basin was 38 mm (Graham et al., 1980). No empirical data was available for the length of bull trout at scale formation. A body scale relationship was developed for bull trout in the Pend Oreille drainage in 1983. Length at scale formation was estimated at 22 mm, probably an underestimate (Pratt, 1984).

All calculations were done with a Hewlett Packard (33E or 11C) calculator.

Age and growth data collected for rainbow trout in 1984 were analyzed for the year and reanalyzed as a combined sample with the 1983 data. For both, age growth data from 1983 and 1984 were combined due to small sample sizes.

Age Composition

Representative length data were collected by cooperative anglers who recorded the length of each fish caught, whether or not the fish was kept. Length frequencies derived from this data were used to delineate age structure of the population. Survivorship curves were constructed from length frequency and age data to estimate mortal ity.

Stream Distribution

Spawning

Sections of stream were identified as possible spawning areas for cutthroat and rainbow trout where fry and appropriate substrates were observed. Past records of spring spawning were also reviewed. Bull trout spawning areas were delineated by observation during the fall. Stream sections were selected for 1984 surveys if bull trout redds had been observed in the stream during the 1983 spawning survey. Areas not surveyed in 1983 due to time constraints were also surveyed. Redd counts were conducted in tributaries to Pend Oreille Lake between September 20 and October 26, 1984.

In order to refine timing of redd counts, several areas were resurveyed and observations of spawning activity, as well as the number of adult bull trout, were recorded during all surveys. Criteria for redd identification were described in Pratt (1984).

The distribution of spawning within a stream was recorded by counting footfalls or paces between redds and landmarks while walking along the stream. The number of paces and the map distance between landmarks were used to calculate a conversion factor of paces per kilometer for each survey. The distribution of redds within a survey section and redd densities were calculated and compared to the 1983 data.

Bull trout spawning escapement was estimated by multiplying the number of redds observed by 3.9 fish per redd (Fraley et al., 1980).

Rearing Areas

Snorkeling techniques were used to assess fish distribution and relative abundance in tributary streams to Pend Oreille Lake. These techniques were described in detail in Pratt (1983).

At least one snorkeling site was selected in each tributary stream. The sites were selected with three considerations: 1) representation of the stream habitat in the area, 2) easy identification and relocation of the site, and 3) accessibil ity. In some streams, several sites were snorkeled to encompass the variation in habitat and corresponding fish populations from the headwaters to the mouth of the stream.

Fish densities were calculated as a measure of relative abundance for each site snorkeled. Total fish density and densities of each trout species were calculated. All measures of density were expressed as fish per 100 square meters.

Stream Habitat

Spawning Habitat Quality

A cooperative program between the U.S. Forest Service and the Idaho Department of Fish and Game (IDFG) was established in 1984 to evaluate the quality of spawning gravels in tributaries to Pend Oreille Lake. Percent dry weight composition of the streambed was used to estimate survival of cutthroat, rainbow and bull trout (Tappet and Bjornn, 1983; Irving and Bjornn, 1984; Weaver and White, 1984). Both agencies used similar, but not identical, hollow coring techniques to sample the streambed. Differences between the USFS and IDFG field collection methods are described in Appendix A. The USFS evaluated Granite, Johnson, and North Fork Grouse creeks. IDFG evaluated Twin Spring, South Gold, and Grouse creeks.

The sampl ing scheme for this monitoring program required an examination of two areas within each stream. Adfluvial fish were known to spawn within the study areas. At each site, three cores were collected at each of three transects for a total of nine cores per study area and 18 per stream. Coring locations were selected to represent spawning habitat available in the study area by trained personnel. The validity of selecting, instead of randomizing core locations, was described by Platts et al. (1983).

A McNeil sampler was worked down into the streambed far enough to collect a sample at least 15 cm deep. The contents of the 15 x 15 cm core were removed by hand and placed in the catchment basin until the device was removed from the streambed. Samples were bagged and taken to the laboratory for sieving.

Before the corer was removed from the streambed, the amount of fine particles suspended during the coring process was estimated. The depth of the water in the corer was recorded while it was still in place. The water volume of the corer was estimated from water depth in the core using Appendix B. Two one-liter water samples were then placed in Imhoff Cones and left to stand 20 minutes. The wet volume of fines was recorded. The total amount of fines was then estimated by expanding the average volume of sediment per liter of water into volume of sediment within the total water volume of the corer (Appendix B).

Streambed composition (including fines suspended in the corer) was determined in the laboratory. Gravel samples were dried in a Precision Quincy batch oven overnight at 120^{0}F. The dried samples were placed in a series of six sieves and an automatic shaker for 12 minutes. Gravels retained in each size sieve were weighed with a Triner scale to the nearest .01 pound (4 grans). The dry weight of the fines, which had been suspended during sampl ing, was estimated by multiplying the total wet volume of fines by 0.44 g/ml. Streambed composition was described as the percent dry weight of six particle size classes.

Fry survival was estimated for cutthroat, rainbow, and bull trout based on percent fines less than 6.35 mm in diameter. Models used to calculate survival are presented in Table 1.

Stream Restoration

A work project was initiated in 1984 to restore the qual ity of spawning gravels in Spring Creek. Gravels were cleaned i n a short section of the main channel and fish passage was improved in the artificial spawning channel.

Manual labor with shovels and rakes in conjunction with high pressure water hoses was used to remove weed beds and clean gravels in Spring Creek. Floating water pumps cycled water from the stream back through a water hose into the streambed dislodging fines and root wads. Only a portion of the channel was cleaned, leaving weeds on the channel margins and around the duning sand.

Explosives were used to improve fish passage in the spawning channel by opening old beaver dams and an area of silt and weed accumulation.

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Table 1. Models used to calculate the survival of cutthroat eyed eggs to fry emergence, and rainbow and bull trout water-hardened eggs to emergence based on percent fines less than 6.35 mm.

Document	Species	Model
Weaver and White (1984)	Bull trout	$y = -5.13x + 225.2$
Irving and Bjornn (1984)	Cutthroat	$y = 107.7/1 + e^{(-2.22 + 0.116x)}$
Irving and Bjornn (1984)-	Rainbow	$y = 104.6/1 + e^{(-3.11 + 0.111x)}$

RESULTS

Rainbow Trout

Lake Population

Age-Growth. Anglers collected 785 rainbow trout scales during the 1983 and 1984 fishing seasons. Many of these scales had eroded edges or regenerated centers and were unsuitable for age-growth analysis. Age determinations were made on the scales fran 491 rainbow trout.

Rainbow trout collected in Pend Oreille Lake were between 1 and 8 years old. During their first year of life, rainbow trout grew 8 cm (3 inches) (Table 2). Estimated length at annulus formation for other age classes were dependent upon the age juvenile rainbow trout migrated into Pend Oreille Lake.

Most (62%) of the rainbow trout aged had migrated into Pend Oreille Lake as 2-year-old fish. Twenty-eight percent of the rainbow examined had migrated as either 3-year-old or young-of-the-year fish. Rainbow trout grew approximately 19 cm (7.6 inches) in their first year in the lake (Table 3). The differences in length at age between migration classes became less apparent with age (Fig. 5).

Spawning marks were found on 59 (12%) of the rainbow trout aged. Age at first spawning was between 3 and 7 years old. Less than 5% of the 3 and 4 year olds aged had spawning marks, while half of the 6- and 7-year old rainbow had spawned (Table 4; Fig. 6). Most of the repeat spawners had first spawned as 4-year-old fish.

Age composition. The lengths of 398 rainbow, were collected by anglers during the 1983 and 1984 fishing seasons. Length frequencies were constructed for two seasons each year (Fig. 7).

More smal I rainbow trout were recorded in 1984 than in 1983 during summer periods. During the summer (July 15-Sept. 15) in 1983, the fishery was dominated by rainbow trout over 50 cm (19.7 inches). In 1984, the summer fishery (April-Sept. 15) was dominated by 35-50 cm rainbow. The numbers of fish in each length class over 50 cm were similar in 1983 and 1984.

Different length frequency patterns were observed during the fall (Sept. 16-Nov. 30) seasons. Approximately half of the rainbow trout recorded in 1983 were between 60 and 80 cm, while in 1984, very few fish were recorded in this length group. In 1983, rainbow were either between 25-40 cm or 60-80 cm. In 1984, the length frequency was not as clearly defined into two groups as it had been in 1983. Most of the fish recorded in 1984 were between 25 and 55 cm.

Table 2. Average back-calculated length at age (annulus formation) for all rainbow trout and each migration class ages 1, 2 and 3 of rainbow trout from Pend Oreille Lake, Idaho, 1983-1984.

Group of fish		Age 1	2	3	4	5		7
All rainbow 1983-1984								
	cm	7.8	17.0	33.4	46.0	58.1	67.2	78.0
	in	3.1	6.7	13.2	18.1	22.9	26.5	30.7
	(N)	(490)	(472)	(400)	(285)	(177)	(70)	(18)
Migration at age 0								
	cm	9.8	19.4	33.1	44.6	55.4	75.2	-
	in	3.9	7.6	13.0	17.6	21.8	29.6	-
	(N)	(14)	(14)	(12)	(9)	(7)	(2)	-
Migration at age 1								
	an	8.3	28.3	40.2	51.9	65.0	70.0	-
	in	3.3	11.1	15.8	20.4	25.6	27.6	-
	(N)	(135)	(117)	(90)	(61)	(34)	(7)	-
Migration at age 2								
	an	7.5	13.2	33.0	45.3	57.7	67.6	76.9
	in	3.0	5.2	13.0	17.8	22.7	26.6	30.3
	(N)	(308)	(308)	(265)	(193)	(122)	(55)	(15)
Migration at age 3								
	cm	7.4	12.3	18.6	37.0	45.9	57.5	-
	in	2.9	4.8	7.3	14.6	18.1	22.6	
	(N)	(33)	(33)	(33)	(22)	(14)	(6)	-

Table 3. Mean Increments of growth (cm) for rainbow trout of each age class and for each age class of fish migrating at age 1, 2, and 3 to Pend Oreille Lake, Idaho, 1983-1984.

Group of fish		Age group 0-1	1-2	2-3	3-4	4-5	5-6	6-7
All rainbow 1983-1984								
-	cm	7.8	9.2	16.4	12.6	12.1	9.1	10.8
	in	3.1	3.6	6.5	5.0	4.8	3.6	4.3
Migration at age 0								
	an	9.8	9.6	13.7	11.5	10.8	19.8	-
	in	3.9	3.8	5.4	4.5	4.3	7.8	-
Migration at age 1								
	cm	8.3	20.0	11.9	11.7	13.1	5.0	-
	in	3.3	7.9	4.7	4.6	5.2	2.0	-
Migration at age 2								
	an	7.5	5.7	19.8	12.3	12.4	9.9	9.3
	in	3.0	2.2	7.8	4.8	4.9	3.9	3.7
Migration at age 3								
	an	7.4	4.9	6.3	18.4	8.9	11.6	-
	in	2.9	1.9	2.5	7.2	3.5	4.6	-

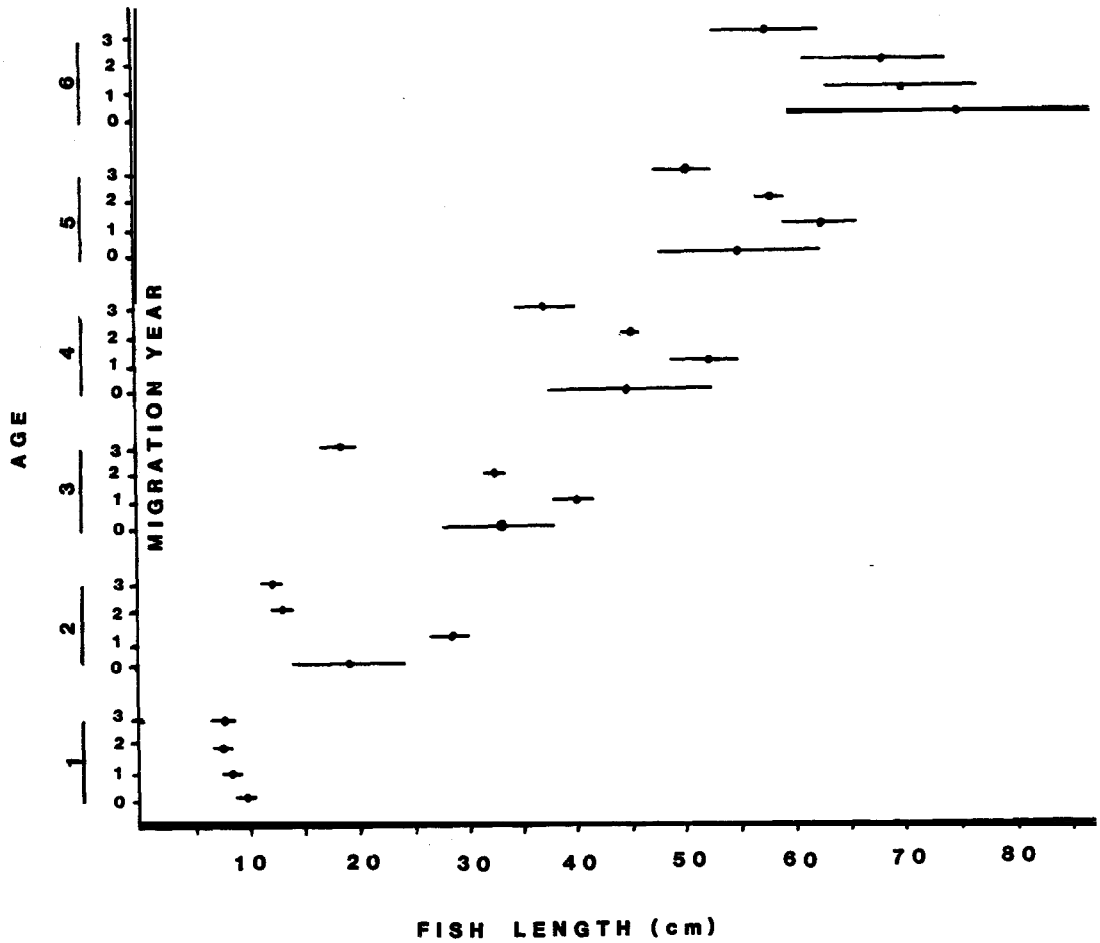

Figure 5. Comparison of length at age for 4 migration classes of rainbow trout in the Pend Oreille Basin, Idaho, 1983-1984.

Table 4. The age at first spawning and migration year of rainbow trout from Pend Oreille Lake which had spawned at least once, 1983-1984.

Age at first spawning	Number spawned	Migration year 0	1	2	3
3+	3	1	2	0	0
4+	11	0	5	5	1
5+	13	0	5	8	0
6+	22	0	2	19	1
7+	10	1	1	8	0
	59	2	15	40	2

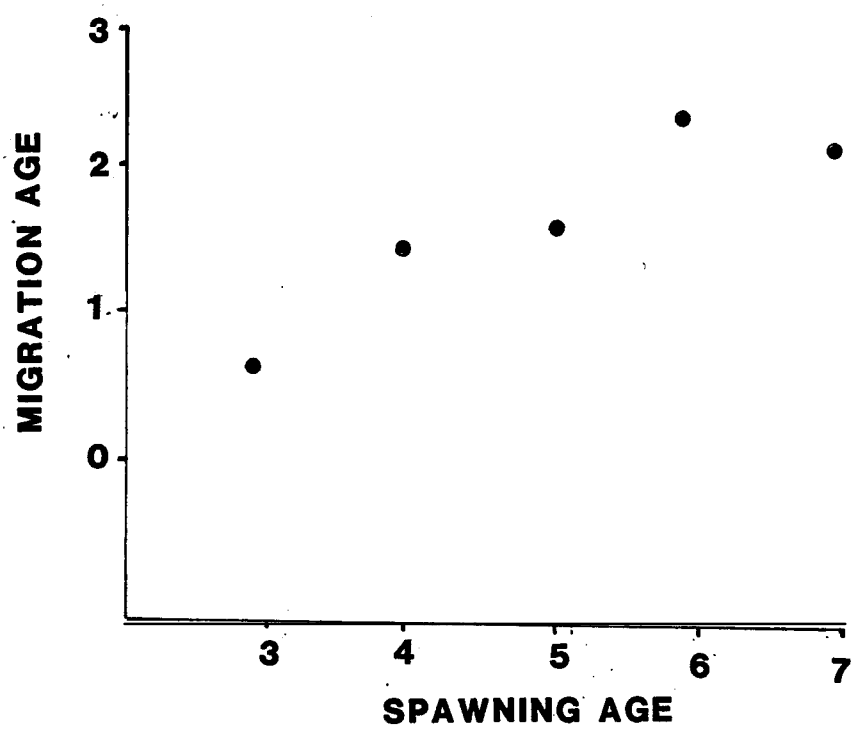

Figure 6. Comparison of age-at-first-spawning and age-at-migration for rainbow trout from Pend Oreille Lake, Idaho, 1983-1984.

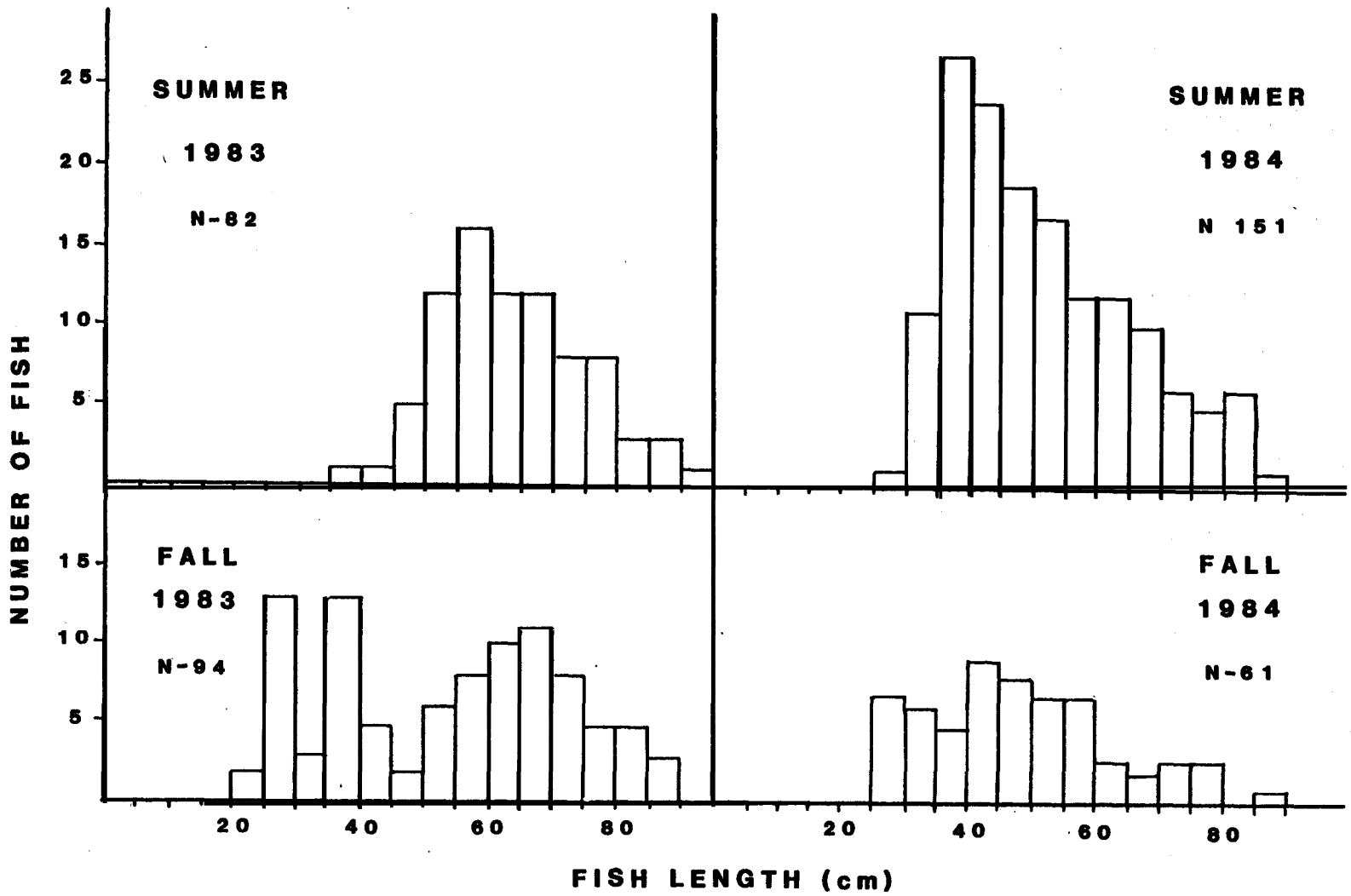

Figure 7. Summer and fall length frequencies of rainbow trout in Lake Pend Oreille, Idaho, 1983-1984.

Age composition of the rainbow trout population in Pend Oreille Lake was estimated from length frequency and age data (Fig. 8). Rainbow trout were recruited to the fishery as 3- or 4-year-old fish. Total annual mortality was estimated between 34% and 47% fran pooled data for 1983-1984 (Fig. 10). Mortality estimates calculated for each individual year ranged between 24% and 69% mortality (Fig. 9, Appendix C).

Genetic evaluation. Leary et al. (1984) found that the genetic material of trophy rainbow trout from Pend Oreille Lake was primarily derived from Kootenay Lake stocks (Appendix D). Hybridization with other stocks of rainbow trout and westslope cutthroat trout was evident. Other stocks of rainbow trout could only be generally identified as domestic stocks derived from coastal rainbow trout.

Stream Population

Spawning. The spawning distribution of adfluvial rainbow trout was suggested by both historic records and the current distribution of young-of-the-year fish (Fig. 10, Appendix E). _Rainbow trout spawning probably occurs in the middle reaches of Lightning Creek, Grouse Creek, and the Pack River as well as the lower reaches of the North Fork Grouse, Twin, Rapid Lightning, and Spring creeks.

Rainbow trout fecundities in the Pend Oreille basin ranged from 2,000-6,000 eggs per female between 1976-1984 (Table 6). In the hatchery, between 75% and 99% of the eggs reached the eyed stage.

Rearing. Juvenile rainbow trout were found in densities ranging up to 120 fish/100 sq m (Fig. 11, Appendix F). Rainbow were present in over 70% of the streams surveyed. Juvenile rainbow were most abundant in the middle and lower reaches of the drainages. Young-of-the-year (fry) were the predominant age class at all sites where densities over 20 rainbow/100 m^2 were observed.

The timing of fry emergence influenced the relative abundance data. Rainbow fry emerged throughout the summer months from mid-June to the end of July. In certain areas, like Twin Creek, the relative abundance of rainbow trout at the same site was between 10-15/100 m^2 in mid-June, and 50-120/100 m^2 in late August and September (Appendix F).

Stream Habitat

Stream restoration. The section of Spring Creek between the hatchery outfal l and the confluence of the spawning channel was partially cleaned. The percentage of fines <0.063 mm was reduced by the project, but sand (2.00-0.063 m) was only displaced by the cleaning project. Gravel compaction was reduced in the project area. The streambed should be sampled after 1985 spring run-off to measure the movement of sand out of the system.

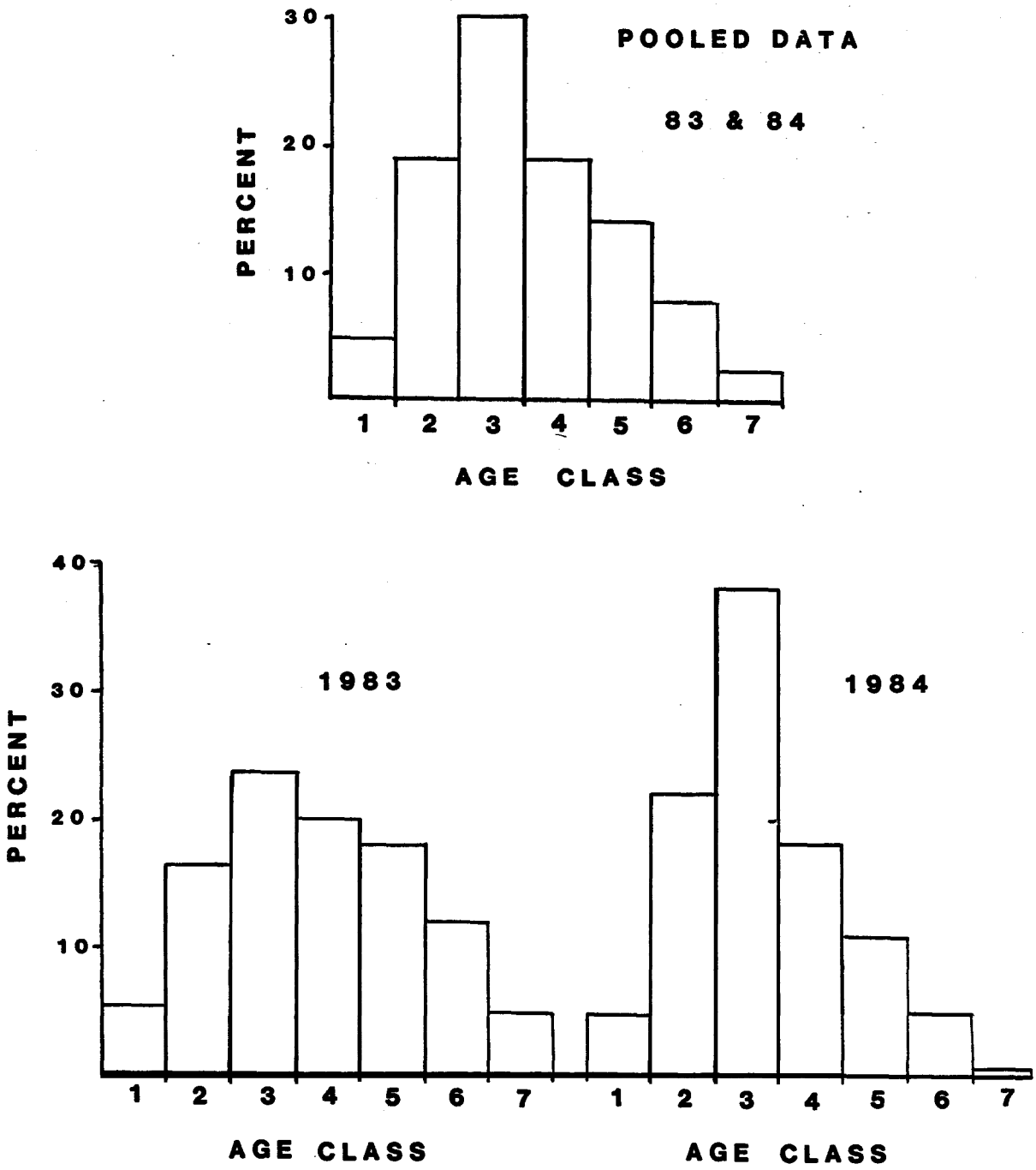

Figure 8. Age frequencies of rainbow trout in Lake Pend Oreille, Idaho, estimated for 1983-1984 and the pooled data.

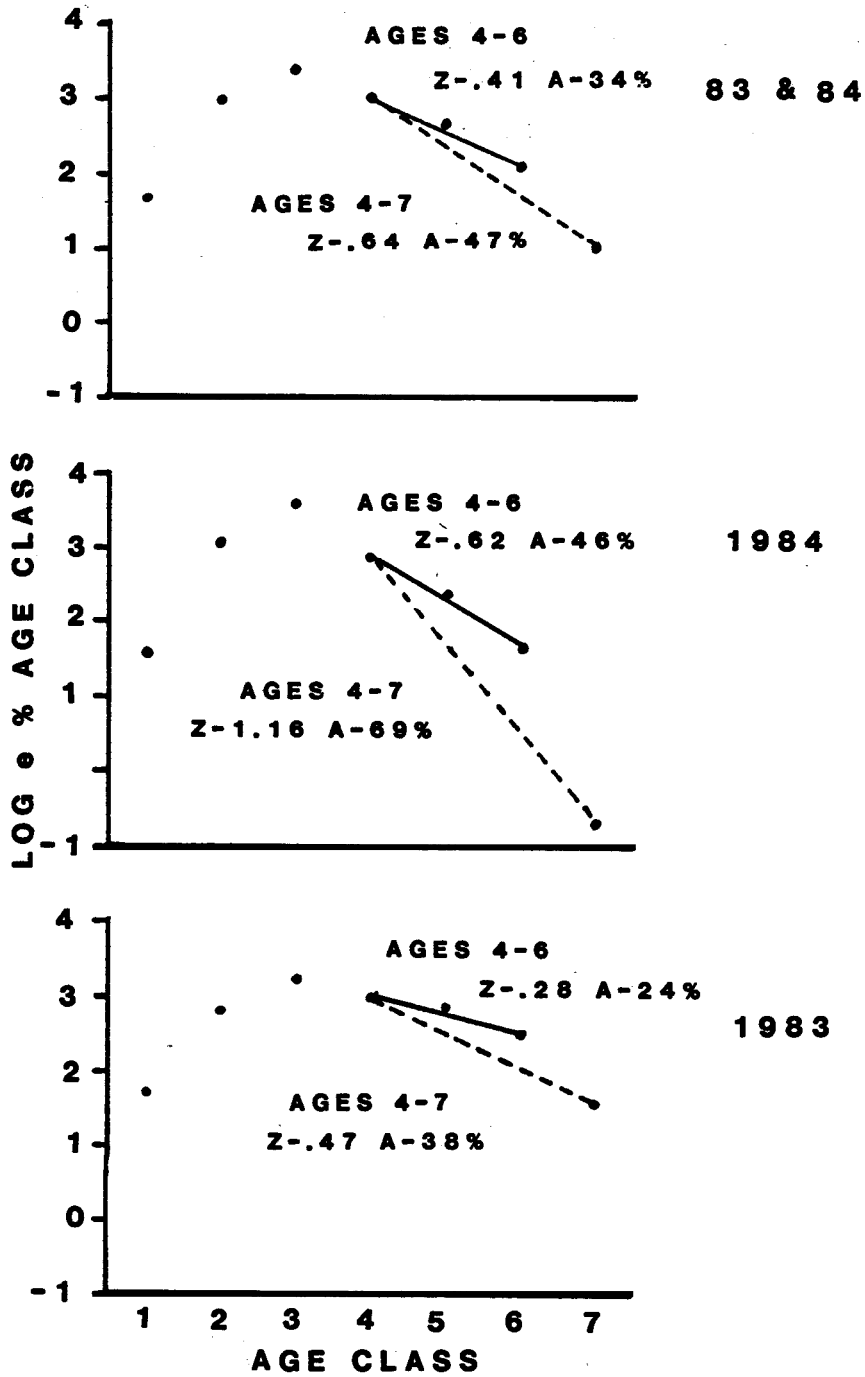

Figure 9. Estimate of total annual mortality of rainbow trout in Lake Pend Oreille, Idaho, from 1983-1984 and the pooled data.

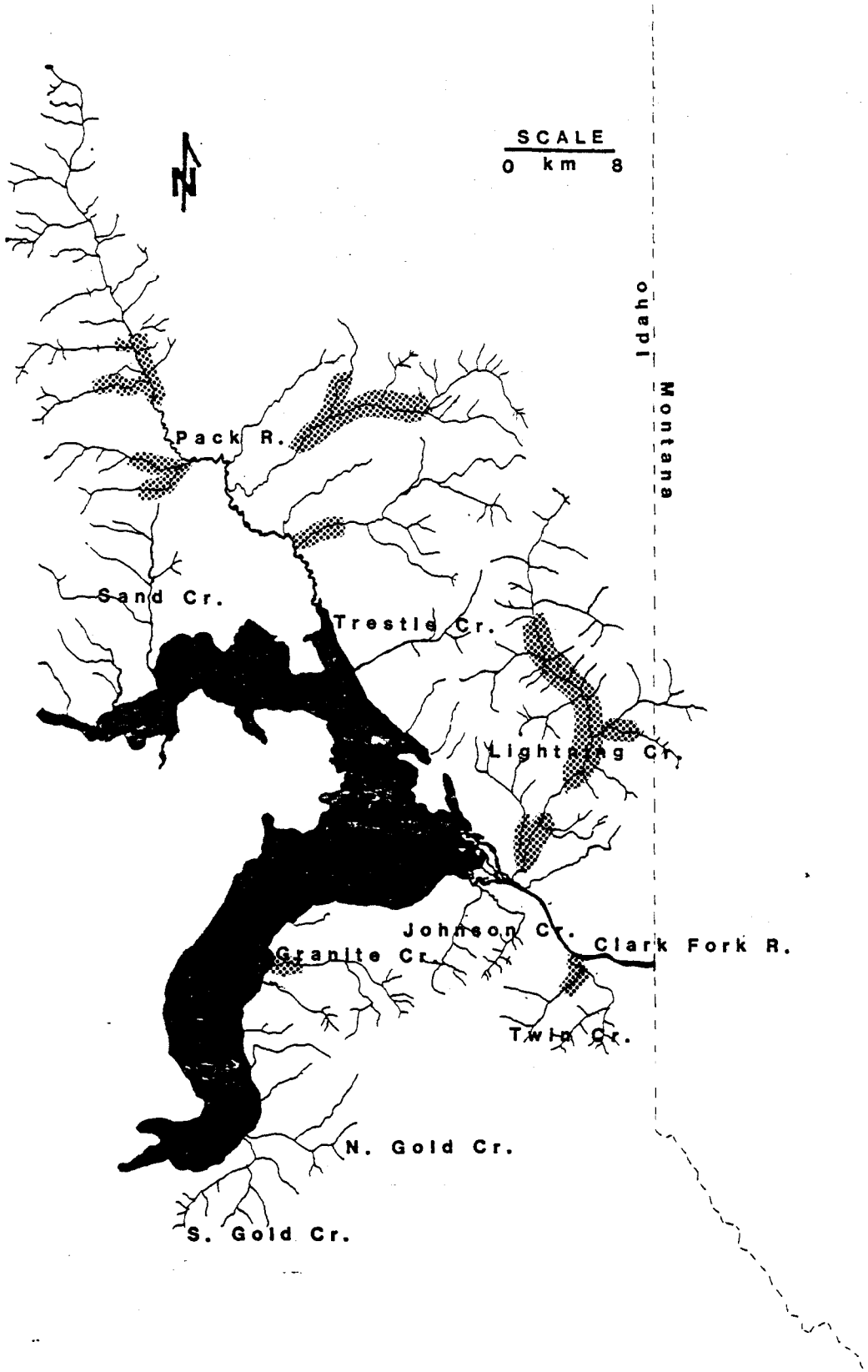

Figure 10. Estimated distribution of adfluvial rainbow trout spawning habitat based on fry densities in tributaries to Pend Oreille Lake, Idaho, 1983-1984.

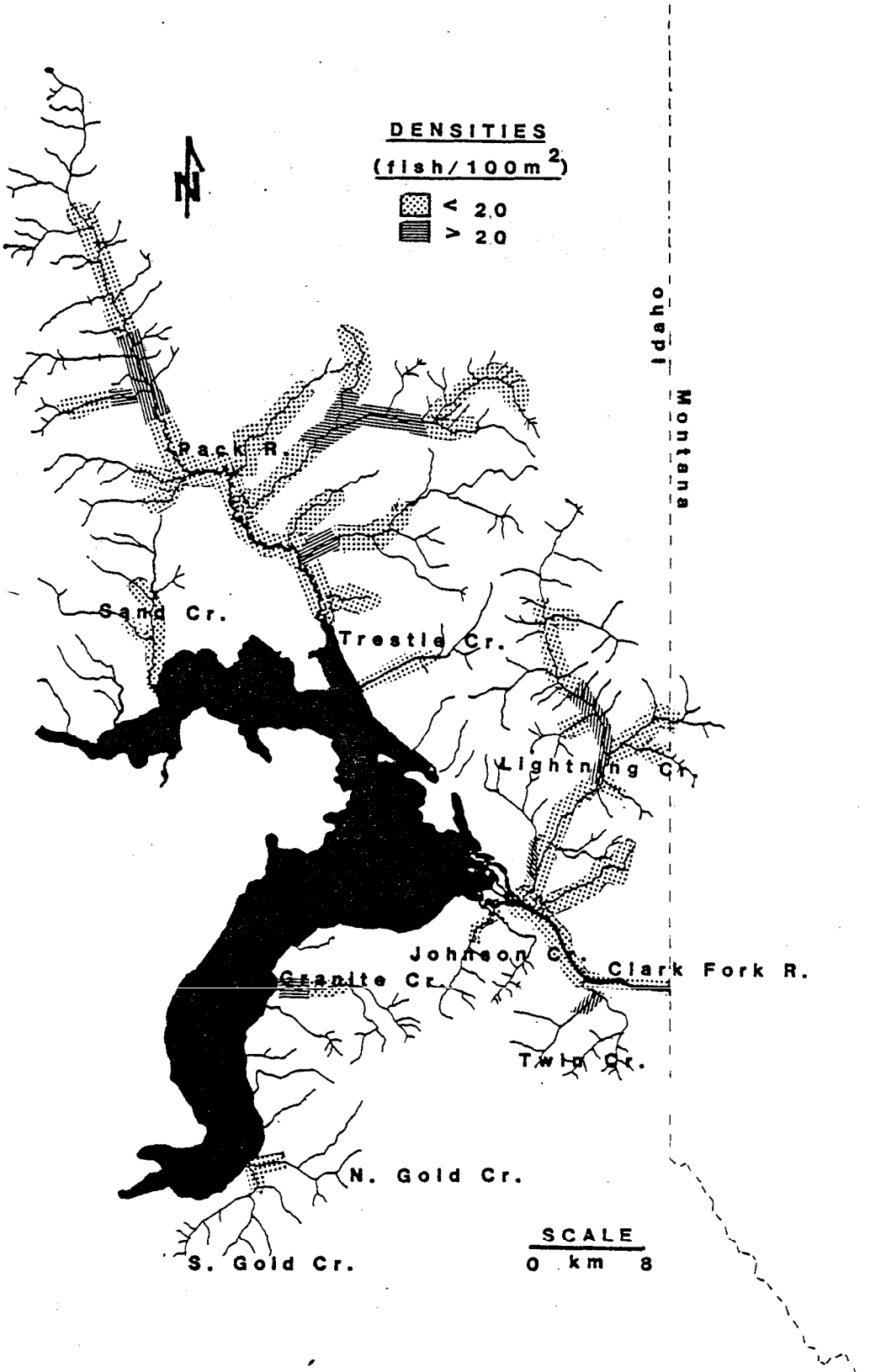

Figure 11. Distribution of juvenile rainbow trout in tributaries to Pend Oreille Lake, Idaho, 1983-1984. Shaded areas represent exceptionally high densities of juvenile rainbow ($\geq$ 20/100m^2).

Table 5. Percent of rainbow trout from Pend Oreille Lake spawning more than once from 1983-1984 collections.

Age at first spawning	Number of fish spawn! nq twice	Percent of spawners aged	Percent of total aged
3	0		
4	7	11.9	1.4
5	1	1.7	0.2
6	1	t.7	0.2
7	1	1.7	0.2
Total	10	17.0%	2.0%

Table 6. Average fecundity (eggs/female) for rainbow trout from the Pend Oreille Basin based on field data or hatchery data from 1976-1984.

Date	Eggs/female $\bar{x}$	Number of females
1983[a]	5,863	3
1983[b]	5,279	12
1982[b]	3,056	9
1981[b]	5,940	2
1978[b]	2,194	28
1976[b]	2,857	21

[a]Field data angler collection.
[b]Data courtesy of Clark Fork Hatchery.

Spawning habitat quality. Areas in Grouse, Spring, and Twin creeks, where rainbow trout were l ikel y to spawn, were typified by two-patterns of streambed composition (Figs. 12, 13). In Grouse and Twin creeks, the substrate was predominantly cobble and -gravels (>16 mm in diameter), 20% small gravel (<16, >6.3 mm), 30% sands (<6.3, >0.063 mm), and less than 1% fines (<0.063 mm). The streambed composition of Spring Creek was quite different with a predominantly large gravel substrate, very little cobble, and more sand and silt than Grouse or Twin creeks. -

Egg-to-fry survival estimates were extremely variable between streams (Table 7). Fry survival in Grouse Creek was between 37 and 75%. Estimated survival was higher (58-75%) for the upstream site than for the region below the North Fork Grouse (37-52%).

Bull Trout

Lake Population

Age-Growth. Anglers and Department personnel collected 194 bull trout scale samples during the 1983 and 1984 fishing season. Scale samples were collected from both Pend Oreille Lake and several tributary streams. Age determinations and growth measurements were used from 169 bull trout. All other scales had severely eroded edges or regenerated centers.

Bull trout ages 1-6 were collected. The 1- and 2-year-old bull trout were not collected in the lake. Bull trout grew 9 cm (3.6 inches) their first year and 16.4 cm (6.5 inches) their second year. Bull trout collected in the lake were at least 3 years old and had grown to approximately 27 cm (10.7> inches). During their third and fourth years, bull trout grew rapidly. Growth rates slowed down to 3 inches per year after spawning (Table 8).

Bull trout spawned for the first time as 4-, 5-, or 6-year-old fish (Table 9). Spawning marks were observed on 11 (6%) of the 169 bull trout aged. None of -the bull trout aged had spawned more than once. Although no scales were available, otoliths (ear bones) from a 96 cm (38 inch) bull trout were aged. This fish had probably spawned as a 4, 6, and 8 year old.

Age composition. Anglers recorded the lengths of 163 bull trout during the 1983 and 1984 field seasons. Due to the small sample size, a sample length frequency was developed for the pooled data (Fig. 14). Bull trout between 40 and 55 cm (15-22 inches) predominated the catch.

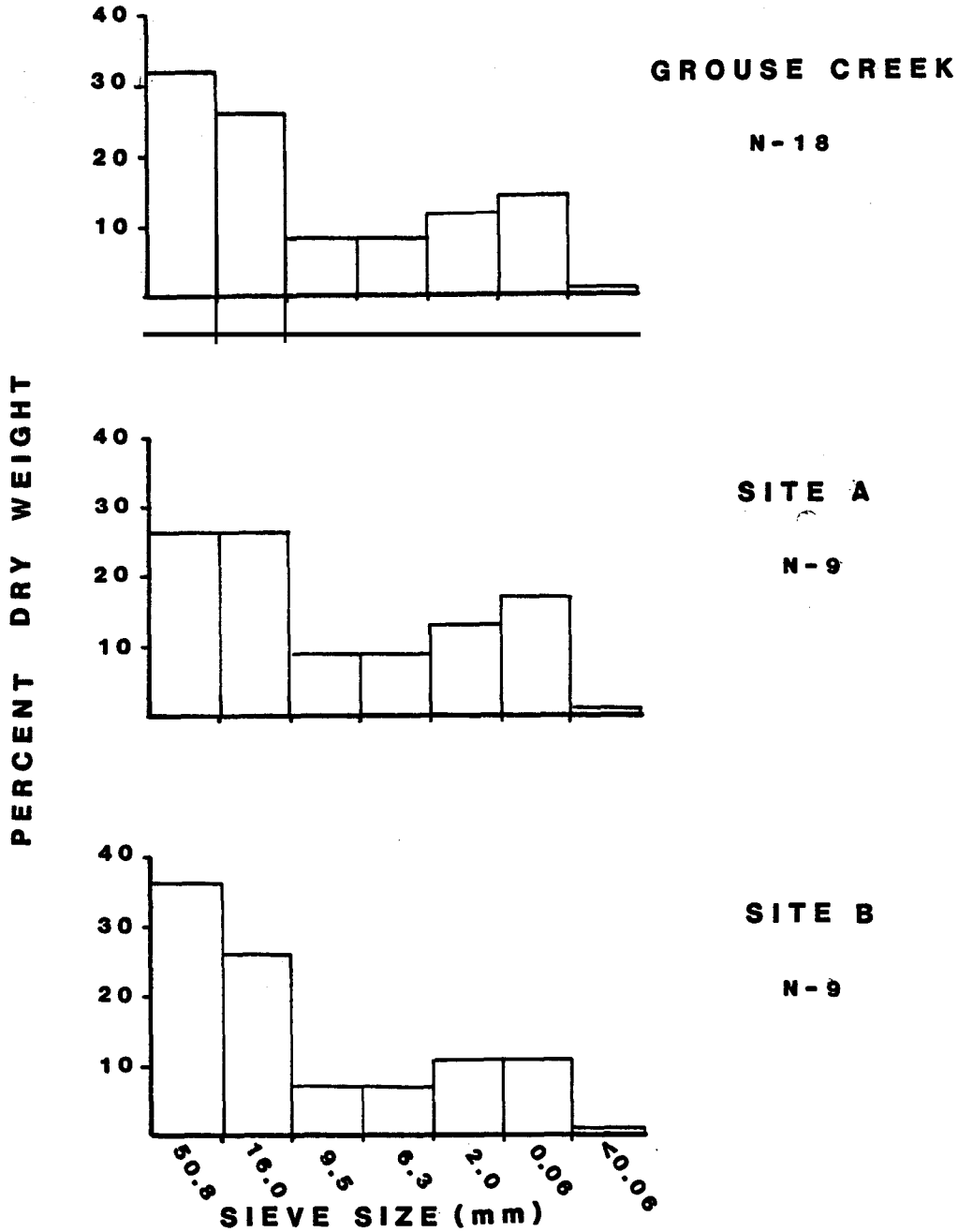

Figure 12. Streambed composition of Grouse Creek, and two separate locations in Grouse Creek based on hollow core data collected in August, 1984.

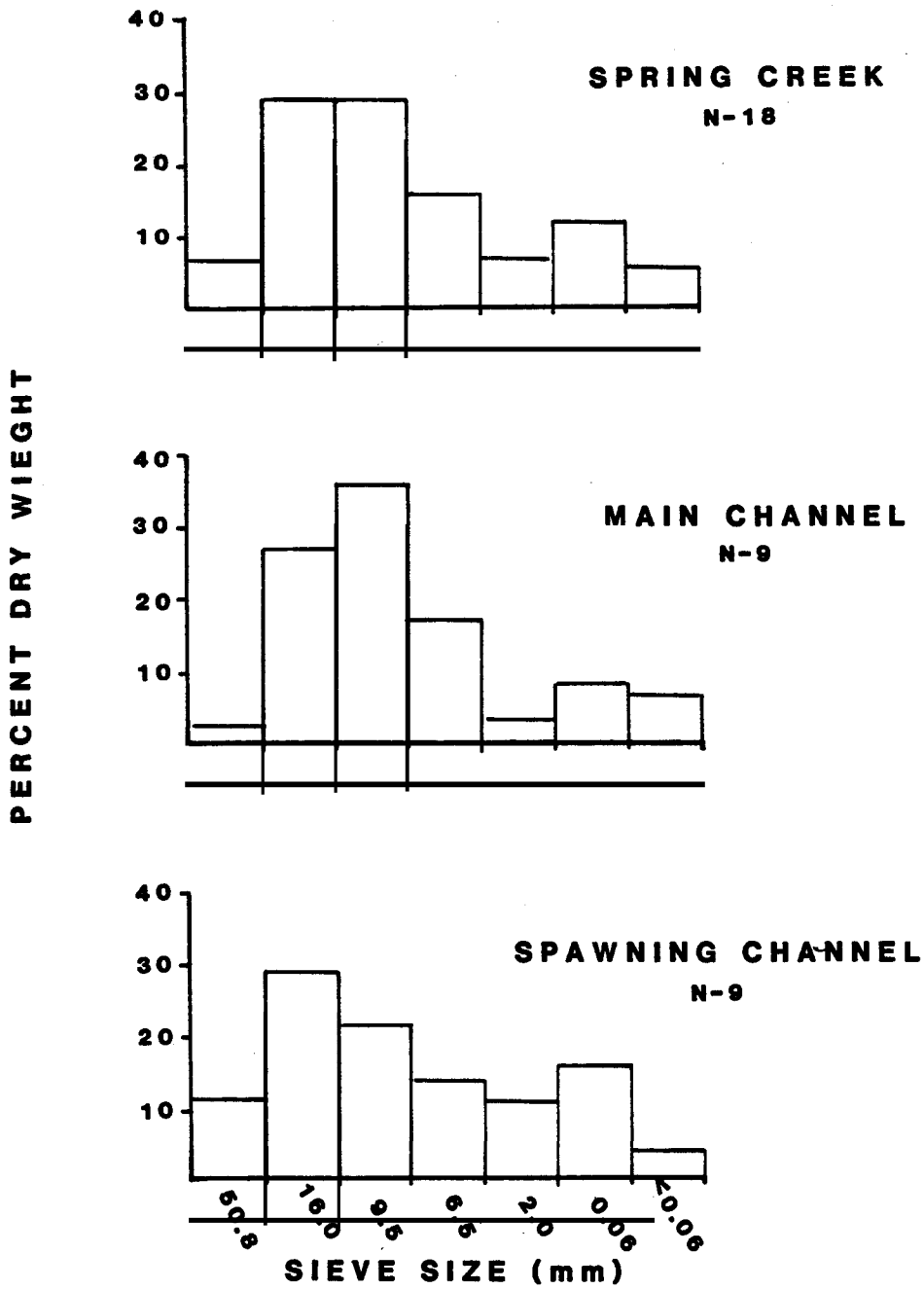

Figure 13. Streambed composition of Spring Creek, the main channel and the spawning channel, based on hollow core data collected in August, 1984.

Table 7. Estimated percent egg-to-fry survival for rainbow trout based on percent fines >6.35 mm in diameter in selected tributaries to Pend Oreille Lake, 1984.

Creek	Site -	(N)[a]	Estimated % survival $\bar{x}$	V	SE	95% confidence interval
Grouse	A	9	44.6	11.3	3.8	37.1-52.1
	B	9	66.3	13.1	4.4	57.5-75.1
	Total	18	55.5	16.3	3.8	47.8-63.2
South Gold	A	8	32.2	10.3	3.6	25.0-39.4
	B	8	30.8	17.2	6.1	24.7-36.9
	Total	18	30.1	13.5	3.2	26.9-33.3
Twin	A	5	21.0	11.0	4.9	11.2-30.8
	B	4	37.2	19.8	9.9	17.4-57.0
	Total	18	38.8	24.6	5.8	27.2-50.4
Spring	A	9	78.1	7.4	2.5	73.1-83.1
	B	9	56.9	23.5	7.8	41.2-72.6
	Total	18	67.5	20.1	4.7	58.1-76.9
	Rehab	7	78.4	10.4	3.9	70.5-86.3

[a] Sample size overall varies in sites A and B due to the disintegration of labels distinguishing between sites.

Table 8. Average back-calculated length at age (annulus formation) and incremental growth of bull trout frcm Pend Oreille Lake, Idaho, 1983-1984.

Estimated length	Age class (0—1) 1	(1—2) 2	(2—3) 3	(3—4) 4	(4—5) 5	(5—6) 6
At annul us formation						
cm	9.1	16.4	27.2	40.3	49.	57.8
in	3.6	6.5	10.7	15.9	19.6	22.8
(N)	(169)	(167)	(164)	(135)	(66)	(12)
Incremental growth						
cm	- -	7.3	10.8	13.1	9.4	8.1
in	3.6 —	2.9	4.2	5.2	3.7	3.2

Table 9. Age at first spawning, percent of fish in age class which spawned, and percent of spawned fish in each age class for bull trout from Pend Oreille Lake, 1983-1984.

Age	Number aged	Number spawned	Age at first spawns nq	Percent of of total spawned per age class	Percent of spawned fish per age class_
1	2	0	-	-	
2	3	0	-	-	
3	29	0	-	-	
4	68	3	4	4%	27%
5	56	4	5	7%	36%
6	12	4	5,6[a]	33%	36
Total	169	11			6%

[a]Two had spawned for the first time as 5 year olds.

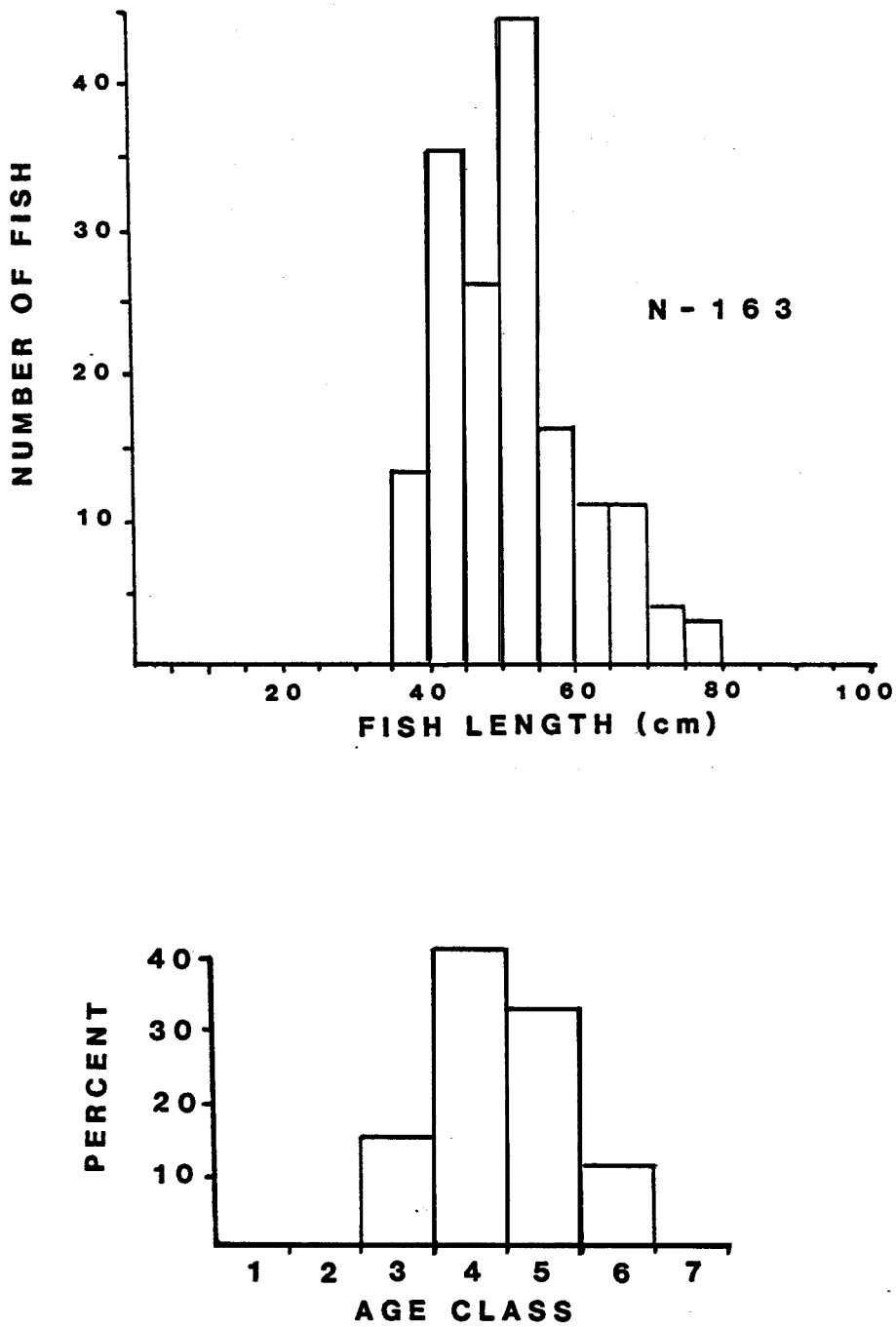

Figure 14. Length frequency (upper) and age frequency of bull trout from Lake Pend Oreille, Idaho, 1983-1984.

Bull trout were recruited to the fishery between the ages of 4 and 5 (Fig. 14). Estimates of total annual mortality were between 47% and 82% (Fig. 15).

Stream Population

Spawning. The distribution of spawning bull trout was limited to 40 km (25 miles) of stream or 23% of the accessible stream habitat (Fig. 16, Table 10). Bull trout spawned in similar areas in 1983 and 1984 (Table 11, Appendix G). A few new areas were surveyed in 1984, and an additional 5 km of spawning habitat was identified. At the same time, less spawning area was available in Rattle, East Fork Savage, and Char creeks due to low flaws resulting in longer sections of dry streambed.

Although bull trout redds were observed in the same areas during 1983 and 1984, the dispersal of redds throughout the basin was different. In 1983, 90% of the bull trout spawning occurred in Trestle and South Gold creeks and the tributaries to Lightning Creek. In 1984, 62% of the redds were counted in those areas. Fewer bull trout redds were observed in the Rattle and East Fork drainages. More redds were observed (12%) in areas previously inaccessible due to temporary barriers to migration. Additional redds (16%) were also observed in areas not surveyed in 1983.

The peak of the spawning season was later in the fall of 1984 than it had been in 1983. The peak of spawning activity had probably occurred by the first week of October in 1983 and mid-October of 1984.

Bull trout redd counts were attempted in the Clark Fork River by boat in October 1984. No redds were seen between Cabinet Gorge Dam and the mouth of Lightning Creek. No redds were seen along the spawning channel below the dam, where bull trout were known to have spawned in the past.

Bull trout spawning escapement in the Pend Oreille drainage was estimated to be 3,175 in 1983 and 3,436 in 1984.

Rearing. Bull trout were not as widely distributed in streams as either rainbow or cutthroat trout. Bull trout were observed in less than half (42%) of the tributary streams (Fig. 17, Appendix F). Juvenile bull trout were rarely seen throughout an entire drainage.

Bull trout were less abundant than rainbow or cutthroat trout. The average density of Juvenile bull trout was estimated at 4.3/100 m^2. The highest density recorded for bull trout in tributaries to Pend Oreille was 17/100 m^2 (Appendix F).

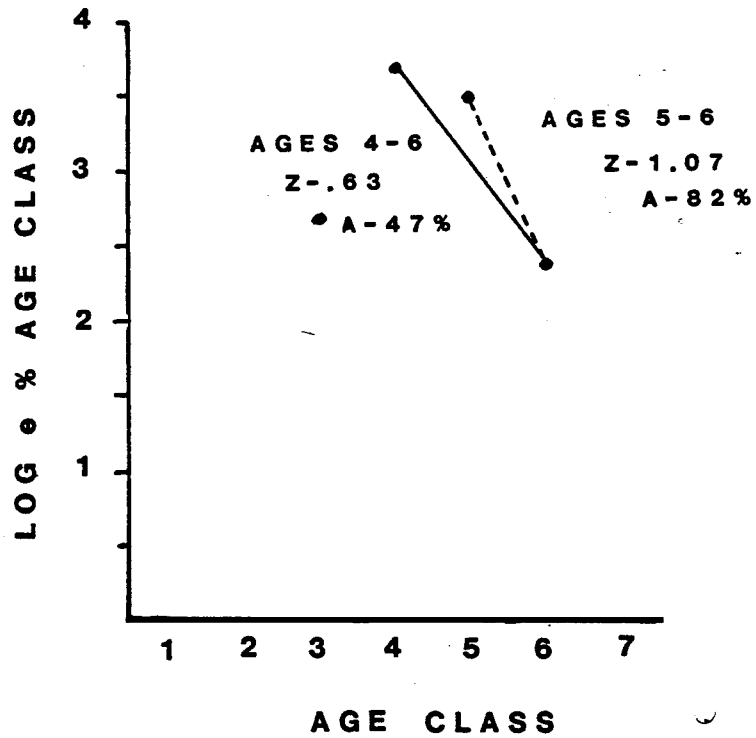

Figure 15. Estimated total annual mortality of bull trout from lake Pend Oreille, Idaho, 1983-1984.

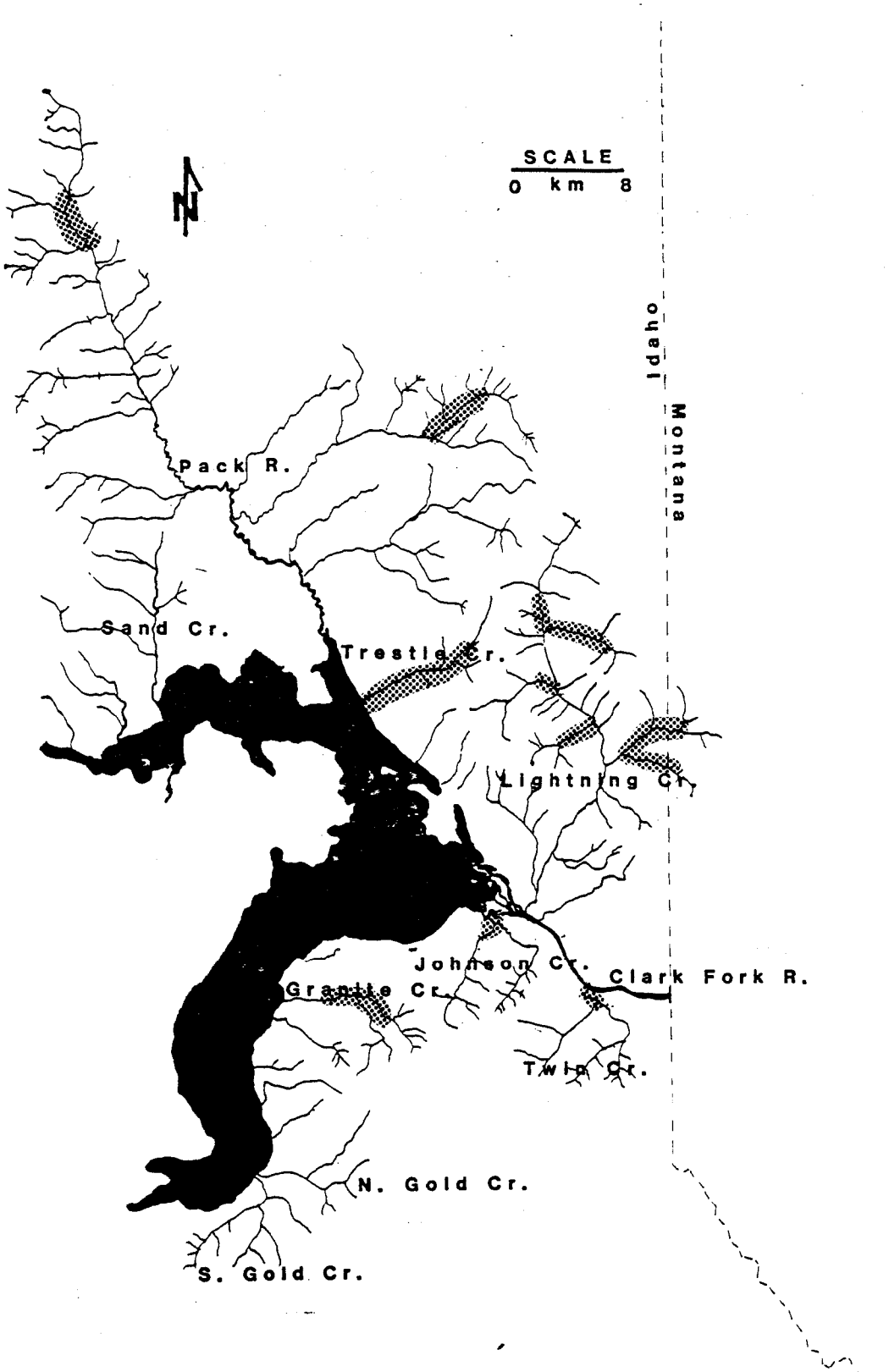

Figure 16. Distribution of bull trout spawning in tributaries to Lake Pend Oreille, Idaho, 1983-1984.

Table 10. Length of stream present, available, surveyed, and used by bull trout in the Pend Oreille drainage (below Cabinet Gorge Dam).

Stream distance	Miles	Kilometers	Percent drainage	Percent of area available
Present in drainage	159[a]	254	100	
Available to migrating fish	108[a]	173	68	100
Surveyed for bull trout redds	72	117	46	68
Used for spawning bul I trout	25	40	16	23

[a]Data from USFS Sandpoint Ranger District.

Table 11. Bull trout redd densities calculated for regions with redds (to the nearest 0.5 km) for each tributary to Pend Oreille Lake surveyed during the 1983 and 1984 field seasons.

Stream	Redds counted		km walked		km with[a] redds		Redds[b] km	
	1983	1984	1983	1984	1983	1984	1983	1984
CLARK FORK RIVER								
Lightning	28	9	27.0	1.0	5.5	1.0	4.9	9.0
Rattle	51	32	5.7	4.7	3.5	2.0	14.6	11.0
Wellington	21	18	0.5	0.5	0.5	0.5	42.0	36.0
East Fork	110	24	6.8	7.0.	5.5	3.0	20.0	10.5
Savage	36	12	2.1	2.8	2.5	2.0	14.4	6.0
Charr	18	9	1.2	1.2	0.5	1.2	36.0	6.0
Porcupine	37	52	3.0	4.0	2.5	3.0	14.8	17.0
Spring	0		2.0	-	0		0	
Twin	7	25	3.2	3.2	1.0	1.5	7.0	17.0
Johnson	13	33	1.3	1.3	1.5	1.0	8.7	33.0
NORTHERN SHORE								
Trestle	298	272	8.5	10.0	8.5	9.0	35.1	30.0
Pack River	34	37	16.0	6.1	3.0	3.0	11.3	15.0
Jeru	0	-	0	-	0		0	
Hell roaring	0	-	0	-	0		0	
Grouse	2	108	2.6	11.5	1.0	6.0	2.0	17.0
Rapid Lightning	0	-	4.8	-	0		0	
EASTERN SHORE								
Granite	3	81	5.8	7.8	1.0	3.0	3.0	25
Sullivan Springs	9	8	0.5	0.5	0.5	0.5	18.0	16
North Gold	16	37	1.2	1.2	1.0	1.2	16.0	31
South Gold	131	124	2.3	2.5	2.5	2.0	52.4	62
TOTALS	814	881	94.5	65.3	40.5	39.9	20.8	22.4

[a]To the nearest 0.5 km.
bWhere redds were present.

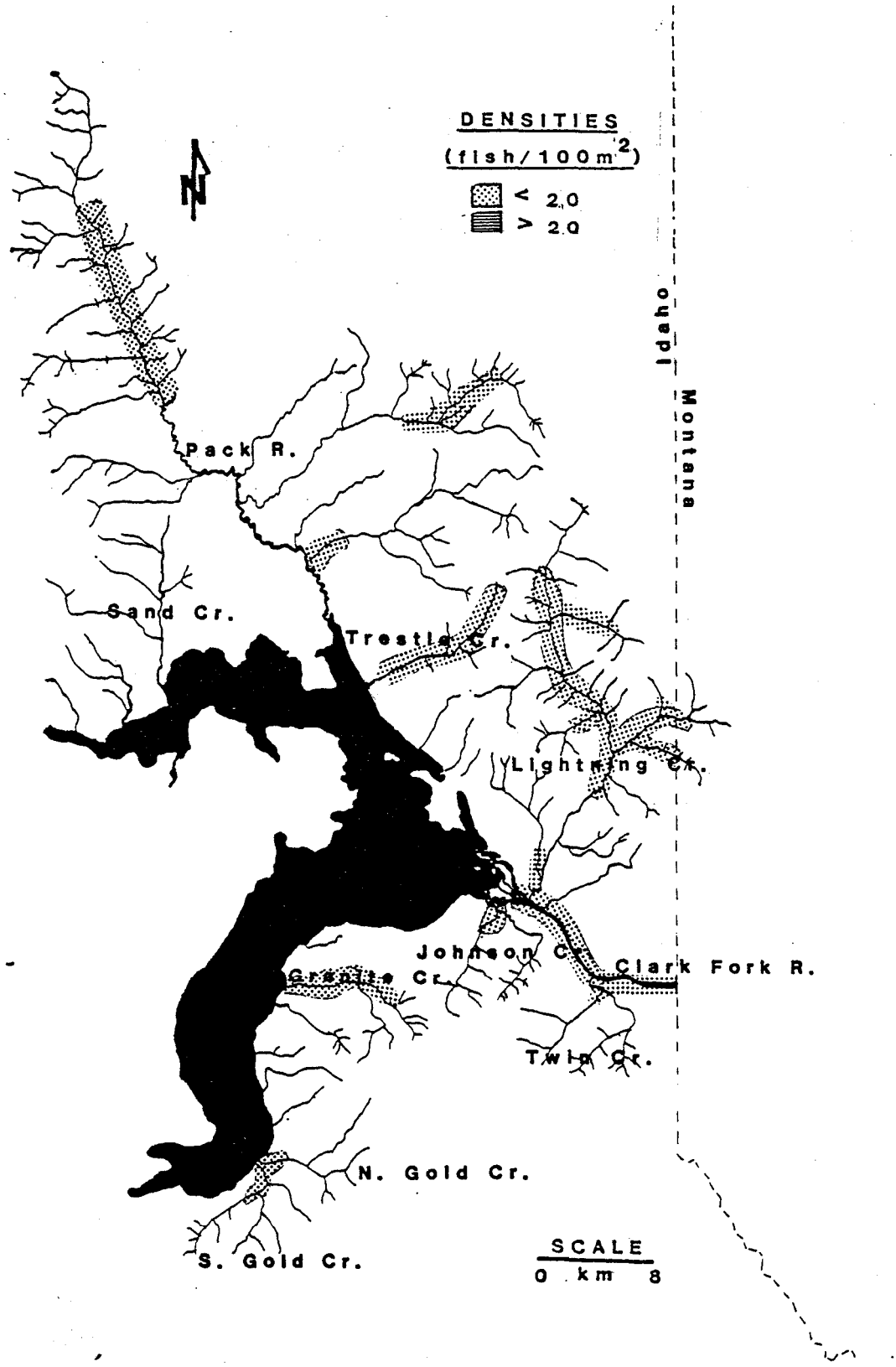

Figure 17. Distribution of juvenile bull trout in tributaries to Lake Pend Oreille, Idaho, 1983-1984.

Where bull trout were found, the streams were often characterized by large substrate, closed or partial canopy, and high gradients. The combination of characteristics least likely to maintain bull trout in tributaries to Pend Oreille were open, low gradient, downstream reaches where summer temperatures frequently reached 65-70°F, such as lower Pack River, lower Grouse Creek, Sandpoint Creek, and lower Lightning Creek.

Stream Habitat

Spawning habitat quality. The streambed composition in spawning areas used by bull trout in South Gold and lower Twin creeks were similar (Fig. 18). The predominant substrate was large gravel (50.8-16.0 mm). About 20% of the samples were pea gravels (9.5-6.35 mm), 40% sand (2.0-0.06tmn), and 2% suspendable fines.

The estimates of bull trout egg-to-fry survival were low in areas bull trout used for spawning (Table 12). Egg-to-fry survival for bull trout in South Gold Creek was estimated to be 26-52%. Estimates for survival in Twin Creek were 29-67%, but half of these samples (Site B) were collected in areas unavailable to bull trout.

Estimates of egg-to-fry survival were quite high in areas accessible to, but not used by, bull trout in Grouse and Spring creeks. Factors other than streambed composition and access may have influenced the distribution of bull trout spawning.

Cutthroat Trout

Lake Population

Age-Growth. Anglers collected scales from 103 cutthroat trout during the 1983 and 1984 fishing seasons. Age determinations and growth measurements were taken from scales of 84 cutthroat trout.

Cutthroat trout samples were between 1 and 5 years of age. During their first year, cutthroat grew approximately 8 cm (3 inches) in the stream environment (Table 13). Like rainbow, cutthroat emigrated fran the stream as 1-, 2-, or 3-year-old fish. Therefore, growth rates within age classes varied depending upon age at migration (Tables 14, 15).

The differences between length at annulus formation for cutthroat trout migrating at different ages were evident, but not as pronounced as the trend had been for rainbow trout. Cutthroat, migrating as 1 year olds, grew at a rate of 10-11 cm (4 inches) during their second and third years. In contrast, cutthroat trout migrating as 2 year olds grew about 6 cm their second year in the stream, and 17 cm (7 inches) the first year in the lake.

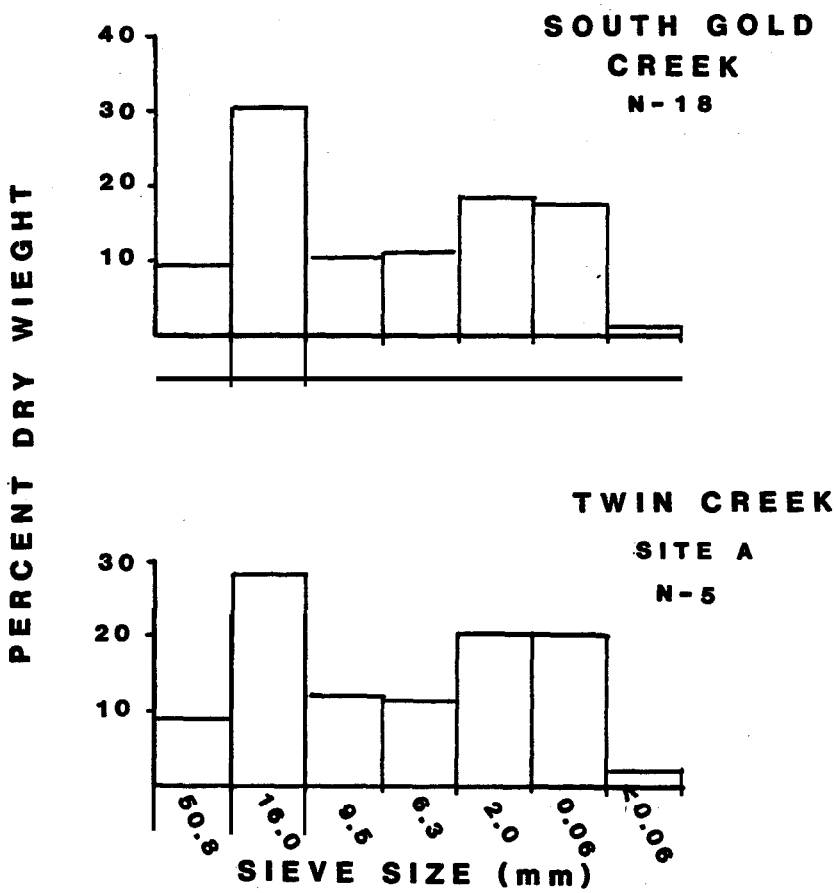

Figure 18. Streambed composition in South Gold and Twin Creek in bull trout spawning areas, based on hollow core data collected in August, 1984.

Table 12. Estimated percent egg-to-fry survival for bull trout based on percent fines >6.35 mm in diameter in selected tributaries to Pend Oreille Lake, 1984.

			Estimated survival			
Stream	Site 1	N	X	V	SE	95% confidence
Grouse	A	9	66.6	19.3	6.4	53.8-79.4
	B	9	93.7	12.5	4.2	89.5-97.9
	Overall	18	80.2	21.1	5.0	70.2-90.2
South Gold	A	8	41.8	23.6	8.3	33.5-50.1
	B	8	47.7	31.8	11.2	30.8-64.6
	Overall	18	38.7	27.1	6.4	25.9-51.5
Twin	A	5	19.2	25.4	11.3	0-38.3
	B	4	50.4	40.0	20.0	30.4-70.4
	Overall	18	48.0	39.7	9.4	29.2-66.8

Table 13. Average back-calculated lengths at age (annulus formation) and incremental growth of cutthroat trout from Pend Oreille Lake, Idaho 1983-1984.

	Age cI ass						
Estimated length	1	1-2	2	2-3	3	3-4	4
At annulus formation							
cm	8.0	-	14.8	-	26.1	-	35.8
in	3.1	-	5.8	-	10.3	-	14.1
(N)	(84)	-	(79)	-	(42)	-	(9)
Incremental growth							
cm	-	6.8	-	11.3	-	9.7	-
in	-	2.7		4.5	-	3.8	-

Table 14. Comparison between average back=calculated length at age of cutthroat trout migrating into Pend Oreille Lake as young-of-the-year (age 0), 1-, 2-, and 3-year-old fish, 1983-1984.

		Ages			
		1	2	3	4
Total					
	cm	8.0	14.8	26.1	35.8
	in	3.1	5.8	10.3	14.1
	(N)	(84)	(79)	(42)	(9)
Migration year 0					
	cm	7.8	13.0	17.5	
	in	3.1	5.1	6.9	
	(N)	(15)	(9)	(2)	
Migration year 1					
	cm	8.1	19.1	29.3	33.9
	in	3.2	7.5	11.5	13.3
	(N)	(18)	(18)	(7)	(1)
Migration year 2					
	cm	8.3	14.0	31.2	34.7
	in	3.3	5.5	12.3	13.7
	(N)	(37)	(37)	(19)	(3)
Migration year 3					
	cm	7.3	12.5	18.8	36.9
	in	2.9	4.9	7.4	14.5
	(N)	(14)	(14)	(14)	(5)

Table 15. Comparison of the incremental growth of cutthroat trout migrating into Pend Oreille Lake as young-of-the-year (age 0), 1-, 2-, or 3-year-old fish, 1983-1984.

	Ape increments			
	0-1	1-2	2-3	3-4
Total	8.0	6.8	11.3	9.7
	3.1	2.7	4.4	3.8
Migration year 0	7.8	5.2	4.5	
	3.1	2.0	1.8	
Migration year 1	8.1	11.0	10.2	4.6
	3.2	4.3	4.0	1.8
Migration year 2	8.3	5.7	17.2	3.5
	3.3	2.2	6.8	1.4
Migration year 3	7.3	5.2	6.3	18.1
	2.9	2.0	2.5	7.1

Age composition. Age composition and mortality estimates were not calculated for cutthroat trout due to the smal I sample of representative lengths collected In 1983 and 1984.

Stream Populations

Spawning. Cutthroat trout fry were not observed in consistently high densities (>20/100 m^2) anywhere in the Pend Oreille basin. However, areas with moderate densities of Juvenile cutthroat were observed and used to indicate possible spawning areas (Fig. 19).

Idaho Fish and Game records indicate cutthroat trout were both widespread and abundant in the Pend Oreille basin; however, spawning areas were not identified (Jeppson, 1955).

Rearing. Cutthroat trout were widely distributed, but not generally abundant in tributaries to Pend Oreille Lake (Fig. 20, Appendix F). Cutthroat were observed in 84% of the tributary streams. Densities of cutthroat trout were low (<5/100 m^2) in areas which could be used by adfluvial fish (Appendix F).

Resident cutthroat populations were present above waterfalls. In areas like North Gold Creek, resident cutthroat were abundant (56/100 m^2), while in other areas, like upper Lightning Creek, densities were low (2-5/100 m^2).

The period of cutthroat trout fry emergence was not easily observed in the Pend Oreille basin. Cutthroat fry were rarely seen. Relative abundance data for cutthroat trout did not seem to be effected by the timing of fry emergence.

Stream Habitat

Spawning habitat quality. Cutthroat trout were not observed in large numbers in any stream where the streambed composition was described in 1984. A few cutthroat trout were observed in the study areas of Spring, South Gold, and Twin creeks. The substrate typically present was predominantly large gravels, some small gravels (20%), 40% sand, and 1-6% suspendable fines (Fig. 21). Estimated survival of cutthroat trout eggs-to-fry emergence was low, ranging from 4 to 65% (Table 16).

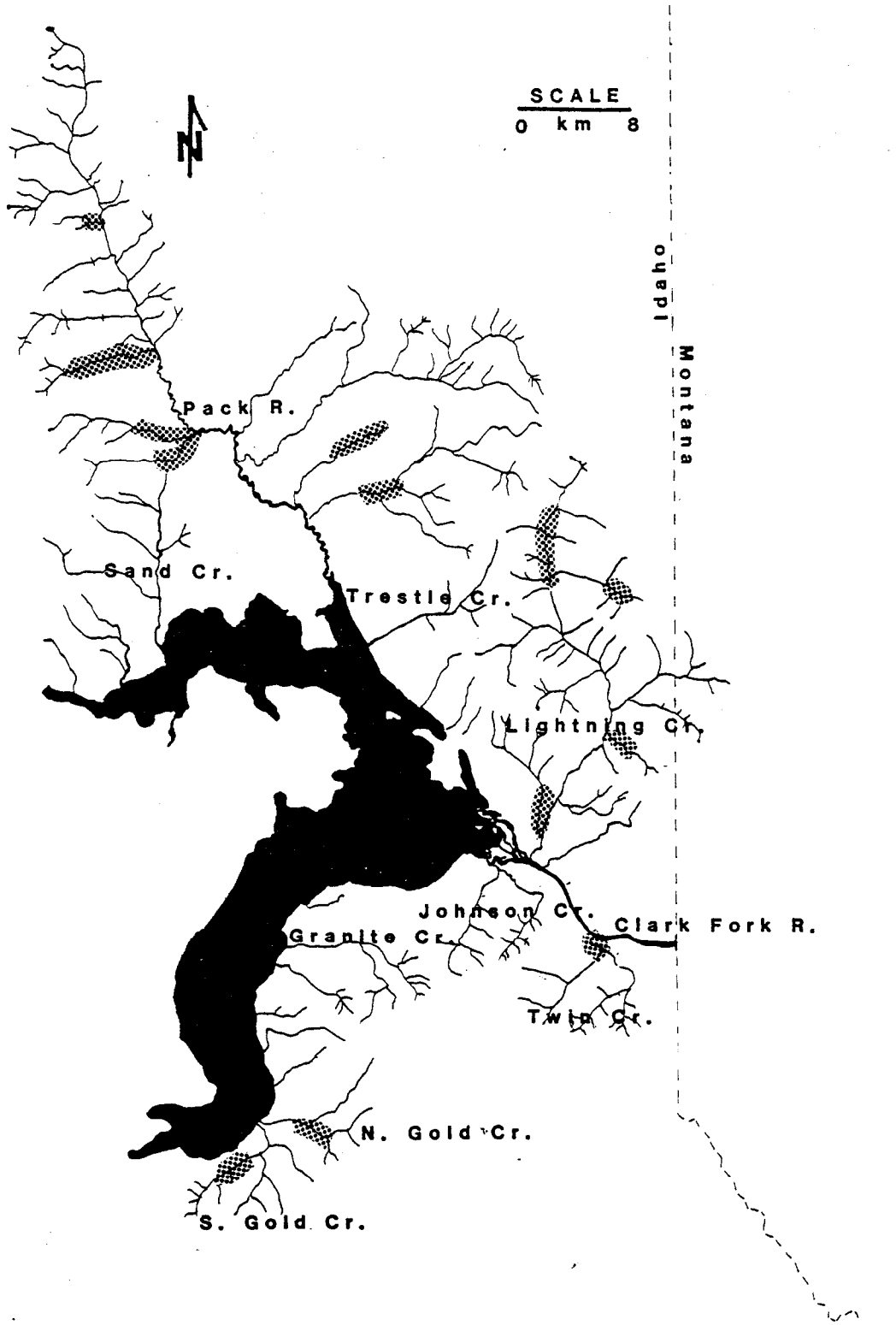

Figure 19. Estimated distribution of cutthroat spawning in tributaries to Lake Pend Oreille, based on observation of fry and juvenile cutthroat trout, 1983-1984.

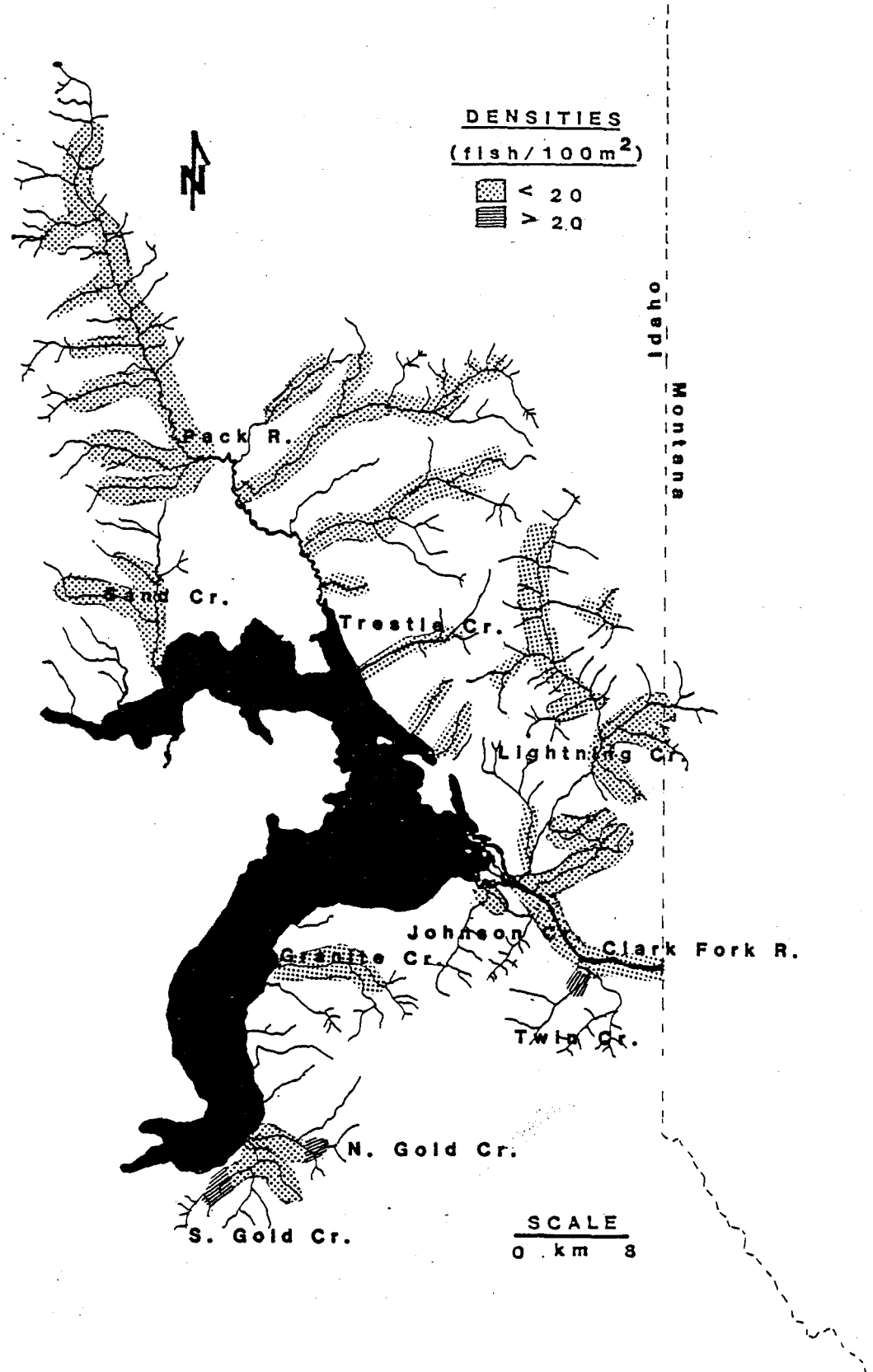

Figure 20. Distribution of cutthroat trout in the tributaries to Lake Pend Oreille, Idaho, 1983-1984.

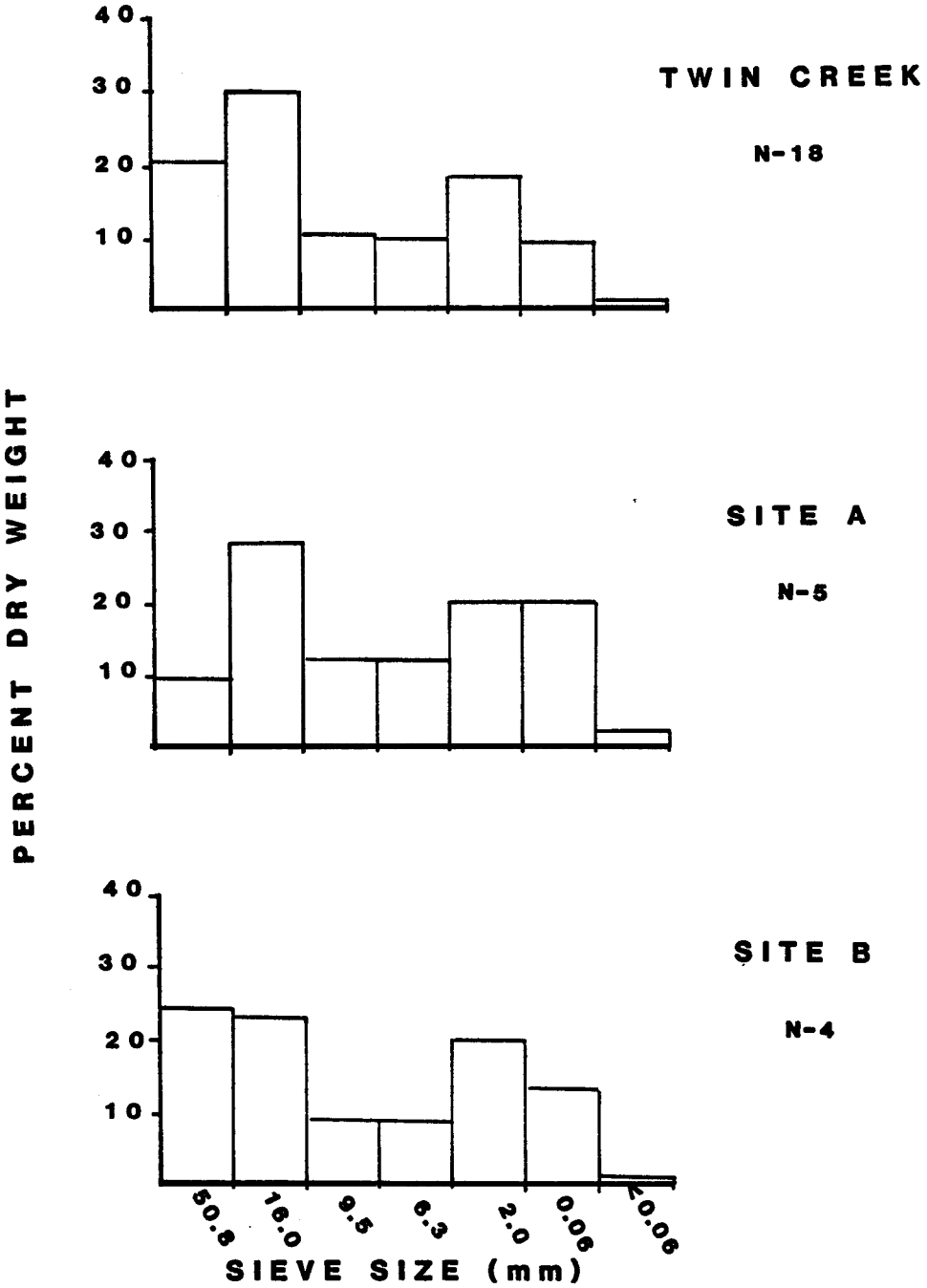

Figure 21. Streambed composition of Twin Creek in areas where juvenile cutthroat have been observed, based on hollow core data collected in August, 1984.

Table 16. Estimated percent egg-to-fry survival for cutthroat trout based on streambed analysis in selected tributaries to Pend Oreill\e, 1984.

			Estimated % survival			
Creek	Site	(N)	X	V	SE	95% confidence interval
Grouse	A	9	23.1	8.9	3.0	17.1-29.1
	B	9	43.5	14.2	4.8	33.9-53.1
	Total	18	33.3	15.6	3.7	25.9-40.7
South Gold	A	8	14.7	5.7	2.0	10.7-18.7
	B	8	13.9	10.7	3.8	6.3-21.5
	Total	18	13.6	8.1	2.9	7.8-19.4
Twin	A	5	3.9	6.0	2.7	3.5-4.3
	B	4	19.1	13.3	6.6	5.8-32.4
	Total	18	22.3	20.0	4.8	12.7-31.9
Spring	A	9	57.3	10.0	3.3	50.6-64.0
	B	9	37.2	16.5	5.5	26.2-48.2
	Total	18	46.7	18.2	4.3	38.1-55.3
	Rehab	7	58.6	16.1	6.1	52.5-64.7

DISCUSSION

Rainbow Trout

Current Status of Lake Population

Growth rates. Growth rates of rainbow trout in Pend Oreille Lake were similar for fish collected in 1983-1984 and 1972-1976 (Table 17). The growth rates observed for Pend Oreille rainbow and stock from Kootenay Lake were similar (Cartwright 1961; Appendix I).

Population composition. The sport fishery did not appear to limit the rainbow trout population of Pend Oreille Lake based on the estimates of annual mortality for 1983-1984. However, careful examination of the data implies the role of fishing may have been underestimated. In 1983, the small trout in the catch were probably underestimated, and therefore annual mortal ity was underestimated. The 1984 data was probably more accurate because lengths were recorded during the entire fishing season, and sportsmen were more knowledgeable about the program. The mortality estimates from 1984 data alone were as high as 69%, and probably more accurately described the population than the pooled or 1983 data.

Other factors influence the accuracy of mortality estimates calculated from length frequencies recorded by sportsmen. The sportsmen collecting data were primarily seeking trophy trout and using gear designed for larger fish. Most (84-70%) of the rainbow harvest from 1960-1980 were subtrophy (less than 43 cm or 17 inches) fish (Table 18). These smaller trout were harvested by sportsmen seeking kokanee, cutthroat, small trout, and trophy trout. Since the subtrophy component of the rainbow trout sport fishery was not completely sampled during 1983-1984, it is likely that estimates of 50-69% mortality were conservative.

The percentage of total annual mortality, which can be attributed to the harvest, is unknown.

Age at maturity. Large trophy rainbow in Pend Oreille Lake and their parent stock from Kootenay Lake have been characterized as a late maturing stock (Anderson, 1978; Cartwright, 1961). Anderson (1978) described the rainbow population in Pend Oreille Lake from 1970-1976 estimating that 95% of the mature rainbow had spawned for the first time as 5-, 6-, or 7-year-old trout (Table 1 9). I n 1983-1984, only 75% of the mature rainbow had spawned for the first time as 5-, 6-, or 7-year-old trout (Table 18).

Both Pend Oreille rainbow trout and their parent stock were known to spawn more than once in their lifetime (Table 20). Cartwright (1961) describes a rainbow population in Kootenay Lake (1941-1960) in which as

Table 17. Comparison of average back-calculated length at annulus in cm (inches) for rainbow trout from Pend Oreille Lake, Idaho, for samples collected 1983-1984, a subsample of 1972-1976 data and Anderson (1978).

Sample		Age class 1	2	3	4	5	6
This study	cm	7.8	17.0	33.4	46.0	58.1	67.2
1983-1984	in	3.1	6.7	13.1	18.1	22.9	26.4
	(N)	(490)	(472)	(400)	(285	(70)	(18)
Subsample	cm	8.0	16.2	31.8	44.0	58.5	63.1
(Pratt 1984)	in	3.2	6.4	12.5	17.3	23.0	24.8
1972-1976	(N)	(61)	(53)	(39)	(26)	(16)	(4)
Anderson (1978)	cm	8.0	14.3	28.9	43.4	62.5	77.9
1972-1976	in	3.2	5.6	11.4	17.1	24.6	30.7
	(N)	(378	(375	(329	(258	(163)	(40)

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Table 18. Estimated minimum catch of rainbow and the portion of the catch classified as trophy (> 17 inches, 43 cm) and subtrophy (<17 inches, 43 cm).

Year	Total rainbow	Trophy rainbow	Percent catch trophy	Percent catch subtrophy
1960	9,626	1,380	14	86
1961	5,355	873	16	84
1962	6,556	1,136	17	83
1963	10,323	1,442	14	86
1964	4,942	870	18	82
1965	4,763	1,141	24	76
1966	4,978	1,040	21	79
1967	3,349	767	23	77
1968	4,169	832	20	80
1969	3,297	889	27	73
1970	4,419	1,105	25	75
1971	4,462	892	20	80
1972	3,384	880	26	74
1973	4,422	663	15	85
1974	4,337	737	17	83
1975	3,671	1,101	30	70
1976	5,868	1,643	28	72
1977	5,861	1,524	26	74
1978	6,878	1,754	25	75
1979	10,133	2,381	23	77
1980	8,157	2,292	28	72

Table 19. Comparison of age at first spawning of native rainbow trout aged from samples collected during the 1972-1976 and 1983-1984 fishing seasons from Pend Oreille Lake, Idaho, and Kootenay Lake rainbow.

Time period		Age at first spawning				
	N	3	4	5	6	7
PEND OREILLE						
1972-1976 (Anderson 1978)	Number 132		2	24	80	26
	Proportion		1%	18%	61%	20%
	Sam. 6-7				----- 81%-------	
	Sam. 5-7			--------- 99%----------		
1983-1984 This study	Number 59	3	11	13	22	10
	Proportion	5%	19%	22%	37%	17%
	Sam. 6-7				----- 54%-------	
	Sam. 5-7			--------- 76%----------		
KOOTENAY LAKE						
1942-1957 Cartw right (1961)	Number	-	-	-	-	-
	Proportion	-	4%	------92%---------		4%
	San. 6-7	-	-	-		
	Sam. 5-7	-	-	--------- 96% ----------		

+Table 20. Number of the trophy (>17 in, 43 cm) rainbow trout collected frail Pend Oreille Lake, 1972-1976 and 1983-1984, and the number and proportion of the population that spawned at least once, and proportion that had more than one spawning mark. Data used for 1972-1976 from Anderson (1978).

Year	Total rainbow sample > 43 cm	Total number >1 spawn mark	Proportion >1 mark	2 marks	3 or 4 marks
1972[a]	75	42	56	24	12
1973[a]	80	22	28	9	4
1975	43	4	9	2	0
1976	124	25	20	5	3
Total 1972-76	322	93	29	10	5
Total 1983-84	432	59	14	2	0

[a]Sample is biased toward larger fish.

much as 45% of the sport catch over 14 inches were trout at least 6 years old and had spawned once. Anderson (1978) reports 29% of the rainbow trout over 17 inches, collected fran Pend Oreille Lake, had spawned at least once. As many as 50% of the mature rainbow trout, collected between 1972-1976, had spawned more than once (Anderson 1978). Several of the rainbow Anderson (1978) describes had spawned three and four times.

Rainbow trout which had spawned more than once were uncommon in 1983-1984 in the Pend Oreille Lake sport catch. Less than 14% of the fish over 43 cm (17 inches) had spawned, and only 2% had spawned twice (Table 20). Although the comparative data should be interpreted with caution, a change in the composition of the rainbow trout population is implied. This apparent shift toward earlier maturity, and the reduction of kelts (fish spawning more than once), may imply a declining potential for a self-sustaining sport fishery in Pend Oreille Lake.

Maturity and migration year. Rainbow trout age at maturity seems to be related to age at emigration fran the stream. The relationship between slow growth during early life and late maturity has been documented in other areas. Excessive mortality during stream residence could reduce the proportion of the rainbow population emigrating as 2 or 3 year olds and in turn the production of late maturing fish. Although the proportion of the rainbow population in each migration class (1972-1976) was not available for comparison, the predominant migration class of the late maturing fish seemed to be 2 year .olds during the 1970s and 1983-84.

The effect of the stream fishery on the composition of the trophy rainbow trout population should be evaluated. I n 1970, a creel census of Lightning Creek indicated 53% of the wild rainbow trout harvest were 2 years old and 42% were 3 years old. Only 79% of the rainbow aged from the lake 1983-1984 had emigrated as 3-year-old fish, while 63% had emigrated as 2-year-old fish. I n 1983-84 low densities of age 1 and older rainbow trout were noted in all the tributaries to Pend Oreille, including Lightning Creek. The sport fishery harvest in nursery streams could be selectively removing older Juvenile rainbow and effectively reducing age at maturity.

Genetic composition. Kootenay Lake stocks still predominate the gene pool of Pend Oreille trophy rainbow trout. However, some introgression with both domestic coastal strains of rainbow and westslope cutthroat trout has occurred. The genetic evaluation implied, but could not confirm, the presence of more than one spawning stock (Dr. Fred Allendorff pers. comm.). In order to clarify if there are streams which maintain rainbow trout with a higher percentage of genes from the Kootenay Lake stocks than other streams, the genetics of Juvenile trout in several nursery areas should be assessed.-

Stream Population

Spawning. Attempts should be made to confirm the location of rainbow trout spawning areas. The use of fry distribution provides a generalized distribution rather than specific information on spawning

sites. An attempt should be made to count rainbow trout redds or spawning adults to escapement or relative numbers of spawners from year to year.

Numbers of adult rainbow spawners have been recorded for several Pend Oreille tributaries (Goodnight and Reininger, 1978). Spawners were observed in 1976 and 1977 in the Pack River, Grouse, Rapid Lightning, North Fork Grouse, and Lightning creeks. Total spawning escapement was estimated between 200 and 300 adult rainbow (Goodnight and Reininger, 1978). In 1976-1977, at least one-third to one-half of the spawners were observed in Lightning Creek. The most complete trend information concerning spawning rainbow was available for Spring Creek (Table 21). The number of spawners observed in Spring Creek seems to have declined over the past 10 years.

Rearing. Juvenile rainbow trout use of middle and lower reaches of many tributaries in the Pend Oreille basin was similar to distributions of steelhead rainbow trout stocks within the Salmon drainage (Platts, 1979; Thurow, 1983). Cartwright (1961) reports the highest densities of Gerrard strain rainbow fry in the upper reaches of the Lardeau River. Considering the size of the Lardeau River and its position between two lakes, the area can be considered similar to the larger, lower stream reaches used in the Pend Oreille basin used by juvenile rainbow.

High densities of young-of-the-year rainbow trout were localized, but over a larger area than reported for 1983. Rainbow young-of-the-year were observed in Lightning Creek at densities >20/100 m^2 from slightly below Wellington Creek to the mouth of Morris Creek. Large numbers of rainbow fry were seen when water was present in the intermittent section of Lightning Creek, between Cascade and Morris creeks, during the fall of 1983. This same region was dry in 1984.

Young-of-the-year rainbow trout have been known to migrate downstream in large numbers from the North Fork of Grouse, Spring, and Lightning creeks (Goodnight and Reininger, 1978). This may be a mid-summer dispersal mechanism or an emigration to the lake.

The relative abundance of Juvenile rainbow trout was greatly effected by the emergence and dispersal of rainbow fry. Trends in relative abundance, based on snorkeling data, including fry, should be interpreted carefully. More precise measures of abundance in areas critical to rainbow production would be more useful to a comprehensive management program.

Spawning habitat quality. Estimated sury ival of rainbow trout in both Grouse and Spring creeks was similar (40-60%) even though the substrate compositions were quite different. Survival estimates were based on the percent fines less than 6.35 mm diameter.

Table 21. Number of adult rainbow spawners observed during miscellaneous years between 1954 and 1984 in Spring Creek, a tributary to Pend Oreille Lake, Idaho.

	Observed number of spawners	Redd count	Citation
1954	40	-	Jeppson 1955
1955	15[a]	-	Jeppson 1955
1956	44	-	Jeppson 1956
1953-1958	30-60	-	Jeppson 1960
1976	12	-	Goodnight 1978
1977	29-34	-	Goodnight 1978
1980	2	-	Thompson 1984
1981	-	18	Thompson 1984
1982	-	-	Thompson 1984
1983	-	23	Thompson 1984
1984	8	13-18	Thompson 1984

[a]Observation one day early in the spawning run. More fish are expected.

These data may be too general. A more refined technique, comparing several gravel sizes, should be used next year if appropriate sieves (0.85 mm) can be obtained. Although attempts were made to estimate percent composition of the substrate 0.85 mm in diameter, the method, as described by Shepard and Graham (1982), was unsuccessful. Gravel composition is assumed to be log-normal in natural situations. In Spring Creek gravels have been added and the f l ow regulated, altering the normal substrate composition and precluding the use of standardized methods to estimate the percentage of intermediate substrate size classes.

Stream rehabilitation. The stream cleaning project conducted in Spring Creek during 1984, exposed more gravels and reduced the amount of fines >0.063 mm (suspendable fines). The survival of rainbow trout was not significantly different (= .05), but estimated minimum egg-to-fry survival increased from 26 to 52% after clean up.

The evaluation of the stream rehabilitation project should be designed differently in the future. Pre- and post-rehabilitation sampling should be done in the area to be cleaned. In 1984, samples were collected along transects, and only portions of those transects were cleaned.

Bull Trout

Status of Lake Population

Growth rates. Estimated growth rates for bull trout in the Pend Oreille drainage were higher than those reported for other drainages (Table 22).

Bull trout spawned for the first time as 4-, 5-, and 6-year-old fish. Some bull trout in the Pend Oreille basin spawn every other year. Bull trout in the Flathead drainage spawn 6 year olds (Leathe and Graham, 1982).

During this study, and in past Idaho Department of Fish and Game reports, "small" bull trout were observed in the spawning beds. Jeppson (1953) calls these fish jacks or precocial males. Small, mature bull trout were not commonly observed in the Flathead River basin (Shepard et al., 1983). Males matured at a small size In their natal streams before migrating to a larger river in the Clearwater basin of Alberta (Allen, 1980).

Population composition. Bull trout seem to be recruited to the trophy fishery as 4- or 5-year-old fish. Annual mortality is high, ranging from 47-82%. The mortality of bull trout associated with the spawning

Table 22. Bull trout growth (mm) in various waters (adapted from Leathe and Graham (1982).

		Total length (cm) at annulus								
		I	II	III	IV	V	VI	VII	VIII	
Pend Oreille Lake	mm	9.1	16.4	27.2	40.3	49.7	57.8	-	--	--
1983-1984	(n]	(169)	(167)	(164)	(135]	(66)	(12)			
Flathead Lake										
Leathe and Graham (1982)	mm	6.8	13.0	20.4	29.2	38.4	47.2	56.7	65.8	73.1
	(n)	(929)	(929)	(926)	(851)	[601)	(290)	(102)	(28)	(4)
Block (1955)	mm	7.6	15.0	23.4	33.5	45.7	56.6	69.1	78.0	--
	(n)	(80)	(51)	(44)	(43)	(41)	(31)	(15]	(1)	--
Rohrer (1963)	mm	7.1	14.0	20.8	32.3	45.2	59.4	72.4	87.6	--
	(n)	(289)	(289)	(289]	(245)	(203]	(80)	(14)	(1)	--
North and Middle Fork	mm	7.2	10.8	14.0						
Flathead tributaries	(n)	(196)	(97)	(16)						
Fraley at al. (1981)										
Middle Fork Flathead	mm	4.8	9.7	17.4	28.6	38.9	48.4	57.5	63.6	--
River	(n)	(122)	(83)	(41)	(31)	(31)	(29)	(14)	(3)	--
Fraley et al. (1981)										
Hungry Horse Reservoir	mm	7.2	14.4	22.5	32.4	42.9	51.3	59.4	67.1	--
1953 and 1972	[n)	(212)	(212)	(185)	(130)	(60)	(28)	(5)	(3)	--
Huston (1974)										
Lake Koocanusa	mm	6.7	12.3	21.2	30.9	39.0	48.2	51.8	--	--
May at al. (1979)	(n)	(162)	(162)	(157)	(96)	(37]	(11)	(1)	--	--
Priest Lake	on	7.1	11.4	18.3	31.0	42.4	51.6	60.5	--	--
BJornn (1961)	(n)	(61)								
Upper Priest Lake	mm	6.6	10.2	15.5	23.9	35.8	46.2	54.6	61.2	--
BJornn (1961)	(n)	(41)								

run may be quite high due to the length of time bu l l trout are easily accessible in small streams. Illegal harvest of spawners holding in streams is difficult to estimate, but probably contributes to the high rate of total annual mortality.

Status of Stream Population and Habitat

Spawning areas. Bull trout spawn in a small portion of the accessible tributaries of the Pend Oreille drainage. The key areas in the Pend Oreille system could be monitored from year to year with very little effort to assess the status of bull trout population in the lake. Similar monitoring programs are conducted successfully in other drainages, including North and Middle Fork of the Flathead and the Swan Lake drainages (Shepard and Graham, 1983; S. Leathe, Montana Department of Fish, Wildlife, and Parks, pers. comm.).

Bull trout spawning escapement should be done by counting bull trout redds during the first two weeks of October. Bull trout redds could be counted in sections of the Pack River, Grouse, Wellington, Rattle, East Fork Lightning, Savage, Char, Porcupine, Twin Johnson, Granite, North Gold, South Gold, and Trestle creeks in 12 man days. It is important to count as many areas as possible each year since the relative importance of each stream may vary from year to year.

Bull trout redds were not located in the Clark Fork River and Rapid Lightning Creek. Bull trout have been caught by sportsmen in Rapid Lightning Creek, but no redds were observed in 1983 or 1984. Helmer (1965) counted bull trout redds in the Clark Fork River along the spawning channel. No redds were located in the Clark Fork River in 1984.

Many bull trout in the Pend Oreille system probably enter tributary streams early in the year when flows are still high, particularly in the Lightning Creek drainage. In the tributaries of the Lightning Creek drainage, spawning was observed above seasonally dry sections of streams. I n the Pend Oreille, 37% of the bull trout redds were above seasonal ly dry sections of stream in 1983. I n 1984, a much dryer year, only 18% of the bull trout redds were located above seasonally dry sections of stream. In the Flathead, bull trout rarely move above seasonally dry areas (Pratt, 1984).

Estimates of bull trout spawning escapement were similar in 1983 and 1984. The number of spawning bull trout per unit area of Pend Oreille Lake was comparable to similar measures for Flathead Lake, but an order of magnitude less than Swan Lake (Table 23). In the Swan Lake system there was sane evidence that estimates of 2 fish per redd may be more appropriate for that drainage than the 3.9 fish per redd derived for the Flathead River basin. To ensure an accurate escapement estimate, the number of adult bull trout per redd could be determined for the Pend Oreille drainage.

Table 23. Comparison of adfluvial bull trout population densities in Pend Oreille Lake, Idaho; Flathead Lake, Montana; and Swan Lake, Montana.

Drainage	Surface area of lake (km^2)	Number of redds	Year	Fish[a] redd	Estimated escapement	Adult density
Pend Oreille	383	881	1984	3.9	3,436	9.0/km^2
Pend Oreille	383	814	1983	3.9	3,175	8.3/km^2
Flathead[b]	477	1,300	1982	3.9	5,070	10.6/km^2
Swan	10.1	220	1982	3.9	858	84.9/km^2
		260	1983	3.9	1,014	100.4/km^2

[a]Estimate from Fraley et al. 1981.
[b]Number of redds expanded from actual counts of monitoring area.

Rearing. Juvenile bull trout were found in the upper and middle reaches of accessible streams. Bull trout were found in the upper reaches of other drainages, such as the St. Joe and Salmon River drainages (Mauser, unpub. data; Thurow, 1983; Partridge and Plans, 1983). In contrast, the distribution of bull trout in the Flathead was not limited to upper reaches, and in some areas, relatively high densities of Juvenile bull trout were found in the lower stream reaches (Fraley et al., 1983; Shepard et al., 1984).

At the sites where bull trout were present in the Pend Oreille system, their densities were within the range of values seen in the Flathead and Priest Lakes systems (Mauser and Horner, 1982; Shepard et al., 1982).

Spawning habitat quality. The streambed composition in spawning areas of South Gold and Twin creeks were similar to bull trout spawning areas described for Coal Creek in the Flathead system (Shepard and Graham, 1982). Those authors felt that bull trout spawning areas in Coal Creek were significantly impacted by sediment.

Bull trout egg-to-fry survival declines rapidly as fines >6.35 mm in diameter exceed 30% (Weaver and White, 1983). In the Pend Oreille spawning sites sampled, the percent fines >6.35 mm averaged 34-37%, and estimated egg survival was less than 50%.

Since approximately 125 bull trout redds were observed in South Gold during 1983 and 1984, and the percent fines present in the stream were at a level impacting bull trout survival, every effort should be made to prevent additional sedimentation in the drainage.

Cutthroat Trout

Status of Lake Population

Cutthroat trout were historically abundant in the Pend Oreille drainages. Jeppson (1960) observed that cutthroat were the most abundant native salmonid, and that, historical ly, more cutthroat were taken annually than any other trout species. Today, cutthroat trout are less abundant in the sport catch than rainbow or bul I trout.

Westslope cutthroat trout growth rates were higher in the Pend Oreille than other drainages (Table 24). Growth rates of Pend Oreille fish were calculated with the assumption that all fish formed scales their first year. In many westslope cutthroat trout populations, this is not the case. Data were not available to substantiate whether or not cutthroat in the Pend Oreille drainage form an annulus the first year.

Age composition and mortality estimates for cutthroat trout were not possible this year due to a small sample of representative lengths.

Table 24. Calculated mean total lengths of westslope cutthroat trout from various western streams in Idaho and Montana (adapted from Lukens 1978).

Location	Number of fish	Computed mean length at each annulus (cm) 1	2	3	4	5	6
Pend Oreille Lake 1983-84	84	8.3	14.8	26.1	35.8	--	--
Wolf Lodge Creek (Lukens 1978)	324	7.3	11.1	13.6	18.5	--	--
Hungry Horse Creek (Huston 1969, 1971, 1972, 1974a)	1,239	7.3	12.1	16.2	--	--	--
Young Creek (May and Huston 1974)	92	4.9	10.9	16.0	--	--	--
St. Joe River tributaries (Averett 1963)	161	7.2	14.2	21.6	--	--	--
St. Joe River (Rankel 1971)	347	5.2	9.1	14.3	19.2	24.3	29.1
Priest and Upper Priest Lake tributaries (BJornn 1957)	232	8.5	12.9	17.1	20.1	25.4	--
North Fork Flathead River tributaries (Johnson 1963)	106	5.8	11.4	17.8	21.6	24.4	30.2
Main rivers of Flathead R. drainage (Johnson 1963)	559	5.6	11.9	19.6	28.7	33.3	37.8
Salmon River (Mallet 1963)	474	6.0	10.0	17.4	25.4	32.2	37.1
Kelly Creek (Johnson 1977)	208	6.6	10.1	15.3	21.2	25.1	30.6

Cutthroat are known to hybridize with rainbow where the two species are present (Behnke, 1971). Cutthroat-rainbow integration was confirmed during analysis of rainbow trout genetic composition (Leary et al., 1984; Appendix D).

Status of Stream Populations and Habitat

Spooning

Adfluvial cutthroat trout spawning areas are poorly defined in the Pend Oreille system today. In the past, Idaho Fish and Game reports indicated that cutthroat were prevalent and spawned throughout the drainage (Jeppson, 1955).

Rearing

Cutthroat were widespread in the drainage during 1983. However, in areas which could be used by adfluvial cutthroat trout, densities were low in the Pend Oreille system in comparison with other adfluvial cutthroat and rearing areas (Lukens, 1978; Fraley et al., 1983; Shepard et al., 1984).

The low densities of juvenile cutthroat in accessible streams during 1983 and the declining cutthroat trout harvest i n the Pend Oreille drainage points toward a declining cutthroat trout population. Cutthroat trout populations have declined in other areas due to habitat loss, angler harvest, and hybridization (Rankel, 1971; Behnke, 1979).

Anglers seek cutthroat trout in both Pend Ore it l e Lake and its tributaries. The maintenance of adf I uv ial cutthroat stocks is important to both of these user groups. The anglers in the Clark Fork and Sandpoint areas were concerned about the cutthroat harvest, and supported restrictive regulations in the Lightning Creek drainage (Idaho Fish and Game files). In contrast, over) imits of as many as 35 cutthroat were reported in 1984 by IDFG personnel. The fishery in tributaries to Pend Orei l l e Lake have not been re-evaluated for over 10 years. Cutthroat harvest from tributary streams, angler opinion, and fishing regulations should be reviewed.

Cutthroat-rainbow hybrids were evident in the streams as well as the lake. During snorkel ing surveys, a 'zone, of cutthroat-rainbow integration was evident in many tributary streams.

Spawning Habitat Quality

Cutthroat trout egg-to-fry survival was calculated for all areas where streambed composition was sampled in 1984. Similar trends were observed between survival rates of cutthroat trout eggs and Juvenile trout densities. In Twin and South Gold creeks, very few Juvenile cutthroat were seen, and egg survival was estimated between 8-32%. In 3rouse Creek below the North Fork, very few cutthroat were seen, and

survivals of 17-29% were estimated. In Spring and upper Grouse creeks, where some juvenile cutthroat were observed, cutthroat egg survivals were estimated to be 34-65%.

The poor quality of cutthroat trout spawning habitat could be impacting the distribution and relative abundance of cutthroat trout in the Pend Oreille system.

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APPENDICES

Appendix A. Differences between the USFS and IDFG field techniques for hollow coring streambeds.

There were four differences in the field techniques used by USFS and IDFG personnel during the collection of hollow core data. Each of the four issues are described below.

1. Diameter of the core

USFS used a hollow core sampler that was 12 inches in diameter. This corer permitted the sampling of most size substrate without any problems. It also provided the potential for a larger sample size, and, therefore, minimized possible biases (Platts et al. 1983) .

IDFG used a 6-inch diameter hollow core sampler. The 6-inch corer sampled most sizes of substrate in the spawning areas without problems. The sample size usually approximated 20 lbs, an optimum weight to minimize sample bias (Platts et al. 1983). The smaller diameter sampler was easier to use because it was smal ler and was designed with several extra features a larger sampler would have to do without due to the size and weight handl ing limitations of a larger sampler.

2. Depth of the core sample

The substrate composition changes and fines increase as you go deeper into the substrate (Platts et al. 1983). In order to permit the best comparisons from place to place and year to year, cores should be collected down to the same depth. Since fish lay their eggs under 6 inches or more of streambed materials, and samples were to be used to estimate embryo survival, cores should have included the upper 6 inches of the streambed. The IDFG core had a metal flange 6 inches from the bottom of the core to help standardize the depth of the core.

3. Measurement of suspended fines

The USFS poured all the mirky water in the corer into an Imhoff cone-permitting the water to overflow. Only the heaviest fines were sampled with this method. The IDFG method permitted a sample of water to stand for 20 minutes, thus, measuring most of the fines in the sample. Then the volume of water in the core was calculated, and the amount of fines within the corer was estimated. Both methods are an approximation of fines.

4. Number of samples per transect

USFS collected two cores per transect.IDFG collected three cores per transect. Both agencies had a replicated sample.The more replicates, the more statistical power the sample has. The three samples collected by IDFG gave the data more statistical power, and partially compensated for the small sample volume.

Processing three small samples did not' take that much longer than processing two large samples due to the limitations of the sieve and shaker equipment used.

Appendix B1. Volume of water (liters) related to depth of water (cm) within the McNeil-Ahnell hollow core sampler (Shepard and Graham 1982).

Depth of water (cm)	Volume of water (1)	Depth of water (cm)	Volume of water (1)
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[a]	41.13

[a]Top of corer.

Appendix B2. Stream flow at time of hollow coresampling forstreambed analysis in selected Pend Oreille tributaries, 1984.

Stream	Date	Flow (cfs)	Site
Spring Creek	8-23-84	2.69	B(1)[a]
Spring Creek	8-23-84	18.30	A(1)[b]
Twin Creek	8-24-84	5.69	B(2)
Grouse Creek	8-25-84	11.18	A(1)
South Gold Creek	8-26-84	12.81	A(3)

[a]Spawning channel.
[b]Above confluence of spawning channel and below hatchery return flow.

Appendix Cl. Data summary used to estimate mortal ity of the rainbow trout population in Pend Oreille Lake, 1983-1984.

	Age composition					
	1983		1984		1983 and 1984	
Age	Percent a m	Natloa	Percent age	Natlog	Percent age	Natloq
1	5.7	1.7	4.8	1.6	5.3	1.7
2	16.5	2.8	21.9	3.1	19.2	3.0
3	23.3	3.1	37.6	3.6	30.4	3.4
4	20.4	3.0	18.2	2.9	19.3	3.0
5	17.6	2.9	11.5	2.4	14.5	2.7
6	11.6	2.5	5.3	1.7	8.4	2.1
7	4.8	1.6	0.5	0.7	2.6	1.0

Appendix C2. Summary of rainbow trout length frequency data collected by sportsmen and used to construct age composition and mortality estimates for Pend Oreille Lake, 1983-1984.

Length class		83 summer earlier than 9/15	83 fall 9/16-11/30	84 summer earlier than 9/15	84 fall 9/16-11/30
inches	cm				
8-10	20-25		2		
10-12	25-30		13	1	7
12-14	30-35		3	11	6
14-16	35-40	1	13	27	5
16-18	40-45	1	5	24	9
18-20	45-50	5	2	19	8
20-22	50-55	12	6	17	7
22-24	55-60	16	8	12	7
24-26	60-65	12	10	12	3
26-28	65-70	12	11	10	2
28-30	70-75	8	8	6	3
30-32	75-80	8	5	5	3
32-34	80-85	3	5	6	-
34-36	85-90	3	3	1	1
36-38	90-95	1	-	0	
Season total		82	94	151	61
Yearly total		176		212	

Appendix D.

ELECTROPHORETIC COMPARISON BETWEEN TROUT COLLECTED FROM PEND OREILLE LAKE AND KOOTENAY LAKE RAINBOW TROUT

Robb F. Leary
Fred W. Allendorf
Stevan R. Phelps
and
Kathy L. Knudsen

Department of Zoology
University of Montana
Missoula, Montana 59812

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ABSTRACT

We have conducted an electrophoretic analysis of Salmo collected from Pend Oreille Lake, Idaho, to determine if there is any evidence that these fish contain genetic variation not present in the Duncan River and Kootenay Lake, British Columbia, rainbow trout (Salmo gairdneri). The data indicate that 4% of the genetic material in the sample is derived from westslope cutthroat trout (Salmo clarki lewisi). In addition, many alleles of rainbow trout origin in the Pend Oreille Lake sample were not detected in a domestic broodstock derived from the Duncan River population or in a sample from Kootenay Lake. Thus, the fish in Pend Oreille Lake almost certainly also contain rainbow trout genetic material not derived from the Duncan River or Kootenay Lake populations. Approximately 75% of the genetic material in the Pend Oreille Lake population is estimated to be derived from Kootenay Lake rainbow trout.

INTRODUCTION

Rainbow 1-rout, Salmo gairdneri, were originally introduced into Pend Oreille Lake, Idaho, in 1942 and 1943 (Karen Pratt, pers. comm.). These introductions used the progeny of individuals collected from a natural spawning run from Kootenay Lake into the Duncan River, British Columbia. Whether or not the current population in Pend Oreille Lake still represents genetically 'pure, Duncan River rainbow trout or contains genetic material from other sources is unknown.

We have conducted an electrophoretic analysis of fish collected from Pend Oreille Lake to determine if there is any evidence that they contain genetic variation not present in the Duncan River. The data indicate that 4% of the genetic material in the sample is derived from westslope cutthroat trout, Salmo clarki lewisi. In addition, we detected many alleles of rainbow trout origin in the sample that we have not detected in a domestic broodstock founded from fish collected from the Duncan River or in a sample from Kootenay Lake. Thus, it is extremely likely that the fish in Pend Oreille Lake also contain rainbow trout genetic material not derived from the Duncan River or other Kootenay Lake populations.

METHODS

Tissue samples were obtained from 56 fish caught from Pend Oreille Lake by anglers during the summer of 1984. Horizontal starch gel electrophoresis (Utter et al. 1974) was used to assay the products of 46 protein loci (Table 1) in muscle, liver, and eye homogenates from all fish. Electrophoretic buffers and staining procedures were after Allendorf et al. (1977). The designation of loci and alleles follows the nomenclature outlined by Allendorf et al. (1983).

The protein products of the Aat3,4, Mdhl,2, Mdh3,4, and Me3,4 loci in rainbow trout are still functionally duplicated. That is, they show no evidence of structural or regulatory divergence so that allelic variants cannot unambiguously be assigned to individual loci of each pair. We treated these four pairs to be single tetrasomic loci to estimate allele frequencies.

RESULTS AND DISCUSSION

Presence of westslope cutthroat trout genetic material

The protein products of the Aatl, Ck2, Gpi3, ldh3, Mel, and Sdh loci can be used to differentiate the rainbow and westslope cutthroat trout (Leary et al. 1984). We detected the presence of westslope cutthroat trout genetic material at all of these loci in the Pend Oreille Lake sample (Table 2). No individual was homozygous for the westslope cutthroat trout alleles or heterozygous at all of these loci. Thus, no individual had a genotype characteristic of a ‘pure’ westslope cut-

throat trout or a first generation hybrid. The sample, therefore, came from an introgressed population containing 96% rainbow trout genetic material and 4% westslope cutthroat trout genetic material averaged over the six diagnostic loci.

Rainbow trout allelic variants not detected in the Duncan strain or Kootenay Lake

We have previously analyzed rainbow trout from Kootenay Lake, British Columbia (N=30) and from the Duncan strain (Phelps and Allendorf 1980, N=33). The Kootenay Lake fish were caught by anglers during the summer of 1982. The deficit of heterozygotes (P<0.005) at Ldh4 in the Kootenay Lake sample indicates that it most likely contains individuals from two or more genetically divergent populations. The Duncan strain is a domestic population derived from no more than 20 individuals collected from the Duncan River in 1971 and 1972, shortly before the natural population became extinct due to the construction of a dam (Peter Brown, pers. comm.). The broodstock is maintained at the Kootenay Trout Hatchery, Wardner, British Columbia. Our sample was obtained from this hatchery in March, 1980.

We detected 10 alleles of rainbow trout origin in the Pend Oreille Lake sample that were not detected in the Duncan strain sample (Table 2). This indicates that either these alleles were present in the Duncan River rainbow trout 40 years ago and have since been lost, or that the Pend Oreille Lake population contains genetic material from other rainbow trout populations.

We expect that the Duncan strain has lost some al I el is variants that existed in low frequency (<0.10) in the natural population because of the relatively small number of individuals used to found the broodstock. The high frequency of the Ldh4 (100) allele (0.429) in the Pend Oreille Lake sample and its absence from the Duncan strain, however, is not likely the result of this founder effect. Even with a founding population size of two, alleles originally present at a frequency of 40% w it l be lost only 13% of the time, and with a founding population of size five they will be lost only 1% of the time. Thus, we believe that the loss of genetic variation from the Duncan strain is not likely the sole explanation for the existence of variants in the Pend Oreille population not detected in the strain. More likely this difference is largely indicative of the presence of genetic material from other rainbow trout populations in the Pend Oreille Lake fish. The absence of eight alleles of rainbow trout origin, detected in Pend Oreille Lake from the Kootenay Lake sample (Table 2), adds further support to this conclusion. This difference also indicates that genetic material from sources other than Kootenay Lake population is present in the Pend Oreille Lake population. These sources are very likely

domestic broodstocks since the Idh2(140), Mdh3,4(83), and Sodl(152) alleles commonly exist in frequencies greater than 0.20, and the Ldh4(100) allele in frequencies greater than 0.90 in many domestic populations of rai nbav trout (Allendorf 1975; Leary and Allendorf 1982a,b; Leary et al. 1983a,b).

The frequencies of the ldh2(140), Mdh3,4(83), and Sodl(152) alleles can be used to obtain a rough approximation of the proportion of the genetic material in the Pend Oreille Lake population that is derived from domestic broodstocks. Comparison of the allele frequencies in the Pend Oreille Lake sample to the maximum frequency we have observed in a domestic broodstock provides a minimum estimate of this parameter. These comparisons indicate that at least 14% of the genetic material in the Pend Oreille Lake population at ldh2 and Mdh3,4, and 19% at Sod1 is derived from domestic broodstocks. The average of these estimates (16%) and the presence of westslope cutthroat trout genetic material (4%) suggest that, at most, only 80% of the genetic material in the Pend Oreille Lake population is derived from Kootenay Lake rainbow trout.

Since it is not possible to determine what domestic broodstocks have contributed genetic material to the Pend Oreille Lake population, the best estimate of their proportional contribution is obtained by using the average frequency of the alleles we have observed in domestic broodstocks. These comparisons indicate that domestic broodstocks have contributed 27% of the genetic material in the Pend Oreille Lake population at ldh2 and Sodl, and 33% at Mdh3,4. Thus, only about 70% of the genetic material in the Pend Oreille population is probably derived from Kootenay Lake rainbow trout.

The Salmo in Pend Oreille Lake spawn in a number of tributaries suggesting that more than one population may exist in the lake. The genotypic proportions at all of the variable loci in our sample, however, conform to random mating proportions. Furthermore, at those variable loci at which more than one copy of an allelic variant was detected, we observed a slight excess of heterozygotes seven times and a slight deficit four times. Thus, if genetically different populations inhabit Pend Oreille Lake, these data indicate that only small allele frequency differences exist among them suggesting that it is very unlikely that any of these would be genetically pure Duncan River or Kootenay Lake rainbow trout.

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Appendix D. (continued)

Table 1. Enzymes and loci examined (E=eye, L= I aver, M=muscl e).

Enzyme	Loci	Tissue
Adenylate kinase (AK)	Akl,2	M
Alcohol dehydrogenase (ADH)	Adh	L
Aspartate aminotransferase (AAT)	Aatl,2	L
	Aat(3,4)	M
Creatine kinase (CK)	CkI,2	M
	Ck3, CkCI,2	E
Glucosephosphate isanerase (GPI)	Gpi 1,2,3	M
Glyceradlehyde-3-phosphate dehydrogenase (GAP)	Gap3,4	E
Glycerol-3-phosphate dehydrogenase (G3P)	G3pI,2	L
Glycyl-leucine peptidase (GL)	GI1,2	E
Isocitrate dehydrogenase (IDH)	Idhl,2	M
	Idh3,4	'L
Lactate dehydrogenase (LDH)	LdhI,2	M
	Ldh3,4,5	E
Leucyl-glycyl-glycine peptidase (LGG)	Lgg	E
Malate dehydrogenase (MDH)	Mdh(1,2)	L
	Mdh(3,4)	M
Malic ensyme (ME)	Mel,2	M
	Me(3,4)	L
Phosphoglucanutase (FGM)	Pgml,2	M
	Pgml-t	L
6-Phosphogluconate dehydrogenase (6PG)	6Pg	M
Sorbitol dehydrogenase (SDH)	Sdh	L
Superoxide dismutase (SOD)	Sodl	L
Xanthine dehydrogenase (XDH)	Xdh	L

Note: The protein products of the pairs of loci in ( ) are electrophoretically identical in rainbow trout, and, therefore, are considered to be single tetrasomic loci in all analyses.

Appendix D. (continued)

Table 2. Electrophoretic variation in Salmo collected from Pend Oreille Lake, Idaho, and rainbow trout from the Duncan strain and Kootenay Lake, British Columbia.

Locus	Alleles	Pend Oreille Lake	Duncan	Kootenay Lake
Aatl	100	0.904	1.000	1.000
	200[a]	0.096	--	--
Ck2	100	0.945	1.000	1.000
	84[a]	0.055	--	--
G3pl	100	0.991	1.000	1.000
	140	0.009	--	--
Gll	100	1.000	1.000	0.983
	115	--	--	0.017
Gp12	100	0.991	1.000	1.000
	120	0.009	--	--
Gpi3	100	0.973	1.000	1.000
	92[a]	0.027	--	--
Idh2	100	0.912	1.000	1.000
	140	0.088	--	--
ldh3	100	0.198	--	0.533
	114	0.044	--	--
	86[a]	0.018	--	--
	71	0.446	0.962	0.233
	40	0.294	0.038	0.233
Ldh3	100	0.955	1.000	1.000
	null	0.045	--	--
Ldh4	100	0.429	--	0.371
	76	0.571	1.000	0.629
Mdh3,4	100	0.845	0.900	0.900
	125	0.109	0.100	0.100
	83	0.036	--	--
	74	0.009	--	--
Mel	100	0.954	1.000	1.000
	115	0.018	--	--
	88[a]	0.028	--	--
Pgm2	100	0.973	1.000	0.984
	90	0.027	--	0.016

Appendix D. (continued)

Table 2. (Continued)

Locus	Alleles	Pend Oreille Lake	Duncan	Kootenay Lake
Sdh	100	0.964	1.000	1.000
	200	0.018	--	--
	40[a]	0.018	--	--
Sod(	100	0.937	1.000	1.000
	152	0.063		

[a]Alleles are derived from westslope cutthroat trout.

Appendix E. Summary of trout fry distribution and abundance data collected during the 1983-1984 field seasons in tributaries to Pend Oreille Lake, Idaho.

Stream	Date	(Fry/100 m²) Rainbow	Cutthroat	Unidentified salmo
Clark Fork drainage				
Twin Creek	8-15-84	103.1	--	
	8-15-84	2.3	0.8	--
	8-15-84	18.3	--	--
Johnson	8-13-84	0.8	--	--
Lightning	8-18-83	--	0.2	--
	8-18-83	--	1.5	--
	8-24-84	32.5	4.0	--
	8-9-83	2.6	--	--
	7-27-84	76.6	--	--
	8-22-83	0.2	--	--
	7-16-84	1.2	--	--
Spring Creek	7-10-84	10.7	--	33.1
	7-10-84	3.3	--	--
	7-18-84	--	--	68.3
Cascade	7-31-84	--	--	38.8
Morris	8-31-83	7.0	3.5	--
East Fork	8-22-84	2.8	--	--
Porcupine	7-31-84	--	--	0.2
Wellington	8-18-83	--	1.8	
Rattle	8-16-83	--	3.9	--
Pack River drainage				
Pack River	8-19-83	--	--	5.3
	8-23-83	1.2	--	--
	8-23-83	51.5	--	--
	7-25-84	115.6	--	--
	7-25-84	42.3	--	--
Trout Creek	8-16-83,	--	--	17.4
	8-15-84	--	2.9	--
Rapid Lightning	8-1-84	103.2	--	--
	8-1-84	--	--	0.2
Grouse	8-15-83	--	--	136/251
	7-24-84	7.5	--	--
	8-6-84	60.6	--	--
	8-9-84	47.3	--	--
North Fork Grouse	8-24-84	92.3	--	--
	8-9-84	101.7	--	--
	8-6-84	118.5	--	--
	8-25	28.2	0.6	
Sand	8-25-83	--	1.1	
Berry	8-30-83	6.8	1.7	--
Col burn	8-24-83	3.1	0.8	--

Appendix E. (Continued)

Stream	Date	(Fry/100 m²) Rainbow	Cutthroat	Unidentified sal mo
Caribou	8-30-83	--	3.9	
	8-30-83	3.9	1.3	
Hell roaring	8-17-83	3.3	--	
Jeru	8-17-83	--	--	14.8
Youngs	8-17-83	--	3.4	
Eastside tributaries				
Granite	8-14-84	26.2	--	--
North Gold	8-12-83	--	14.5	--
South Gold	8-26-84	2.9	--	--
West Gold	8-12-83	--	--	11.5

Appendix F. Summary of fish distribution and relative abundance (fish/100 m^2j data collected during the 1983 and 1984 fielc seasons in tributaries to the eastern end northern shores of Pend Oreille Lake, Idaho.

Stream	Reach	Date	Water Temp. ° C	Unidentified salmo	Rainbow	Cutthroat	Brown trout	Unidentified salvetinus	Bull trout	Brook trout	Other	Total
Eastside tributaries												
Falls		9-7-83	9.5	-.-	-.-	-.-	-	-.-	-.-	2.3	-.-	2.3
Cedar		9-7-83	12.0				-			5.8	-.-	5.8
Granite		8-14-84	9.5	2.8	2.1	1.4	-	0.7	5.5	-.-	-.-	12.5
		8-27-83	12.0	-.-	14.4	2.0	-	-.-	7.6	-.-	-.-	24.0
		9-7-83	8.5	-.-	0.5	1.8	-	-.-	1.6	-.-	-.-	3.7
		8-14-84	14.0	-.-	33.4	0.4	-	-.-	0.9	0.4	-.-	35.1
		8-14-84	9.0	1.5*	41.2	0.7	-	-.-	5.9	0.4	2.2	51.9
Sullivan Springs		8-14-84	8.0	-.-	6.2	-.-	-	-.-	1.1	-.-	2.6	9.8
North Gold		8-12-83	9.0			55.6						55.6
		8-8-84	8.0	1.2	-.-	0.6	-	-.-	0.6	-.-	-.-	2.4
		8-8-84	8.0	0.6	1.1	-.-	-	-.-	5.0	-.-	-.-	6.7
South Gold		8-2$-84	8.5	-.-	2.9	2.3	-	-.-	5.2	-.-	-.-	10.4
		8-8-84	11.0	-.-	5.5	1.1	-	-.-	8.8	-.-	5.5	20.9
		8-12-83	11.0	2.1	-.-	-.-	-	-.-	2.8	-.-	-.-	4.9
		8-8-84	11.0	0.8	2.0	2.3	-				0.5[a]	5.6
West Gold		8-12-83	8.0	-.-	-.-	43.1	-	-.-	-.-	-.-	-.-	43.1
Northside tributaries												
Trestle		8-11-83	11.0				-					0.0
		7-17-84	10.0	0.8	2.2	-.-	-	-.-	7.3	-.-	-.-	10.1
		7-17-84	9.0	-.-	-.-	3.4	-	-.-	5.0	-.-	-.-	8.4
		8-16-83	12.0	-.-	-.-	1.5	-	-.-	1.5	-.-	-.-	3.0
Tributary		7-17-84							17.3	-.-	-.-	17.3
Tributary		7-17-84	10.0	-.-	-.-	-.-	-					0.0
Tributary		7-17-84	10.0				-					0.0
Sandpoint Creek		9-6-83	15.0	4.4	4.4	2.9				23.3	19.0[103]	54.0
Spring Jack		8-24-83	15.0									0.0
Schweitzer		8-6-83	10.0	1.3	15.4	3.8	-	-.-	-.-	5.1	-.-	25.6
Little Sand		9-6-83	11.0	1.0	10.1	1.0						12.1
		9-6-83	11.0	6.7	15.7	17.9						40.3
Riser		7-18-84	12.0	-.-	-.-	1.2	-	-.-	-.-	-.-	-.-	1.2
Strong		7-18-84	11.0	-.-	-.-	13.5	-	-.-	-.-	-.-	-.-	13.5

[a]Mountain whitefish
[b]Sucker squawfish

Appendix F. Summary of fish distribution and relative abundance (fish/100 n2) data collected during the 1983 and 1984 field seasons in tributaries to the Clark Fork River, Pend Oreille drainage, Idaho.

Stream	Reach	Date	Water Temp. ° C	Unidentified salmo	Rainbow	Cutthroat	Brawn trout	Unidentified salvelinus	Bull trout	Brook trout	Other	Total
Clark Fork tributaries												
Mosquito		730-84	9.0	1.3[a]	2.6	2.6	-			13.2	-	19.7
		7-30-84	13.0		1.7	-				33.0	.3	35.0
Twin[a]		8-15-84	13.0		120.8	2.4	3.6		1.2	7.1	-	135.1
		9-8-83	11.0		92.8	1.5			4.6	128.1	-	274.6
		8-15-84	13.0		47.2	-	44.6		-	26.2	-	118.0
		9-8-83	10.0		56.0	9.7	34.1		17.0	204.4	-	321.2
		8-15-84	11.0		16.0	0.8	5.4		2.3	44.3	29.8	98.6
		7-18-84	13.0	1.8	10.2	2.4	3.0		2.4	32.3	2.4	54.5
Johnson		8-13-84	7.5		1.2	7.7	-		1.2	-	-	10.1
		8-31-83	10.0		2.6	0.6			4.5	-		7.7
Lightning	Quartz	8-18-83	10.0			2.2						2.2
	Pools	7-27-84	14.0	0.4*		3.5			2.1		1.8	7.8
	Above Rattle	8-18-83	12.5	0.2	4.0	5.0			0.2	0.2	-	9.8
		8-24-84	14.5	0.5	35.3	4.2		0.2	1.9	0.5	0.2	42.8
	Porcupine											
		8-9-83	15.0		2.6	-			0.2	0.1	-	2.9
		7-27-84	19.0		72.6=fry 1.8=Juv.	0.2			1.2	0.7	0.4	76.9
		8-24-84	17.0		85.4	1.4				0.5	-	87.3
		8-22-83	15.0		8.9	-				0.4	0.5[a]	9.8
		7-16-84	18.0		4.7					2.3	1.8	8.8
		7-16-84	18.0		3.8					-	1.5	5.3
Spring	Run	7-10-84	11.0		77.0+	1.4		-				78.4
	Pool	7-10-84	11.0		18.2	2.2	0.3			0.2	1.8	22.7
Spawning channel		7-18-84	9.5	33.1	31.0	-		18.2		-	-	82.3
Cascade	Web Canyon	7-31-84	14.0	42.8	7.8	1.9				25.2	-	77.5
Morn's		8-31-83		1.8	14.1	6.2			-			22.1
East Fork		7-19-84	12.0	0.8*	2.2	2.2			16.1			21.1
		7-19-84	12.0	3.3 *		3.3			13.6			20.2
		8-9-83	-	1.2	4.4	1.2			4.8	0.6	0.6[c]	12.8
		8-22-84	14.0		8.8	1.8			1.8	0.6	0.3[c]	13.3

Appendix F. (Continued)

Stream	Reach	Date	Water Temp. ° C	Unidentified salmo	Rainbow	Cutthroat	Brown trout	Unidentified sal vet inus	Bull trout	Brook trout	Other	Total
Charr		7-19-84	9.0	1.2*	1.2	0.6			8.0			11.0
Savage		8-31-83		1.2	3.3	4.6			0.4			9.5
		7-19-84	12.0		3.2				1.9	-		5.1
Porcupine		7-31-B1	13.0							13.0	-	13.0
		7-31-84	13.0							18.8	-	18.8
		8-10-83	14.0	1.1	2.5	1.4			1.4	0.4	0.3°	7.1
		731-84	14.0	1.6	1.8	0.8			7.1	-	0.8	12.1
Wellington		7-27-84	14.0	0.5*	0.3	12.8					0.3°	13.9
		8-18-83	12.0	-	2.1	2.4			2.1	2.1	-	8.7
		7-26-84	14.0	0.5*	1.9	0.3			2.9	1.1	1.6[a,c]	8.3
Rattle		8-5-83	-			3.1						3.1
		8-16-83	10.0		-	51.8						51.8
		8-18-83	11.0			8.4			3.0	-		11.4
	Pool	7-26-84	13.0			.17.3			14.4	-		31.7
	Run	7-26-84	14.0			5.0			6.2	-		11.2
		8-9-83	-	0.8	2.8	-						3.6
		7-26-84	16	-	1.3				2.4	-	0.3°	4.0
Banning Mt. tributary		7-26-84	13°			12.2						12.2

°Mountain whitefish
[b]Sucker/squawfish
°Sculpin
*Cutthroat /rainbow hybrid
+Difficult to distinguish between rainbow and cutthroat fry

Appendix F. Summary of fish distribution and relative abundance (fish/100 m^2) data collected during the 1983 and 1984 field season in the Pack River and its tributaries, Pend Oreille drainage, Idaho.

Stream	Reach	Date	Water Temp. ° C	Unidentified selmo	Rainbow	Cutthroat	Brown trout	Unidentified salvelinus	Bull trout	Brook trout	Other	Total
Pack River drainage												
Pack River		8-17-83	11.0	0.3	0.3	6.7	--	--	--	--	--	7.3
		8-19-83	16.0			11.6	--	--	2.4	--	--	14.0
		7-25-84	12.5	0.7		7.0	--	--	3.5	--	--	11.2
		8-19-83	16.0	--		14.8	--	--	2.2	--	--	17.0
		8-29-83	15.0	--	19.2	0.2	--	--	--	0.2	1.0[a]	20.6
		8-23-83	15.0	--	55.3	0.4	--	--	--	0.7	9.3[b]j[c]	65.7
		7-25-84	22	--	121.2		--	--	--	0.2	15.1[d]	136.5
		7-25-84	15-22	--	45.4	0.1	--	--	--	--	7.5[b]	53.0
Trout		8-15-84	-	--	-	0.6	--	--	--	--	--	0.6
		8-16-83	14.0	41.9		2.3	--	--	--	--	--	44.2
Rapid Lightning		8-25-83	15.0	--	0.4	7.3	--	--	--	0.7	1.1[a]	9.5
		8-1-84	21.0	2.0	42.7	3.0	--	--	--	1.0	7.9	56.6
		8-1-84	21.0	--	110.9		--	--	--	0.4	13.4	124.7
Gold		9-8-84	15.0	---	1.1		--	--	--		13.9[a]	15.0
Grouse				--			--	--				
		7-24-84	15.0		1.0	3.8			5.4	0.3	-	10.5
		8-15-83	10.0	--	63.4	--	--	--	0.8	-	--	64.2
		8-15-84	15.0	--	18.9	--	--	--	0.2	0.6	1.2	20.9
		8-6-84	18.0	--	67.2	--	--	--	--	1.0	0.5	88.7
		8-9-84	19.0	0.5	56.6	--	--	--	--	0.6	2.7[f]	60.4
		8-15-83	22.0	--	38.4	0.2	--	--	--	-	1.6[f]	40.2
North Fork		8-24-84	10.0	--	99.0	--	--	0.7	--	4.2	2.1	1 83.0
		8-25-83	15.0	--	53.2	0.6	--	--	--	0.4	1.1[a]	55.3
		8-9-84	19.0	--	110.4	--	--	--	--	3.0	-	113.4
		8-6-84	-	--	126.4	--	--	--	--	1.2	0.6	128.2
Plank		7-24-84	14.0	0.7[*]	--	5.0	--	--	--	--	--	5.7
Chute		7-24-84	14.0	--	--	24.6	--	--	--	--	--	24.8
Sand		8-25-83	12.5	--	5.4	8.6	--	--	--	42.9	-	56.9
		8-25-83	15.0	--	--	--	--	--	--	--	32.0	32.0

Appendix F. (Continued)

Stream	Reach	Data	Water Temp. ° C	Unidentified salmo	Rainbow	Cutthroat	Brown trout	Unidentified salvelinus	Bull trout	Brook trout	Other	Total
Berry		8-30-83	15.0	--	12.5	4.0	--	--	--	1.1	--	17.8
Colburn		8-24-83	12.5	--	5.1	0.8	--	--	--	0.3	--	B.2
Caribou		8-30-83	13.0	--	4.4	12.7	--	--	--	--	--	17.1
		830-83	14.0	4.4	20.9	1.3	--	--	--	--	-	28.6
Hellroaring		8-30-83	14.0	--	9.8	--	--	--	--	--	--	9.8
Jeru		8-17-83	14.0	--	--	38.0	--	--	--		0.9 -	38.9
Youngs		8-17-83	18.0	--	--	32.2	--	--	--	--		32.2
McCormick		8-1-84	18.0	--	--	18.3	--	--	--			16.3
		8-17-83	17.5	--	--	0.9	--	--	--		-	0.9

[e]Mountain squawfish
[b]Squawfish/sucker
[c]Sculpin
[d]Unidentified fry/larval fish
[e]Redside shiners
(Mountain whitefish, squaw fish, sucker, sculpin

APPENDIX G

Distribution of bull trout redds within spawning tributaries in the Pend Oreille basin, Idaho (1983–1984).

Appendix G. Description of bull trout redd surveys in the Pend Oreille drainage, 1984, including distance surveyed, number of definite redds, number of "possible" redds, and number of adult bull trout seen on survey date.

Stream	Survey: Section descriptio	Survey: (km) distance	Survey: Date	Observation: Redd	Observation: Possible redds	Observation: Adult bull trout
CLARK FORK RIVER						
Lightning		1	9-29	9	0	0
Rattle		2.9[a]	10-18	32	13	2
		4.7	9-29	10	1	7
			9-20	1	1	3
Wellington		0.5[a]	9-29	18	1	0
		0.5	9-20	7	0	0
East Fork		7.0	9-29	24	8	1
Charr		1.2	9-29	9	4	0
Savage		2.8	9-29	12	4	2
Porcupine		4.0	9-29	52	8	3
Twin		1.5[a]	10-24	25	1	0
		3.2	9-26	16	0	5
Johnson		1.3	9-26	33	5	1
NORTHERN SHORE						
Pack River		6.1	9-27	37	13	2
Grouse		11.5	9-27, 10-3	108	13	11
		1.6	10-3,	6	4	0
		2.2	9-27,	39	6	0
		7.7	10-3	63	3	11
Trestle		10.0	9-21, 9-24, 9-25	272	24	71
		2.4	9-24	49	4	15
		3.1	9-21	175	11	47
		4.5	9–25	48	9	9
EASTERN SHORE						
Granite		7.8	9-28	81	16	1
Sullivan Springs		0.5	9-28	8	2	0
North Gold		1.2	10-1	37	3	4
South Gold		2.5[a]	10-16	124	12	12
		2.5	10-1	90	11	31

[a]Recount.

R9AD105DM

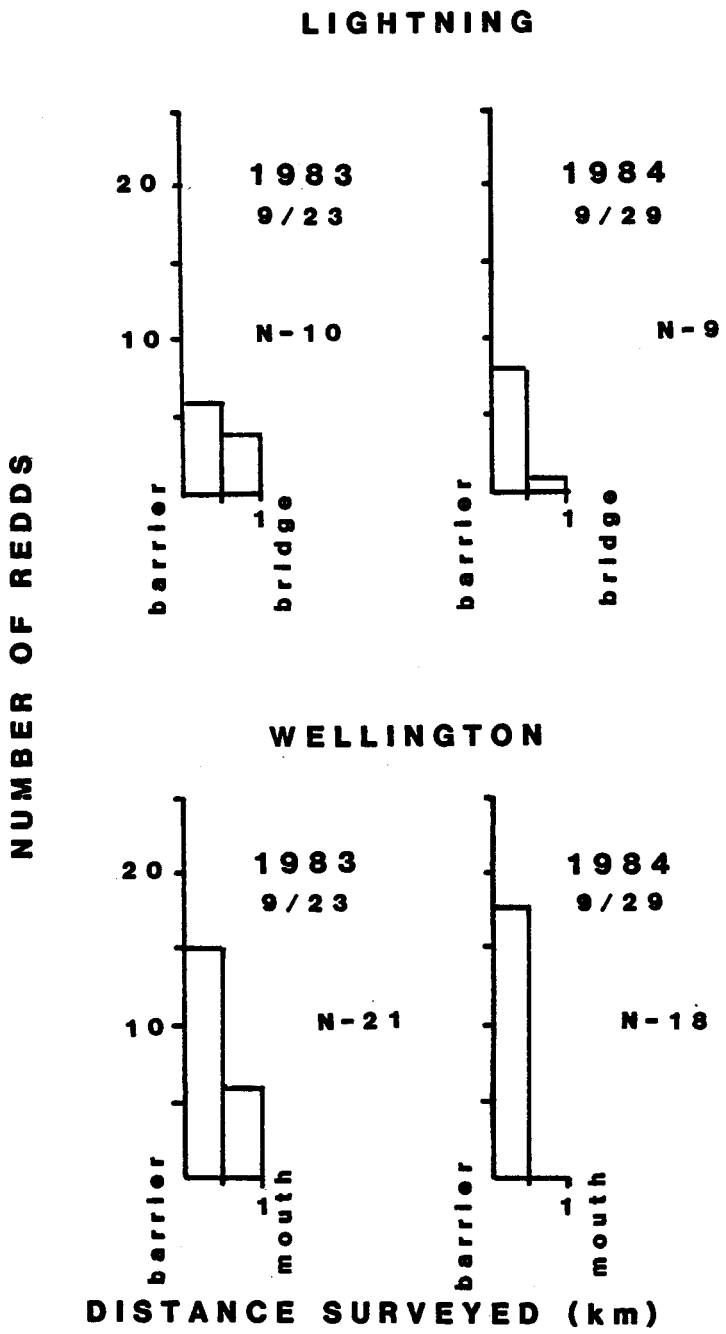

Figure G-1. Distribution of bull trout redds observed in Wellington Creek and upper Lightning Creek during the 1983 and 1984 spawning season.

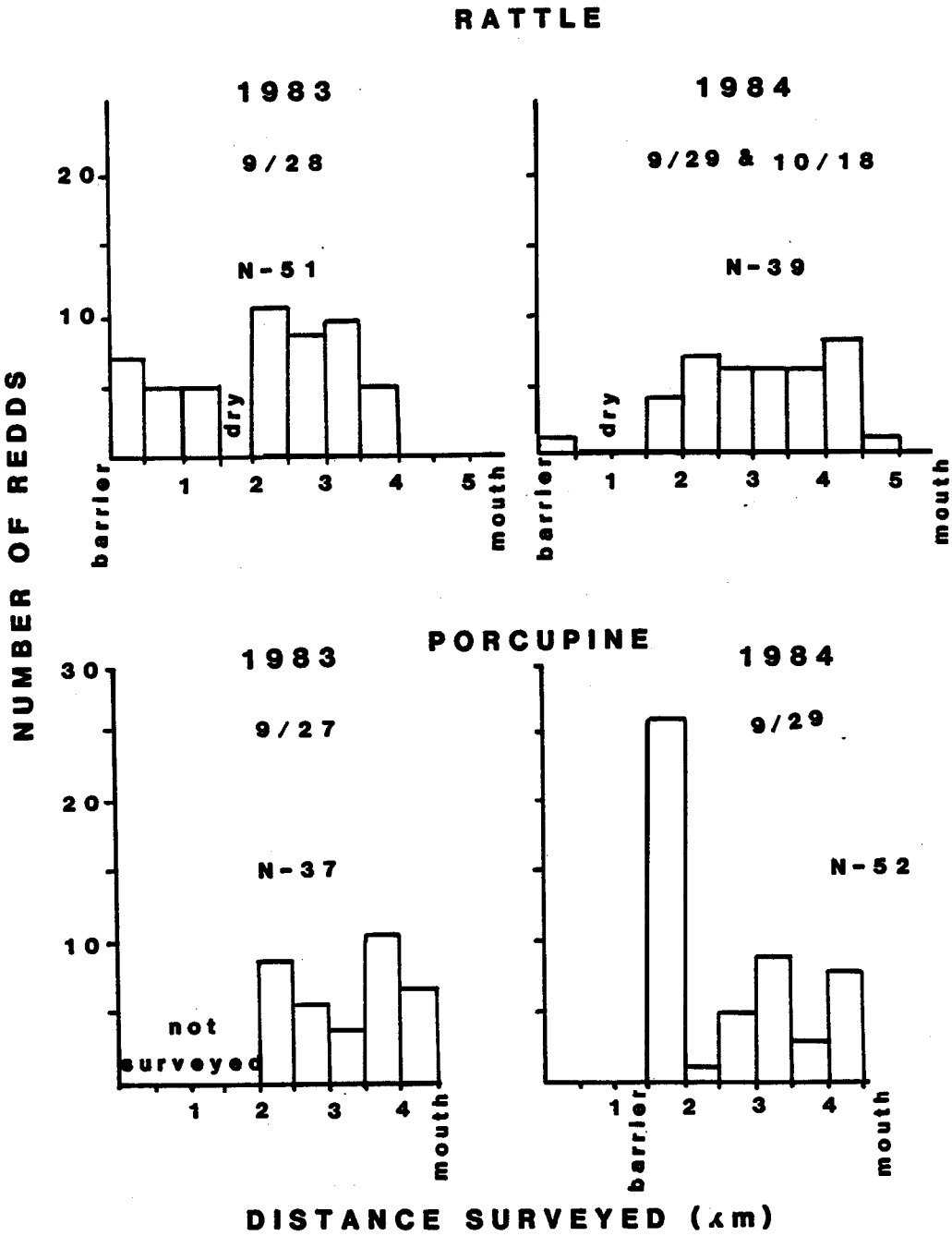

Figure G-2. Distribution of bull trout redds in Rattle and Porcupine creeks during the 1983 and 1984 spawning seasons.

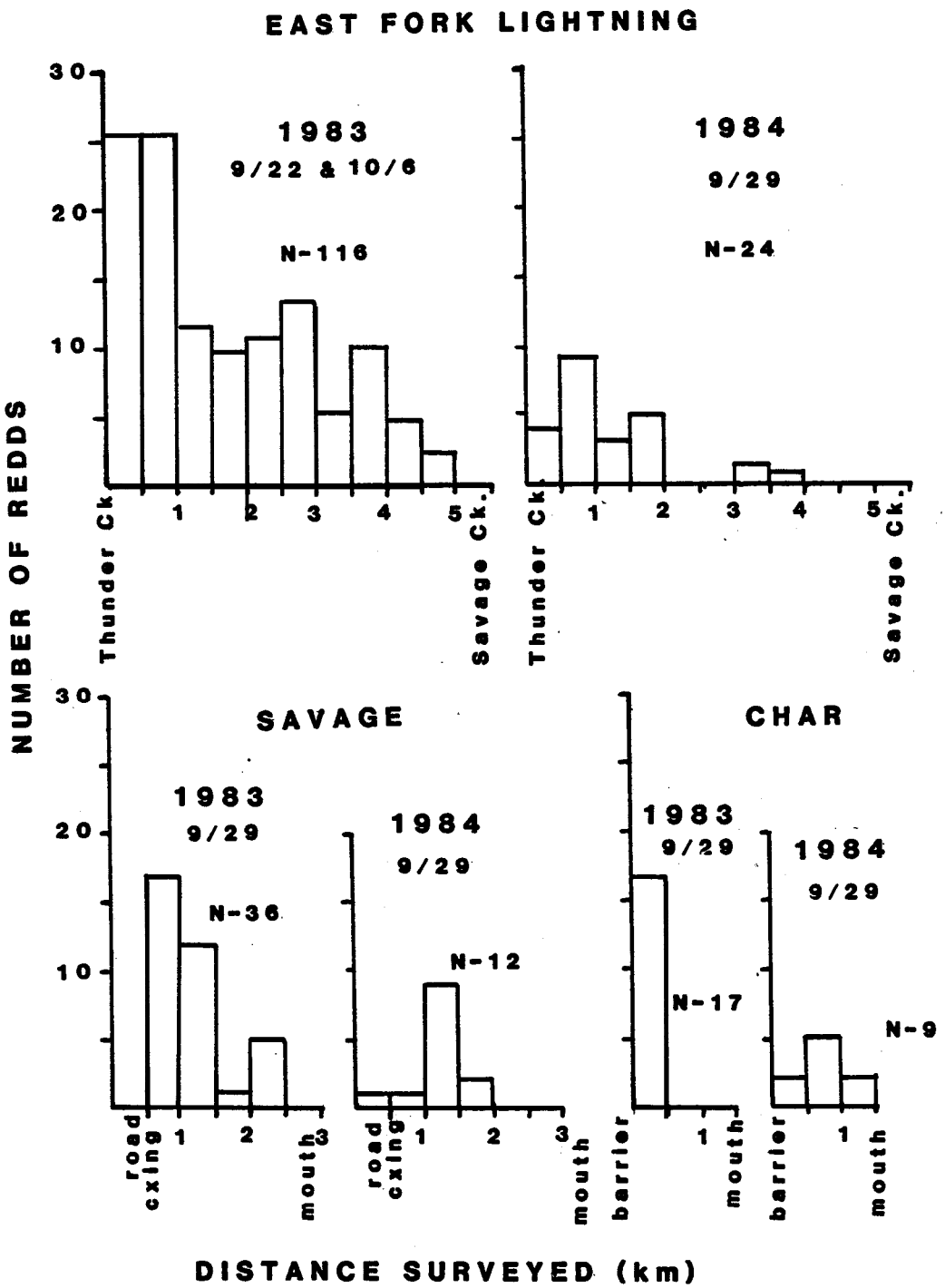

Figure G-3. Distribution of bull trout redds in the East Fork of Lightning and its tributaries, Savage and Char creeks, during the 1983 and 1984 spawning seasons.

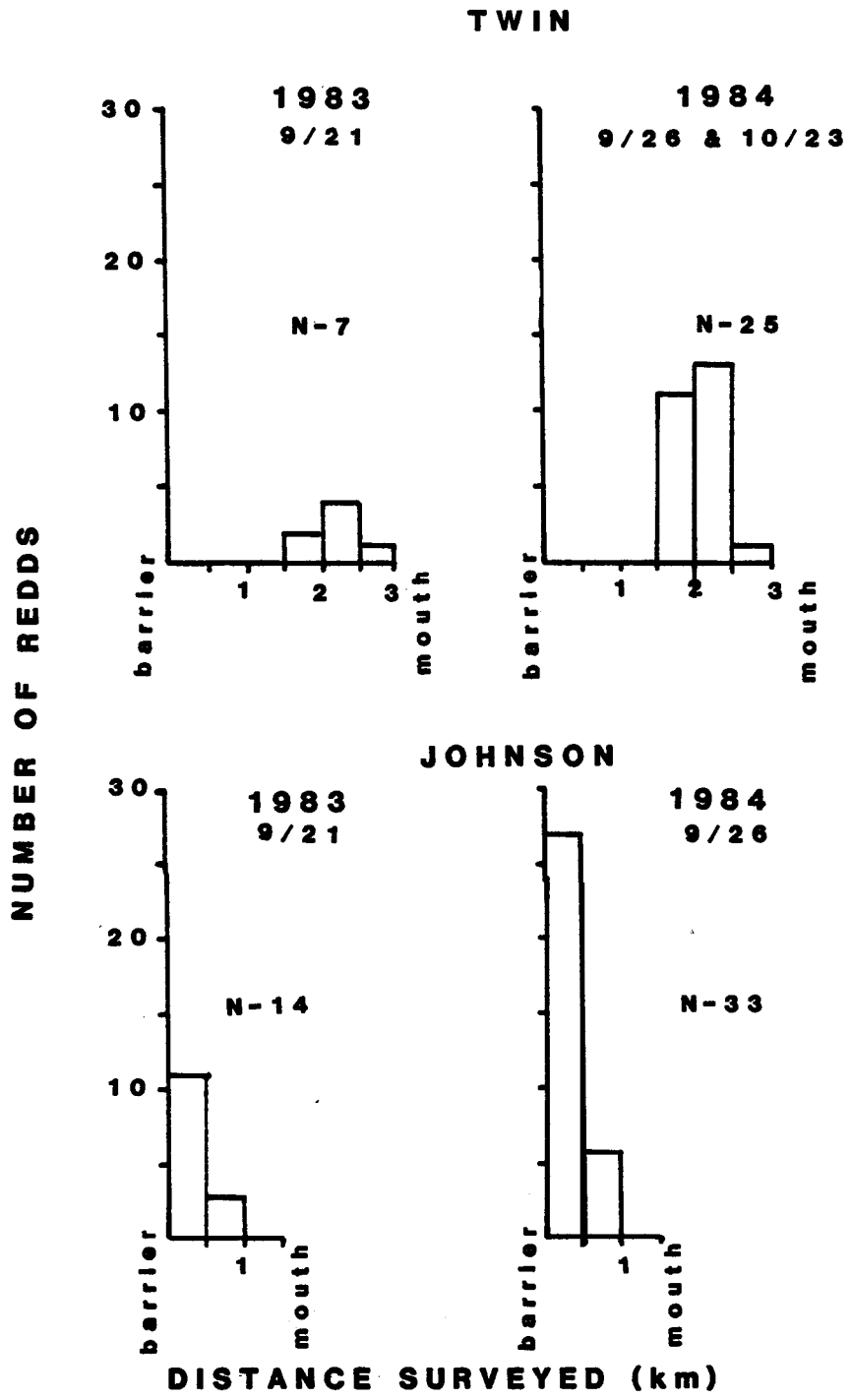

Figure G-4. Distribution of bull trout redds in Twin and Johnson creeks during the 1983 and 1984 spawning seasons.

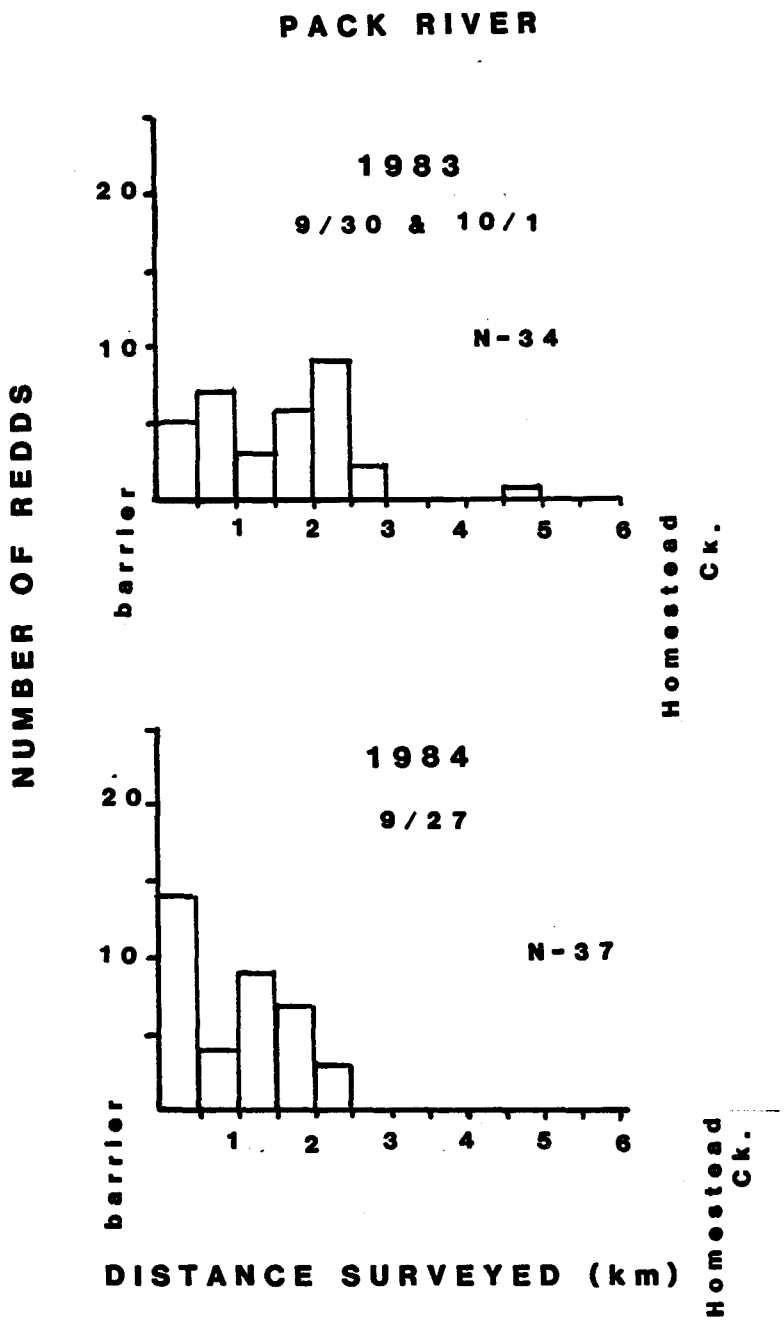

Figure G-5. Distribution of bull trout redds in the upper Pack River during the 1983 and 1984 spawning seasons.

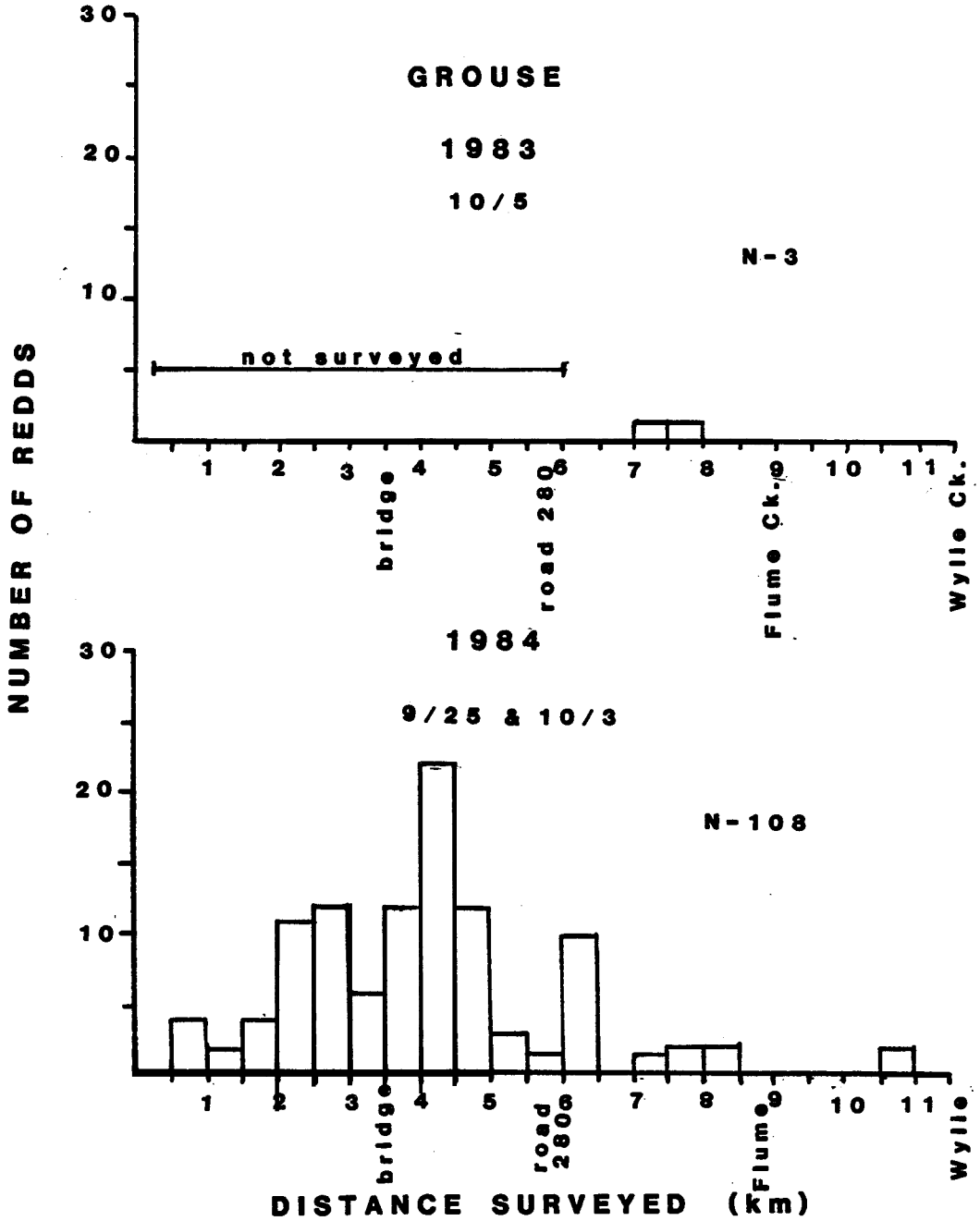

Figure G-6. Distribution of bull trout redds in Grouse Creek during the 1983 and 1984 spawning seasons.

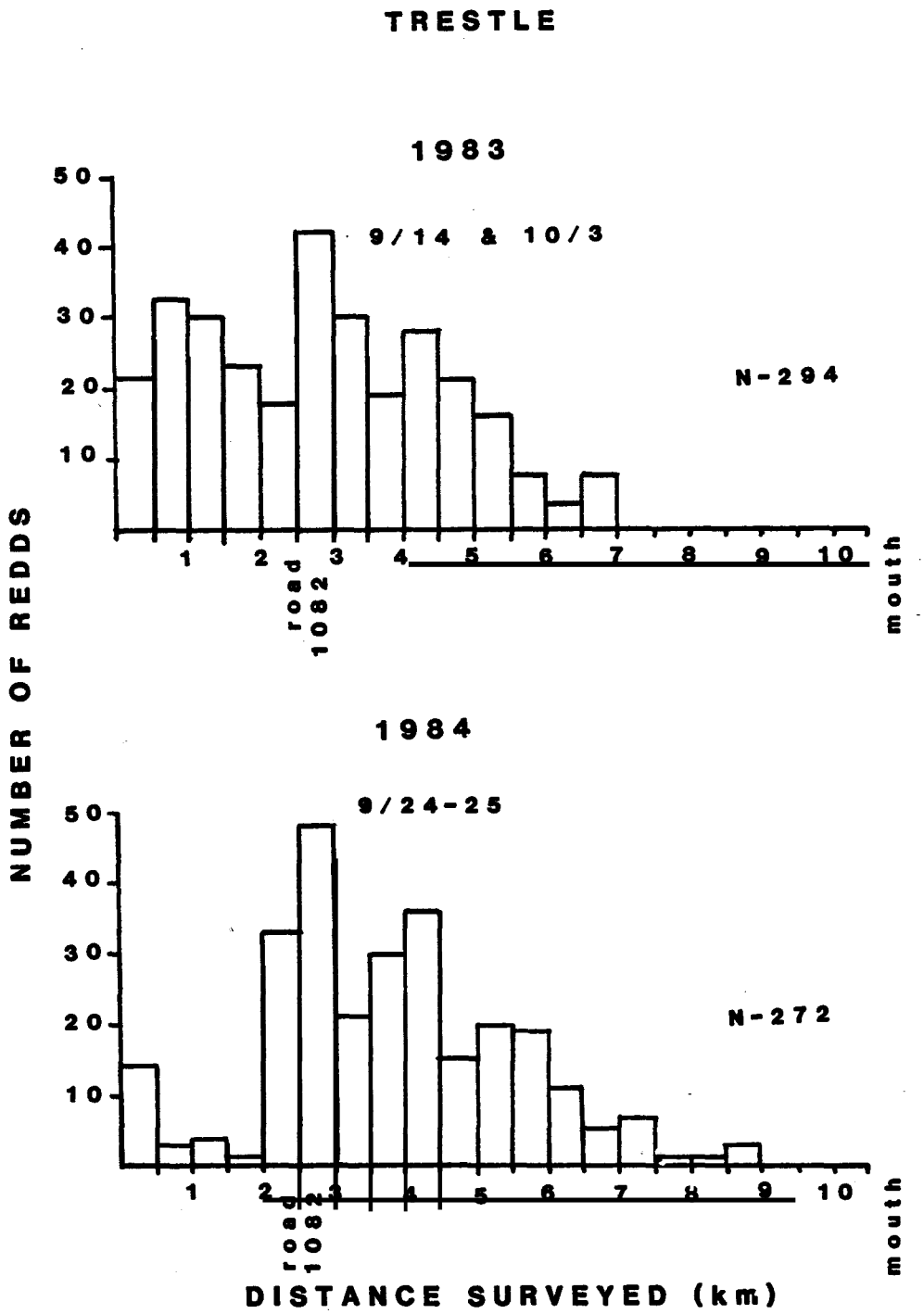

Figure G-7. Distribution of bull trout redds in Trestle Creek during the 1983 and 1984 spawning seasons.

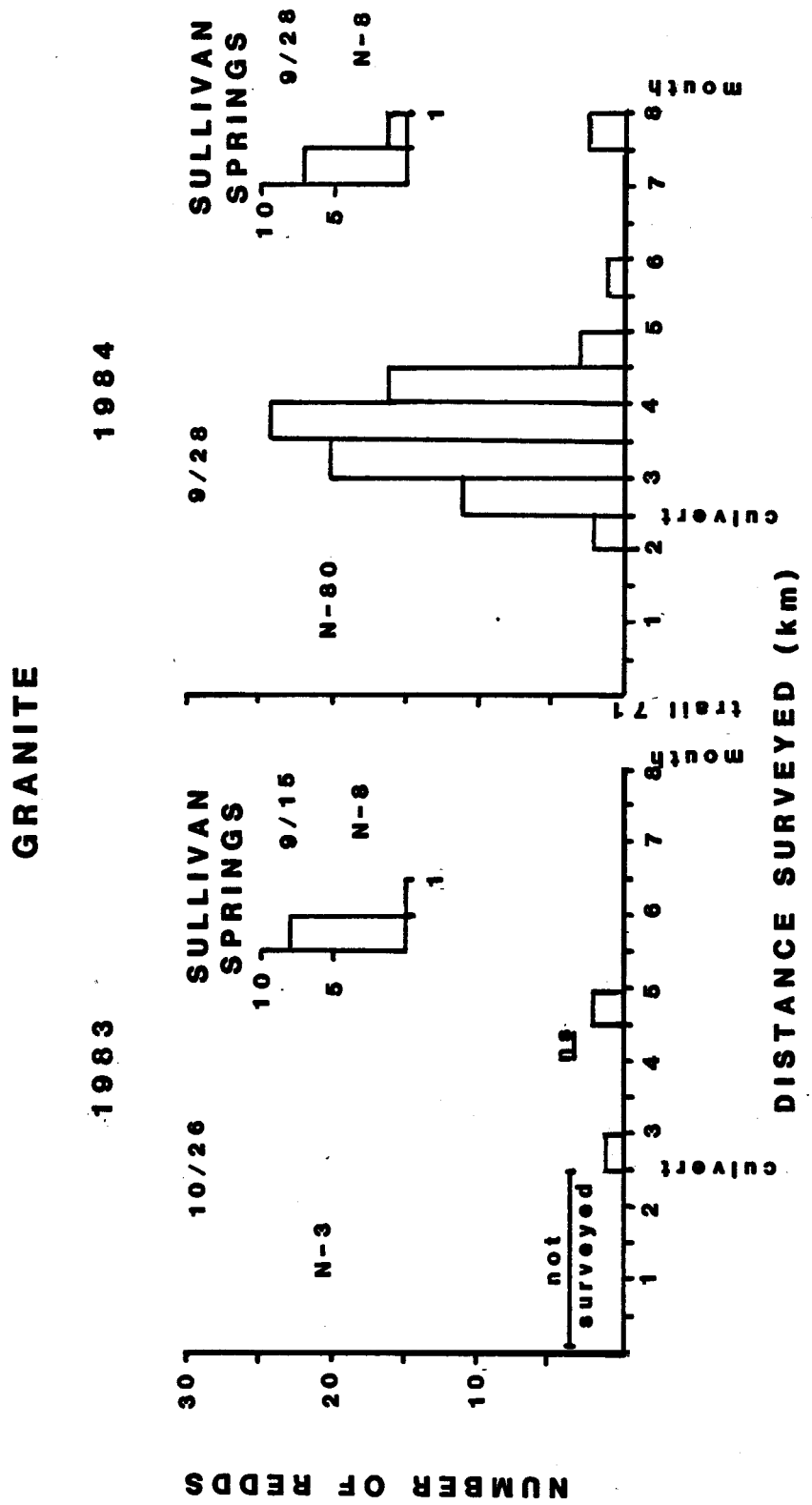

Figure G-8. Distribution of bull trout redds in Granite Creek and Sullivan Springs during the 1983 and 1984 spawning seasons.

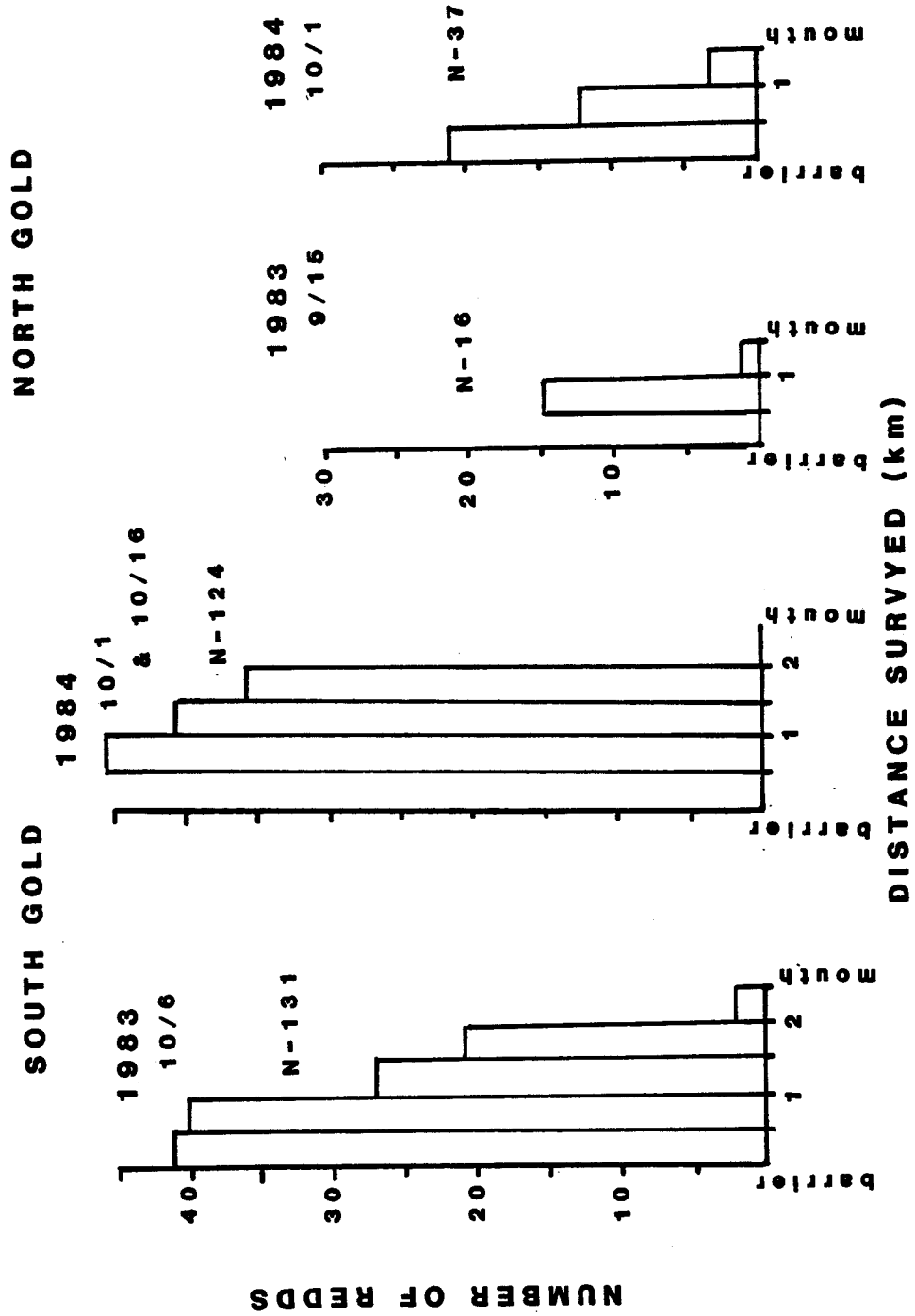

Figure G-9. Distribution of bull trout redds in the North Gold and South Gold creeks during the 1983 and 1984 spawning seasons.

Appendix H. Mean fork length in cm (inches) of each year class of Kootenay Lake rainbow trout from 1942 to 1957 inclusive. Determined by back calculation, using the method of Smith (1955), from scales of angler caught trout (Cartwright 1961).

Year class	Mean fork length (cm) at ages I to VII						
	I	II	III	IV	V	VI	VII
1942	7.06 (2.78)	20.8 (8.2)	30.1 (11.8)	40.9 (16.10)	53.9 (21.22)	68.3 (26.89)	78.0 (30.71)
1943	6.84 (2.7)	14.6 (5.75)	32.6 (12.8)	50.3 (19.8)	66.9 (26.33)	74.7 (29.4)	--
1944	5.70 (2.24)	12.2 (4.8)	27.4 (10.8)	45.7 (18.0)	58.2 (22.9)	--	--
1945	6.47 (2.55)	14.5 (5.7)	28.7 (11.3)	41.9 (16.5)	--	--	--
1946	5.97 (2.4)	12.1 (4.76)	25.6 (10.1)	41.9 (16.5)	59.4 (23.38)	--	--
1947	6.55 (2.6)	15.2 (6.0)	23.7 (9.3)	36.9 (14.53)	--	67.4 (26.53)	--
1948	6.03 (2.37)	15.1 (5.9)	29.1 (11.4)	52.8 (20.8)	--	--	--
1949	6.39 (2.5)	14.6 (5.75)	27.7 (10.9)	43.7 (17.2)	62.9 (24.76)	71.4 (28.11)	--
1950	6.46 (2.54)	15.2 (6.0)	29.2 (11.5)	41.5 (16.34)	66.5 (26.18)	79.5 (31.30)	--
1951	5.53 (2.18)	12.4 (4.88)	27.5 (10.8)	46.7 (18.38)	--	--	72.4 (28.5)
1952	5.77 (2.27)	12.2 (4.8)	27.7 (10.9)	44.2 (17.4)	56.0 (22.1)	68.6 (27.0)	--
1953	6.15 (2.4)	12.5 (4.9)	28.9 (11.38)	44.5 (17.5)	59.8 (23.54)	78.5 (30.9)	--
1954	6.33 (2.5)	13.5 (5.3)	29.2 (11.5)	48.0 (18.9)	61.8 (24.33)	--	--
1955	6.31 (2.5)	13.5 (5.3)	28.8 (11.34)	48.7 (19.2)	--	--	--

Appendix H. (Continued)

Year class	Mean fork length (cm) at ages I to VII						
	I	II	III	IV	V	VI	VII
1956	7.00 (2.8)	15.5 (6.10)	32.3 (12.72)	--	--	--	--
1957	7.31 (2.88)	17.4 (6.85)	--	--	--	--	--

Submitted by:

Karen L. Pratt

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Jerry M. Conley, Director

Monte R. Richards, Chief
Bureau of Fisheries

Virgil K. Moore
Resident Fisheries Manager