FOREST-WIDE FISHERIES MONITORING FLATHEAD

Prepared by:

Thomas M. Weaver

Montana Fish, Wildlife & Parks
Special Projects
490 N. Meridian Road
Kalispell, MT 59901

December 2005

Sponsored by:

USDA – Forest Service
Flathead National Forest

Montana Department of Natural Resources
and Conservation

Bonneville Power Administration

ABSTRACT

We have tracked spawning/incubation habitat quality, juvenile rearing habitat quality, juvenile abundance and spawner escapement annually for migratory fish populations inhabiting the interconnected Flathead System. Over the past 25 years, streambed core sampling results show fine sediment levels in spawning areas peaked around 1990, due to both natural and management-related sources and an extended period of drought. Flushing flows beginning in 1991 improved spawning gravel quality in most sampling areas, with the exception of Coal Creek. Lack of flushing associated with the current drought is evident in recent coring results. Bull trout spawning areas in Coal and Granite creeks are presently at or above the threatened threshold, while all four of the spawning areas utilized by spring spawning fish are at or above this level. The post Moose Fire increase in core sampling results in Langford Creek is statistically significant ($\alpha<0.05$). Over the past 18 years substrate scoring results show juvenile bull trout rearing habitat quality in Coal Creek became threatened during the drought of the late 1980s and again in 2000. It has declined steadily since then and is now at the threshold of impaired status. All other streams sampled have provided adequate bull trout rearing habitat. Juvenile bull trout abundance has declined to extremely low levels in Coal, North Coal and Red Meadow creeks. Both habitat quality and lack of returning spawners are likely responsible. Juvenile bull trout populations have shown maximum relative fluctuations of over 1100 percent and average relative fluctuation of about 200 percent. Genetic testing of westslope cutthroat trout populations in North Fork tributaries is showing introgression by rainbow trout. Annual fluctuations in juvenile cutthroat trout abundance are also quite large, with several sections showing a maximum relative change greater than 1,000 percent over our period of record. Recent fires in the basin appear to have had little influence on migratory fish populations. Between 1980 and 1990, index counts averaged 384 bull trout redds annually. A large decline occurred between 1990 and 1992 due to degraded spawning and rearing habitat conditions brought on by prolonged drought, combined with major trophic changes in Flathead Lake. From 1992 to 1997 our index count averaged 120; a reduction of approximately 70 percent. We observed an increase in 1998 which continued through 2000 then redd numbers declined to the 2004 index count of 136. Redd numbers averaged 192 during the past six years and although we have seen a decline since 2000, current numbers still exceed those observed between 1992 and 1997. Our index counts comprise 45 percent of total bull trout spawning basin-wide, based on nine years of data. There are 19 disjunct bull trout populations in the Flathead Basin of which we are currently tracking five.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

ACKNOWLEGMENTS

I extend my sincere gratitude to the many individuals who have assisted either directly or indirectly during the past 25 years. Continuous data collection efforts over a period of time this long are uncommon, and needless to say, numerous people have come and gone. Regional management personnel along with the BPA contract staff have been instrumental in maintaining continuity in the long-term data set through assistance with the field sampling, data collection and data processing. I thank Jim Vashro for allowing Mark Deleray and Scott Rumsey to take time away from management responsibilities to assist with electrofishing, redd counts or providing manpower whenever a large field crew was required. Likewise, Brian Marotz has seen to budgetary needs and made Grant Grisak, Clint Muhlfeld and the Special Projects staff available for assistance. In recent years Gary Anderson, Jon Cavigli, Gary Michael, Jeff Hutten, Steve Glutting, Rick Hunt, Durae Daniels, Lynda Fried, Kris Tempel and Scott Hawxhurst have ably contributed. Sharon Johnston also tried to help with the fieldwork, compiled numerous manuscript drafts and completed all preliminary word processing. Christine Caye processed the final manuscript. Funding has been provided by Flathead National Forest, Bonneville Power Administration and Montana Department of Natural Resources and Conservation.

INTRODUCTION

This report contains information on the continuing assessment and monitoring of fish populations and instream habitat in the upper Flathead River drainage. The study's primary purpose has been to document annual trends in fish population and habitat parameters. Over time, these fishery variables may be compared with information on land management activities and natural occurrences in the drainage to show if and how they are affecting the fishery.

The framework for the long-term tributary monitoring program developed during the EPA-funded Flathead River Basin Study, which ran from 1978 through 1983. Flathead National Forest (FNF) provided funding beginning in 1982 allowing continuation of standardized data collection at a core group of index sites up through the present time. Additional funding from Bonneville Power Administration (BPA) (1986-ongoing) and Montana Department of Natural Resources and Conservation (DNRC) (1992-ongoing) has enabled us to expand our data collections basin-wide. These activities now provide one of the longest running data sets on a large lake and river system and, specifically to bull trout and their habitat, one of the more complete available anywhere. These data are now included as an integral component of the Flathead Basin Commission's (FBC) Master Monitoring Program to track overall water quality and aquatic health basin-wide.

The following report is submitted to satisfy Provision I-A of the Annual Financial and Operating Plan for Challenge Cost-Share Agreement No. 01-CS-11011000-051 between FNF and MFWP, which we call Project 31004. A larger document is currently in preparation which will combine this information with data collected on the Flathead River System (North Fork, Middle Fork and main stem) and Flathead Lake to provide an overall status update for the interconnected drainage. Similar reports are also being prepared for the Swan and South Fork Flathead drainages.

TRIBUTARY STREAM MONITORING

STREAMBED CORING

Introduction

Successful egg incubation and fry emergence are dependent on gravel composition, gravel permeability, water temperature, and surface flow conditions. The female trout begins redd construction by digging an initial pit or depression in the streambed gravel with her tail. After the spawning pair deposits eggs and sperm into this area, the female moves upstream a short distance and continues the excavation, covering the deposited eggs. The process is then repeated several more times, resulting in a series of egg pockets formed by the upstream progression of excavations. The displaced gravel mounds up, covering egg pockets already in place. After egg laying is complete the female creates a large depression at the upstream edge of the redd, which enhances intragravel flow and displaces more gravel back over the entire spawning area. Excavation of the redd causes fine sediments and organic particles to be washed downstream, leaving the redd environment with less fine material than the surrounding substrate. Weather, streamflow, and transport of fine sediment and organic material in the stream can change conditions in redds during the incubation period. Redds can be disturbed by other spawning fish, animals, human activities, or by high flows which displace streambed materials (Chapman 1988).

Redd construction by migratory bull trout in the Flathead drainage disturbs the streambed to a depth of 18.0 to 25.0 cm (Weaver and Fraley 1991). Egg pockets of smaller fish such as westslope cutthroat tend to be shallower (Weaver and Fraley 1993). The maximum depth of gravel displacement is indicative of egg deposition depth (Everest et al. 1987). Results from freeze coring have shown larger substrate particles (up to 15.2 cm) at the base of egg pockets than in overlying substrates (Weaver and Fraley 1993). These particles are likely too large for the female to dislodge during redd construction. Eggs are deposited and settle around these larger particles (Chapman 1988). Continued displacement of streambed materials by the female then covers the eggs.

Redds become less suitable for incubating embryos if fine sediments and organic materials are deposited in interstitial spaces of the gravel during the incubation period. Fine particles impede movement of water through the gravel, thereby reducing delivery of dissolved oxygen to, and flushing of metabolic wastes away from incubating embryos. This results in lower survival (Wickett 1958; McNeil and Ahnell 1964; Reiser and Wesche 1979). For successful emergence to occur fry need to be able to move within the redd, but high levels of fine sediment can restrict their movements (Koski 1966; Bjornn 1969; Phillips et al. 1975). In some instances, embryos that incubate and develop successfully can become entombed (trapped by fine sediments). Sediment levels can alter timing of emergence (Alderdice et al. 1958; Shumway et al. 1964) and affect fry condition at emergence (Silver et al. 1963; Koski 1975).

Measurements of the size range of materials in the streambed are indicative of spawning and incubation habitat quality. In general, research has shown negative relationships between fine sediment and incubation success of redd constructing salmonids (Chapman 1988). A significant inverse relationship existed between the percentage of fine sediment in substrates and survival to emergence of westslope cutthroat trout and bull trout embryos in incubation tests (Weaver and White 1985; Weaver and Fraley 1991, 1993). Mean adjusted emergence success ranged from about 80 percent when no fine material was present, to less than 5 percent when half of the incubation gravel was smaller than 6.35 mm; about 30 percent survival occurred at 35 percent fines. Entombment was the major mortality factor.

Median percentages of streambed materials smaller than 6.35 mm at fry emergence ranged from 24.8 to 50.3 percent in 29 separate spawning areas sampled during the Flathead Basin Forest Practice Water Quality and Fisheries Study (Weaver and Fraley 1991). Linear regression of coring results and output from models assessing ground disturbing activity and water yield increases in these 29 Flathead Basin tributary drainages showed significant positive relationships (Weaver and Fraley 1991). These results demonstrate a linkage between on-the-ground activity and spawning habitat quality. This testing allowed development of models which predict embryo survival to emergence, given the percentage of material smaller than 6.35 mm in the incubation environment. We monitor spawning and incubation habitat quality by determining the percent fines in a given spawning area through hollow core sampling.

Methods

Field crews used a standard 15.2 cm hollow core sampler (McNeil and Ahnell 1964) to collect four samples across each of three transects at each study area. We located actual coring sites on the transects using a stratified random selection process. The total width of stream having suitable depth, velocity, and substrate for spawning was visually divided into four equal cells. We randomly took one core sample in each cell. In some study areas we deviated from this procedure due to limited or discontinuous areas of suitable spawning habitat. We selected study areas based on observations of natural spawning. We only sampled in spawning areas used by migratory westslope cutthroat trout and bull trout. During the period of study, these fish spawned in the same general areas annually , so sampling locations have remained similar.

Sampling involved working the corer into the streambed to a depth of 15.2 cm. All material inside the sampler is removed and placed in heavy duty plastic bags. We labeled the bags and transported them to the Flathead National Forest Soils Laboratory in Kalispell, Montana, for gravimetric analysis. We sampled the material suspended in water inside the corer using an Imhoff settling cone (Shepard and Graham 1982). Field personnel allowed the cone to settle for 20 minutes before recording the amount of sediment per liter of water. After taking the Imhoff cone sample, they determined total volume of the turbid water inside the corer by measuring the depth and referring to a depth to volume conversion table (Shepard and Graham 1982).

The product of the cone reading (ml of sediment per liter) and the total volume of turbid water inside the corer (liters) yields an approximation of the amount of fine sediment suspended inside the corer after sample removal. We than applied a wet to dry conversion factor developed for Flathead tributaries by Shepard and Graham (1982), yielding an estimated dry weight (g) for the suspended material.

We oven dried the bagged samples and sieve separated them into 13 size classes ranging from >76.1 mm to <0.063 mm in diameter (Table 1). We weighed the material retained on each sieve and calculated the percent dry weight in each size class. The estimated dry weight of the suspended fine material (Imhoff cone results) was added to the weight observed in the pan, to determine the percentage of material <0.063 mm. We summed these percentages, obtaining a cumulative particle size distribution for each sample (Tappel and Bjornn 1983).

Table 1. Mesh size of sieves used to gravimetrically analyze hollow core (McNeil and Ahnell 1964) streambed substrate samples collected from the Flathead River Basin tributaries.

76.1 mm	(3.00 inch)
50.8 mm	(2.00 inch)
25.4 mm	(1.00 inch)
18.8 mm	(0.74 inch)
12.7 mm	(0.50 inch)
9.52 mm	(0.38 inch)
6.35 mm	(0.25 inch)
4.76 mm	(0.19 inch)
2.00 mm	(0.08 inch)
0.85 mm	(0.03 inch)
0.42 mm	(0.016 inch)
0.063 mm	(0.002 inch)
Pan	(<0.002 inch)

We refer to each set of samples by using the median percentage <6.35 mm in diameter. This size class is commonly used to describe spawning gravel quality, and it includes the size range typically generated during land management activities. We examined the range of median values for this size class observed throughout the basin. Currently, field crews monitor selected spawning areas utilized by migratory westslope cutthroat and bull trout stocks from Flathead Lake (North and Middle Fork tributaries).

Results and Discussion

Field crews began core sampling some spawning areas utilized by Flathead Lake's migratory fish stocks in 1981 (Table 2). Initially, we sampled the main bull trout spawning areas in four North Fork tributaries; Big, Coal, Whale, and Trail creeks. We subsequently expanded our program to include Granite Creek, an important bull trout spawning stream in the Middle Fork drainage and two additional spawning areas in the Coal Creek drainage; North Coal and South Coal (Table 2). These seven spawning areas comprise our long-term data set for monitoring bull trout spawning habitat quality relative to Flathead Lake. Cyclone, Langford, and Meadow creeks are cutthroat spawning tributaries in the North Fork drainage and Challenge Creek is a cutthroat spawning tributary in the Middle Fork drainage. These four sites comprise our index data set for monitoring cutthroat trout spawning habitat quality in the Flathead drainage.

Recommendations resulting from the Flathead Basin Cooperative Forest Practice Study identified that fine sediment (<6.35 mm) levels exceeding 35 percent "threaten" embryo survival to emergence (FBC 1991). At 35 percent fines, survival to emergence is approximately one-third. At 40 percent fines, survival drops to approximately one-quarter and at this level, survival to emergence is considered "impaired" (FBC 1991).

Bull Trout

When examining the streambed coring data set by individual spawning area it is obvious that all sites have had periods of high fine sediment levels (Table 2, Appendix A). Big Creek exceed the threshold for impaired status (>40 percent) during three consecutive years beginning in 1988 (Table 2). When sampling results showed fine sediment levels in Big Creek's bull trout spawning area peaked at over 50 percent in 1990, survival to emergence was predicted to be less than 5 percent (Weaver and Fraley 1991). This spike is believed to be drought related with sediment from both natural and management-related sources building up due to the lack of flushing flows over a period of several years. Although some recovery was suggested in 1991, this spawning area again exceeded threatened status (>35 percent) in 1992 and 1993 (Table 2). Since 1994, the Big Creek spawning area sampling results show median sediment levels less than 35 percent. The Moose Fire which occurred in 2001 appears to have had little impact (Table 2), although we have not had a substantial runoff event since the fire. The increase observed in the 2003 sampling may again be due to the lack of flushing flows in recent years.

The main bull trout spawning area in Coal Creek near Dead Horse Bridge has chronically had fine sediment problems (Table 2, Appendix A). Its status has been in the impaired category three years (1982, 1987, and 1990) and threatened for 16 of the past 23 years (Table 2). Although peak level sampling results from Coal Creek were not as high as observed in Big Creek, the chronic presence of high fine sediment levels is likely having serious impact on the fish stocks in Coal Creek (see sections on Juvenile Abundance and Redd Counts in this report). A cooperative effort to identify and if possible remediate this situation is being pursued by FNF, DNRC, FBC, and

Table 2. Median percentage of streambed material smaller than 6.35 mm in McNeil core samples collected from spawning areas in Flathead Lake tributary streams from 1981-2003.

Stream	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Big	23.8	32.6	28.2	27.8	28.7	21.6	29.1	40.4	48.4	53.4	32.9
Coal-DH	34.1	40.2	39.3	32.8	36.4	34.8	40.8	39.2	37.8	42.1	36.1
North Coal	--	--	--	--	34.9	29.4	30.2	39.8	37.8	32.8	32.6
South Coal	--	--	--	--	36.0	31.8	31.4	32.1	36.9	33.6	32.7
Whale	25.1	31.8	32.6	29.5	22.5	26.0	28.9	37.2	35.3	--	34.2
Trail	25.7	36.1	27.2	28.1	26.2	25.0	27.4	30.0	--	34.6	33.7
Granite	--	44.6	--	--	--	49.0	41.3	45.5	45.2	33.0	37.2
Cyclone	--	--	--	--	--	--	--	--	31.0	31.0	--
Langford	--	--	--	--	--	--	--	--	--	--	--
Challenge	--	--	--	--	--	--	32.5	40.9	43.5	33.0	38.2
Meadow	--	--	--	--	--	--	--	--	--	--	--

Stream	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Big	37.4	37.2	34.5	32.2	30.0	31.1	32.2	33.1	31.4	32.1	30.1	33.4
Coal-DH	35.8	35.5	32.6	37.5	38.2	36.4	37.4	37.6	36.5	37.6	38.0	39.4
North Coal	33.5	30.0	25.5	30.8	29.6	30.1	30.9	31.4	31.0	31.8	32.3	31.0
South Coal	34.0	28.4	26.2	28.8	30.1	29.2	30.2	30.8	30.0	30.9	31.4	30.2
Whale	32.2	33.4	29.5	32.6	31.4	30.9	31.3	31.9	30.8	31.6	30.9	32.1
Trail	29.5	33.6	24.8	29.5	34.5	29.8	30.2	30.0	29.7	30.4	29.6	30.3
Granite	41.4	36.0	33.5	34.8	33.6	32.5	32.0	35.1	34.7	33.7	34.2	35.1
Cyclone	--	--	--	33.1	31.6	33.8	32.6	35.2	35.2	35.2	33.9	34.7
Langford	--	--	--	--	--	--	--	--	34.1	36.0	38.3	41.4
Challenge	41.9	36.8	34.6	37.9	38.1	36.4	35.9	33.1	35.1	36.0	35.4	36.0
Meadow	--	--	--	--	--	--	--	38.1	38.1	39.6	39.7	43.2

FWP. For some reason, this section of Coal Creek has not responded to the reduction in timber management and other ground disturbing activities combined with natural processes which maintain spawning habitat quality like neighboring drainages have. At present, Coal Creek is in the worst shape in both fish abundance and habitat quality conditions of all the Flathead Lake nursery streams we sample. Portions of this drainage burned during the 2001 Moose Fire.

Sampling in both North and South Coal creeks as well as Whale Creek showed high levels of fine sediment during the late 1980s (drought effects) with some recovery during more recent samplings (Table 2, Appendix A). The slow but fairly steady increasing trends observed since 1994 in North and South Coal is also likely drought-related, however, current conditions remain below threshold status. Whale Creek has remained relatively stable since the early 1990s, however, a large portion of the drainage burned during the Wedge Canyon Fire in 2003 (Table 2). Whale Creek is the most highly utilized Flathead Lake bull trout spawning area.

Sampling in Trail Creek has shown fine sediment levels in this spawning area have remained more stable over time than most of the other index streams (Table 2, Appendix A). Results have exceeded threatened status only once in 1982. Trail Creek rises from a series of large springs near Thomas Creek. Except during spring runoff there is little or no flow above this point for several miles. Approximately 20 years ago, Trail Creek was included as part of a special Grizzly Bear Management Area; it is the least developed of our bull trout index streams. A large portion of upper Trail Creek drainage burned during the Wedge Canyon Fire in 2003.

Granite Creek in the Middle Fork drainage has shown a similar pattern of fluctuations to the North Fork streams (Table 2, Appendix A). High sediment levels in the late 1980s resulted from prolonged drought and lack of snow pack and spring runoff. Sampling in 1982 and 1986-89 showed embryo survival to emergence was impaired. The 1990 results suggested significant improvement, however, the next three years sampling results again exceeded recommended threshold levels (Table 2). Since 1994, fine sediment levels have hovered around the 35 percent threshold. This portion of the Middle Fork drainage was strongly influenced by the 1964 flood event and impacts are still quite obvious. Unstable soils and high precipitation zones predominate in the upper Granite Creek watershed. This combination of geology and precipitation typically results in reduced spawning habitat quality and large annual fluctuations in sediment levels are common. The Challenge Fire which occurred in 1998 appears to have had an influence on sediment levels downstream in Granite Creek (Table 2). Figures illustrating results of annual core sampling for each individual bull trout spawning area are provided in Appendix A.

Previous studies in the Flathead Basin have shown significant positive relationships between ground disturbing activity and results from hollow core sampling in spawning areas (Weaver and Fraley 1991, FBC 1991). This means that as the amount of disturbed ground in a drainage increases, the amount of fine sediment in spawning gravel also increases. At this point in time we do not have the site specific information on land management activities necessary to assess cause and effect relationships at individual stream locations and it is not our intent to do so, as this type of study was recently completed as part of the Cooperative Forest Practice Study (Potts 1991, FBC 1991). Our sampling results show that sediment sources and water yield problems have and will likely continue to cause fluctuations in fine sediment levels in streams, which strongly effect embryo survival to emergence.

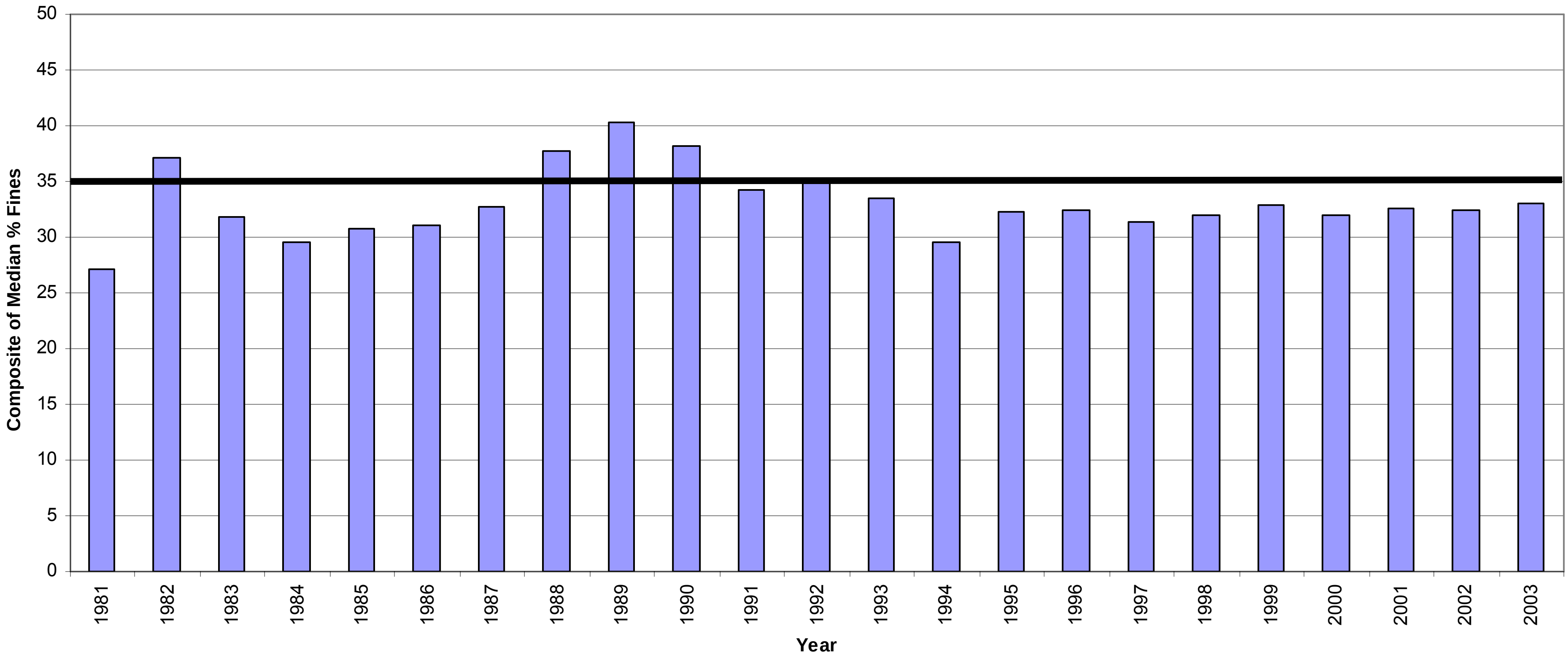
Our index of spawning habitat quality appears to be very sensitive to flushing flows. To illustrate this sensitivity while providing an overall description of bull trout spawning habitat quality we calculated and plotted composite fine sediment levels (Figure 1). The composite percent fines is simply the average of all hollow coring results for the Flathead Lake bull trout spawning streams sampled during any given year. This averaging smoothes out the more dramatic fluctuations we see when looking at streams individually. An increasing trend in composite fine sediment level began in 1986. Fine sediment levels peaked during 1988 through 1990. This increase corresponds to the extended period of drought which spanned the late 1980s. Streamflow during this period were extremely low through fall and winter. Field crews observed dewatered bull trout spawning sites during winter surveys in 1986. During 1988, a section of Coal Creek dewatered except for standing pools. Limited snow pack resulted in only low to moderate runoff during the spring melt periods. Spring runoff in 1991 was the first normal “flushing flow” which occurred during the several preceding years. Our sampling results show a corresponding reduction in the level of fine sediment present in the main bull trout spawning areas (Figure 1). We have had good flushing flows during only several spring runoffs since 1991.

Since this time, composite fine sediment levels have crept up and are currently approaching the 35 percent threshold (Figure 1). During the highest year on record (1989) composite fine sediment level reach 40.23 percent at which point predicted embryo survival to emergence would have been approximately 20 percent. In 1994, the composite was 29.51 percent fines and predicted survival to emergence would have been about 35 percent. This difference in survival of 15 percent could be quite significant and two of the seven streams which comprise the composite value are currently over the recommended 35 percent threshold level.

Westslope Cutthroat Trout

In 1987, field crews began sampling westslope cutthroat trout spawning habitat quality in Challenge Creek. Results showed fine sediment levels exceeded the threshold for impaired status (>40%) during three years (1988, 1989, and 1992) and from 1993 through the present the median percent fines has approached or exceeded threatened status (>35%) annually (Table 2, Appendix A). Challenge Creek is a headwater tributary to Granite Creek and has similar geology and precipitation along with the strong influence from the 1964 flood event. This combination of natural occurrences coupled with the land management activities which occurred in recent years have resulted in the current conditions (Table 2). The Challenge Fire which burned portions

Figure 1. Annual composites of streambed coring results (Median %<6.35 mm) in Flathead Lake spawning areas from 1981 through 2004.



of the drainage in 1998 appears to have had little effect on sampling results in Challenge Creek.

Core sampling results for Cyclone, Langford, and Meadow creeks are only available for recent years. Continuous data collection in Cyclone Creek began in 1995. Prior to that time, this cutthroat trout spawning area was sampled as part of the Flathead Basin Forest Practice Study during 1989 and 1990 (Table 2, Appendix A). Median percent fines has remained at or below the threshold for threatened status (35%) throughout the period of record. Portions of the Cyclone Creek drainage burned during the Moose Fire in 2001, however, sampling detected no change in spawning habitat quality. Streamflow here are moderated by Cyclone Lake in the headwaters of the drainage.

The Meadow and Langford creek sampling began in 2000. Meadow Creek results show median percent fines in the threatened category (>35%) and increasing annually during the first three years (Table 2). The most recent sampling (2003) showed a continuing increase in fine sediment level and at 43.2 percent, embryo survival to emergence is considered impaired. The Moose Fire burned the entire drainage upstream from the sampling locations during 2001, so the initial sampling results (2000) are indicative of pre-fire conditions. The increasing trend is likely fire-related although no substantial runoff event has occurred to date, other than the lower than normal spring melt off from the low snow pack winters during the last four years. Although the increasing trend in median percent fines is obvious it is not statistically significant when comparing annually or pre-fire to present (2000 vs. 2003). We plan to continue sampling Meadow Creek through a major runoff event to further evaluate effects of the Moose Fire.

Results from Langford Creek sampling shows a similar increasing trend (Table 2, Appendix A). The entire drainage upstream from our sampling sites burned intensively and Langford Creek has been subject to the same environmental conditions described above for Meadow Creek. Similar to Meadow Creek, the increases which occurred annually were not statistically significant. However, when we compared the median percent fine sediment from the pre-fire sampling (2000) with the most current results (2003), the increase is statistically significant at a nominal 0.05 percent level in a two-tailed test. Again, we hope to continue monitoring Langford Creek through a substantial runoff event in an effort to further quantify fire-related effects.

SUBSTRATE SCORING

Introduction

Environmental factors influence distribution and abundance of juvenile bull trout throughout the range of the species, as well as within specific stream segments (Oliver 1979, Allan 1980, Leathe and Enk 1985, Pratt 1985, Fraley and Shepard 1989, Ziller 1992). Temperature, cover, and water quality regulate general distributions and abundances of juvenile salmonids within drainages, and juvenile presence at specific locations in a stream is affected by depth, velocity, substrate, cover, predators, and competitors. Although spawning occurs in limited portions of a drainage, juvenile salmonids disperse to occupy most of the areas within the drainage that are suitable and accessible (Everest 1973; Leider et al. 1986).

Juvenile bull trout rear for up to four years in Flathead Basin tributaries. Snorkel and electrofishing observations during past studies indicate juvenile bull trout are extremely substrate-oriented and can be territorial (Fraley and Shepard 1989). This combination of traits results in partitioning of suitable rearing habitat and a carrying capacity for each stream.

Sediment accumulations reduce pool depth, cause channel braiding or dewatering, and reduce interstitial spaces among larger streambed particles (Megahan et al. 1980, Shepard et al. 1984, Everest et al. 1987). Since juvenile bull trout are almost always found in close association with the substrate (McPhail and Murray 1979, Shepard et al. 1984, Weaver and Fraley 1991) we monitor substrate-related habitat potential by calculating substrate scores (Crouse et al. 1981). A significant positive relationship existed between substrate score and juvenile bull trout densities in Swan River tributaries (Leathe and Enk 1985) and Flathead River tributaries (Weaver and Fraley 1991), where a high substrate score was indicative of large particle sizes and low level of embedded ness (Crouse et al. 1981).

A substrate score is an overall assessment of streambed particle size and embedded ness. Large particles which are not embedded in finer materials provide more interstitial space that juvenile bull trout favor. This situation generates a higher substrate score. Low substrate scores occur when smaller streambed particles and greater embedded ness limit the interstices within the streambed materials.

Linear regression of substrate scores against output from a model assessing ground disturbing activity in 28 Flathead Basin tributary drainages showed a significant negative relationship. Researchers also obtained a significant negative relationship between substrate scores and output from a model predicting increases in water yields (Weaver and Fraley 1991). These results demonstrate a linkage between ground disturbance and increased water yield and streambed conditions. Prolonged periods of drought and lack of flushing flows also can result in lower substrate scores.

Methods

Substrate scoring involves visually assessing the dominant and subdominant streambed substrate particles, along with embedded ness in a series of cells across transects. Surveyors assign a rank to both the dominant and subdominant particle size classes in each cell (Table 3). They also rank the degree to which the dominant particle size is embedded (Table 3). The three ranks are summed, obtaining a single variable for each cell. All cells across each transect are averaged and a mean of all transects in a section results in the substrate score.

Table 3. Characteristics and associated ranks for computing substrate score (modified by Leathe and Enk 1985 from Crouse et al. 1981).

Rank	Characteristic
	<u>Particle Size Class</u>[1]
1	Silt and/or detritus
2	Sand (<2.0 mm)
3	Small gravel (2.0-6.4 mm)
4	Large gravel (6.5-64.0 mm)
5	Cobble (64.1-256.0 mm)
6	Boulder and/or bedrock (>256.0 mm)
	<u>Embedded ness</u>
1	Completely embedded or nearly so
2	¾ embedded
3	½ embedded
4	¼ embedded
5	Unembedded

[1]Used for both dominant and subdominant particle ranking

We scored 150 m sections using equally spaced transects. Cell width varied depending on wetted width, allowing a minimum of five evaluations for any transect. Maximum cell width was 1.0 m. Again, lower scores indicate poorer quality rearing habitat; higher values indicate good conditions.

Results and Discussion

Field crews began collecting substrate scores in Flathead Lake rearing streams in 1984 (Table 4). Our initial efforts during 1984 and 1985 included only the Coal Creek Drainage in the North Fork of the Flathead River. Due to this limited sampling, assessment basin wide conditions is not possible. However, by 1986 we were sampling at least six rearing streams annually which are tributaries to the North and Middle forks of the Flathead River. From 1986 on, the data set provides a better index of juvenile bull trout rearing habitat quality throughout the basin.

Recommendations resulting from the Flathead Basin Cooperative Forest Practice Study identified that substrate scores of 10. 0 or less “threatened” juvenile bull trout rearing capacity; at scores less than 9. 0, rearing capacity was considered “impaired” (FBC 1991). When examining the substrate scoring data set by individual site, the section of Coal Creek near Dead Horse Bridge fell into the threatened category between 1987 and 1991 (Table 4). Although substrate scores at this location improved after 1991, this index section in Coal Creek again dropped below the level where rearing capacity is considered “threatened” in 2000 and has steadily declined through the 2004 sampling. The current substrate score of 9.0 is the threshold for “impaired” status and juvenile bull trout densities in Coal Creek reflect this condition (see Juvenile Abundance section of this report). Individually, all other sites scored higher than 10. 0 annually over our period of record. The highest substrate scores have been recorded in the North Coal and Morrison creek sections (Table 4). Figures illustrating results of annual substrate scoring for each individual section are provided in Appendix B.

Although previous studies in the Flathead Basin have shown significant negative relationships between ground disturbance and substrate score we do not have the current site-specific information on land management activities to assess cause/effect at individual stream locations. Our intent here is to provide an overall description of juvenile bull trout rearing habitat quality and how it has changed over the period of record. To best describe basin wide rearing habitat quality we calculated and plotted composite substrate scores (Figure 2). This composite is simply the average of all substrate scores for Flathead Lake bull trout rearing streams sampled during any given year. This averaging smoothes out the more dramatic fluctuations we see when examining individual streams.

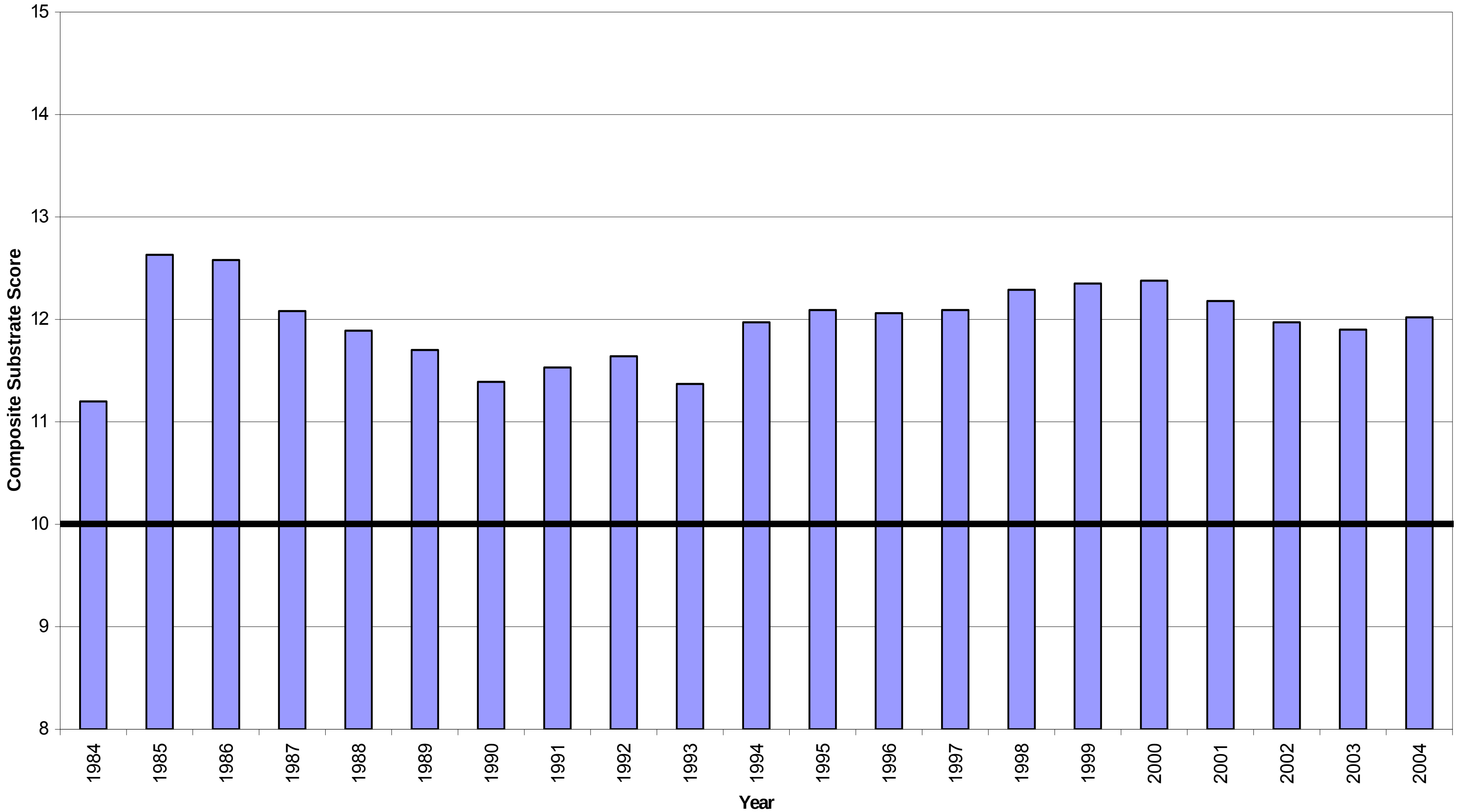
As previously stated, 1984 and 1985 are not representative due to limited sampling. From 1986 through 1990 composite substrate score declined sharply. This corresponds to the extended period of drought which spanned the 1980s. Streamflow during this period were extremely low through fall and winter. Field crews observed dewatered bull trout redds during winter surveys in 1986. During 1988, a section of Coal Creek upstream from Dead Horse Bridge dewatered except for standing isolated pools from mid August through early September. Limited snow pack resulted in only low to moderate runoff during the spring melt periods. A rain-on-snow event in the fall of 1989 was the first “flushing flow” in several years. Spring runoff in 1991 provided flushing as have several more recent spring runoffs, especially 1997. An improving trend in

Table 4. Substrate scores collected from tributaries to the North and Middle forks from 1984 through 2004. These streams provide juvenile bull trout rearing habitat for the Flathead Lake bull trout population.

Stream	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Big	--	--	12.2	11.5	11.2	11.8	11.3	11.8	11.1	10.8
Coal	10.2	11.6	12.3	10.0	9.8	9.6	10.4	9.8	11.2	10.7
North Coal	12.2	13.5	14.2	13.7	13.0	12.3	13.2	12.7	12.5	12.1
South Coal	--	12.8	12.0	12.2	12.0	11.8	11.5	11.4	11.9	11.4
Cyclone	--	--	--	--	--	11.3	11.6	--	--	--
Red Meadow	--	--	--	--	12.7	11.8	10.9	11.3	11.5	11.8
Whale	--	--	--	--	11.7	11.5	11.3	11.8	11.2	11.3
Morrison	--	--	12.3	12.8	12.8	13.0	11.1	11.9	12.1	11.5
Granite	--	--	--	--	--	--	--	--	--	--
Ole	--	--	12.5	12.3	--	11.8	--	--	--	--

Stream	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Big	10.6	10.9	11.1	11.0	11.3	11.8	11.7	11.6	12.0	12.3	12.1
Coal	10.5	10.8	10.7	10.5	10.4	10.1	9.8	9.7	9.4	9.2	9.0
North Coal	13.1	13.6	13.7	13.7	13.9	13.6	13.8	13.6	13.4	13.1	13.2
South Coal	12.4	12.5	12.3	12.7	12.6	12.8	12.8	12.9	12.6	12.2	12.5
Cyclone	--	11.1	11.3	11.6	11.4	11.9	11.4	11.6	11.1	10.7	10.3
Red Meadow	12.0	12.3	12.1	12.3	12.2	12.3	11.9	11.7	11.4	10.9	11.1
Whale	12.1	11.8	12.0	11.6	11.9	12.1	12.5	12.4	12.2	12.6	12.7
Morrison	13.1	12.7	12.5	12.8	13.1	13.3	13.6	13.7	13.2	13.4	13.2
Granite	--	--	--	--	--	--	--	11.6	11.4	11.5	11.7
Ole	--	--	--	--	12.9	12.8	12.9	12.4	12.1	11.9	12.7

Figure 2. Annual composite substrate scores in Flathead Lake nursery streams from 1984 through 2004



composite substrate score began in 1991 and although not continuous, this trend is evident through the 2000 sampling. Since this time we have not had a substantial flushing flow and the composite substrate score for Flathead Basin tributaries is declining (Figure 2). Although bank full flows are needed to maintain rearing habitat quality, major runoff events may recruit additional fine sediment from the large area which has burned recently.

JUVENILE ABUNDANCE ESTIMATES

Introduction

Estimation of fish population abundance is necessary for understanding basic changes in numbers, species composition and year class strength. Direct enumeration is the most accurate technique, but in most situations indirect methods must be employed. Fish populations are dynamic and may fluctuate considerably, even over relatively short periods of time, regardless of human influence. Consequently, managers seeking to assess the effects of various activities on fish populations must understand the nature and causes of such fluctuations as fully as possible.

We developed a protocol to assess fish abundance in the Flathead Basin using electrofishing techniques (Shepard and Graham 1983). Monitoring focuses on quantifying yearly variation of fish abundance in stream sections sampled consistently year after year. We use electrofishing techniques to assess fish abundance in accessible streams because:

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

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

3. Estimates derived using electrofishing techniques are a standard practice used to assess fish abundance.

Methods

Through analysis of fish abundance estimation data collected during development of the above protocol and review of pertinent literature, we developed the following fish abundance monitoring guidelines:

1. In streams less than 10 cfs, use a two-pass electrofishing estimation technique. In these small streams adequate numbers of fish can be captured using a single back-pack mounted electrofishing unit. Probability of first pass capture ($\hat{p}$) should be higher than 0.6 to obtain reliable results

2. In streams 10 to 20 cfs, two-pass electrofishing estimation can be used; however, two backpack units should be used and $\hat{p}$ values must be higher than 0.6. If the $\hat{p}$ value falls below 0. 6 for a sample site, more effort (third pass) should be made instead of simply reporting the two-catch estimate.

3. In streams larger than 20 cfs, two-pass electrofishing estimation technique can be used; however three backpack units should be used and the $\hat{p}$ value must be higher than 0.6. Again, if the $\hat{p}$ value is less than 0.6 more effort (third pass) is required.

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

Two-pass Assumptions (Seber and LeCren 1967):

1. Probability of first pass capture ($\hat{p}$) is large enough to have a significant effect upon population total ($\hat{N}$).

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

2. Probability of capture is constant. Fishing effort is the same for both passes and fish remaining after the first pass are as vulnerable to capture as were those that were caught during the first pass.

Assumption 2 has frequently been found to be faulty when electrofishing (Lelek 1965, Gooch 1967, Cross and Stott 1975, Mahon 1980). White et al. (1982) found if $\hat{p}$ was 0.8 or larger, two-catch estimates were reliable because failure of constant probability of capture (assumption 2) did not matter. We found that as long as $\hat{p}$ was 0. 6 or larger, estimates computed using two-catch estimators were similar to mark-recapture estimates. Zippin (1958) determined that if the probability of capture ($\hat{p}$) decreases with subsequent fishing's, the estimate was an underestimate of the true population size. These estimates may still be reported, but should be used cautiously. They can be used to compare trends in population abundance, provided the same techniques are used throughout the monitoring program.

3. There is no recruitment, mortality, immigration or emigration between the times of the two fishing's.

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

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

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

Two-pass Procedure:

We placed a nylon block net (6.35 mm mesh) at the lower boundary of the shocking section. When using a block net, we placed the net in the stream with the bottom edge facing upstream and place rocks on the bottom edge of the net to hold it in position. We tied the ropes along the top edge of the net to a tree (or any available stable item) on each bank stretching the net tight and holding it perpendicular to the flow. Rocks placed along the entire bottom edge of the net ensure no fish move past the net. Supports 1.0 to 1.5 m in length hold the net upright.

In streams less than 10 cfs, a single backpack mounted electrofishing unit was used to capture fish. In streams larger or equal to 10 cfs, we now use multiple electrofishing units simultaneously. We electrofished the section working from the upstream boundary down to the lower block net. We found that downstream electrofishing was more efficient than upstream electrofishing, and if two passes were needed for each catch, both passes should be downstream. It is important to extend equal efforts during each pass, so that if two passes were used for the first catch, two passes must also be completed for the second or third catch. Mahon (1980) believed longer time periods between catches improved the accuracy of catch per unit effort estimators. For this reason, we recommend waiting a minimum of 90 minutes between fishing's. During this time, work all fish captured on the first pass.

Two-Pass Estimators:

We used the following formula to estimate population number (Seber and LeCren 1967):

$$\hat{N} = \frac{C_1^{\,2}}{C_1 - C_2}$$

Where $\hat{N}$ = the estimated population size prior to the time of the first pass

C_1 = the number of Age I and older fish captured during the first pass (by species)

C_2 = the number of Age I and older fish captured during second pass (by species)

Variance of the estimate:

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

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

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

As stated previously, $\hat{p}$ must be $\geq$0.6 for a reliable two-pass estimate to be made. If $\hat{p}$ <0.6, the estimate can be reported, but must be viewed with caution. If $\hat{p}$ $\geq$0.6 we completed the estimate; otherwise, more fishing effort was generally called for. This effort is expended to complete a multiple pass estimate (by completing an additional electrofishing pass) and calculating a multi-catch estimator using formulas presented in Zippin (1958).

When reporting the estimates of fish numbers computed from electrofishing we report the estimate, the 95 percent confidence interval, the date, and the density (#/100 m^2 of stream surface area). When reporting two-pass estimates, we report the probability of first pass capture ($\hat{p}$) with the estimate. We compared these estimates by section with population estimates calculated from electrofishing during previous years to assess trends in fish abundance.

Results and Discussion

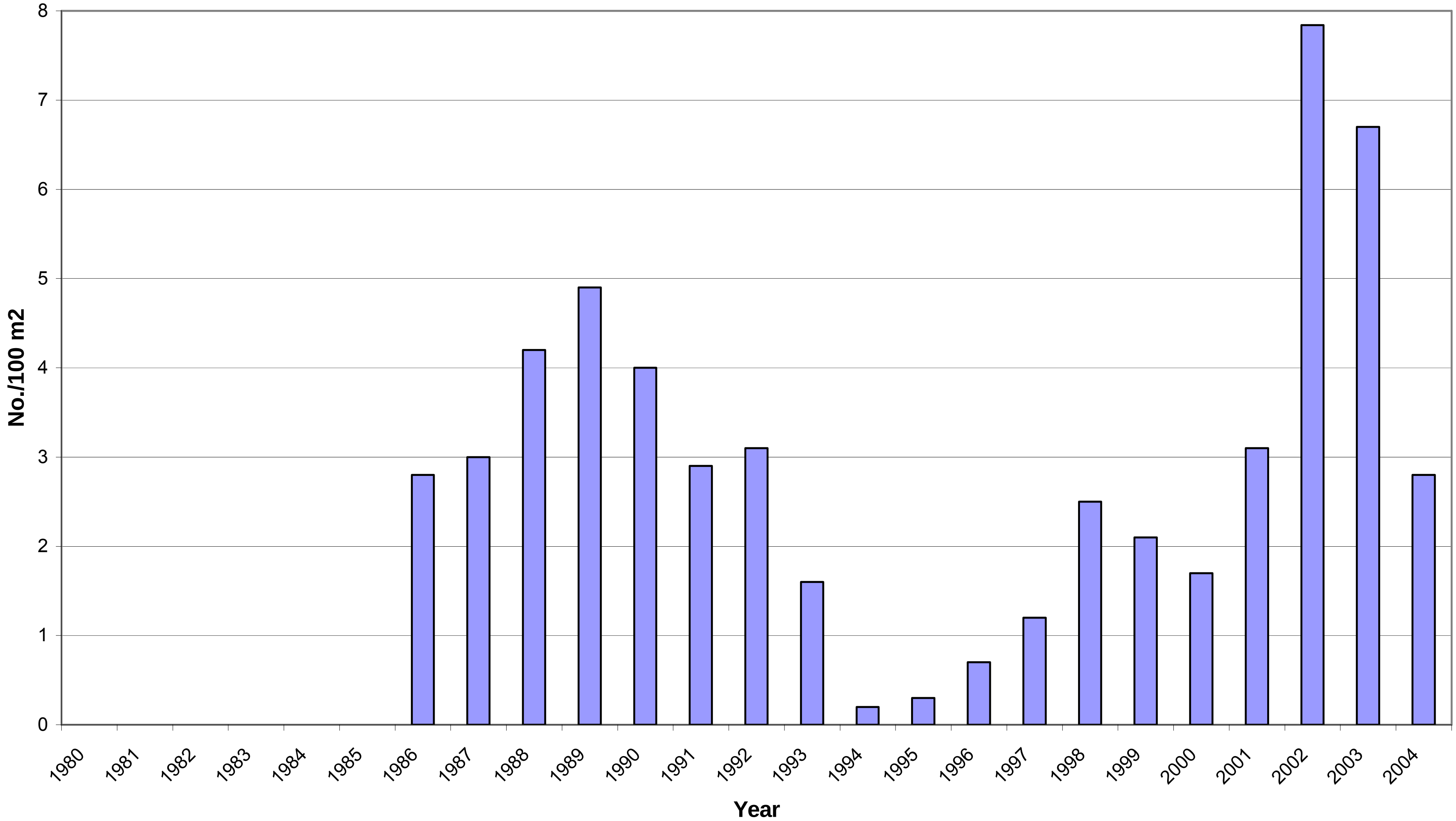
Bull Trout

Big Creek

The Big Creek fish abundance section is located just upstream from the bridge crossing of Forest Road 316E, locally known as Skookoleel Bridge. This section of Big Creek is an important rearing area for juvenile bull trout. Field crews have electrofished this section annually since 1986. Throughout this area the channel is unconfined and stream gradient is less than two percent. The substrate is dominantly cobble and large gravel. The habitat type here is generally riffle/run with occasional pools formed by large woody debris. The channel is highly unstable and major changes have occurred during recent high flow events. This section is in the downstream end of the bull trout spawning reach; we usually observe bull trout redds in or near this section during annual index counts. This section is within the area burned during the Moose Fire in 2001.

Over the past 19 years, estimates of Age I and older bull trout abundance in the Big Creek section have ranged from a high of 126$\pm$11 during 2002 to a low of 21$\pm$2 during 1997 (Figure 3). During the three-year period from 1994 through 1996, the

Figure 3. Densities of Age I and older bull trout calculated from annual electrofishing in the index section of Big Creek from 1986 through 2004.



electrofishing crew did not capture enough juvenile bull trout to calculate valid estimates. The values reported for $\hat{N}$ in Table 1 of Appendix C during those years are the total numbers of juvenile bull trout captured during the first electrofishing pass. During the years when estimates could be calculated the average estimated abundance is 56.2 Age I and older bull trout. Juvenile bull trout density during this period of record has ranged from 7.84 to 0.24 Age I and older bull trout per 100 m^2 of stream surface area (Figure 3). During the ten years when estimates could be calculated juvenile bull trout density in the Big Creek section has averaged 3.40 per 100 m^2. Densities reported in Appendix C, Table 1 for 1994, 1995, and 1996 are expansions from the numbers captured during first pass electrofishing and are underestimates of actual densities.

This section is one of the largest of our index areas. Wetted width can be up to 12 m and discharge can be as high as 50 cfs. The electrofishing crew failed to obtain first pass capture efficiencies of 0.6 or greater during 8 of the16 years when actual estimates could be calculated (Appendix C-1). Multiple pass estimators requiring additional electrofishing effort were employed during these years. This section is most difficult to work during high flow years due to depth in several areas with substantial cover, undercut banks, and backwater areas.

Estimated abundance and density increased from our initial year of sampling in 1986 through 1989 (Figure 3, Appendix C-1). We observed a declining trend over the next several years until in 1994, the electrofishing crew captured only four juvenile bull trout during the first pass. No additional fish were observed avoiding capture so the effort was aborted after completion of pass one. We obtained similar results during 1995 and 1996. No estimates were possible during this three-year period (1994-1996). We again captured estimated numbers of juvenile bull trout during the 1997 effort (Figure 3). An increasing trend followed for the next six years. Juvenile bull trout abundance peaked in 2002 and remained near this level in 2003. The 2004 estimate was conducted during extremely high flow conditions so the 45 percent decrease from the previous year may be partially due to sampling difficulty (Figure 3).

The decline in juvenile bull trout density in the Big Creek index section which began in 1990 occurred during a period when higher than average redd numbers should have produced more juveniles instead of fewer. We observed a significant increase in fine sediment in the core sampling results between 1987 and 1988 which continued through 1990 (see Streambed Coring section in this report). Predicted embryo survival to emergence dropped from approximately 35 percent to about 3 percent over this period. This reduction in spawning and incubation habitat quality corresponds to the extended period of drought we experienced during the late 1980s. Both the coring and substrate scoring results reflect this sediment build up and the associated declines in spawning and rearing habitat quality which caused juvenile densities to decrease to the extremely low levels observed (Figure 3). Our habitat indices show some recovery has occurred since this time and juvenile bull trout abundance has improved in response.

Coal Creek

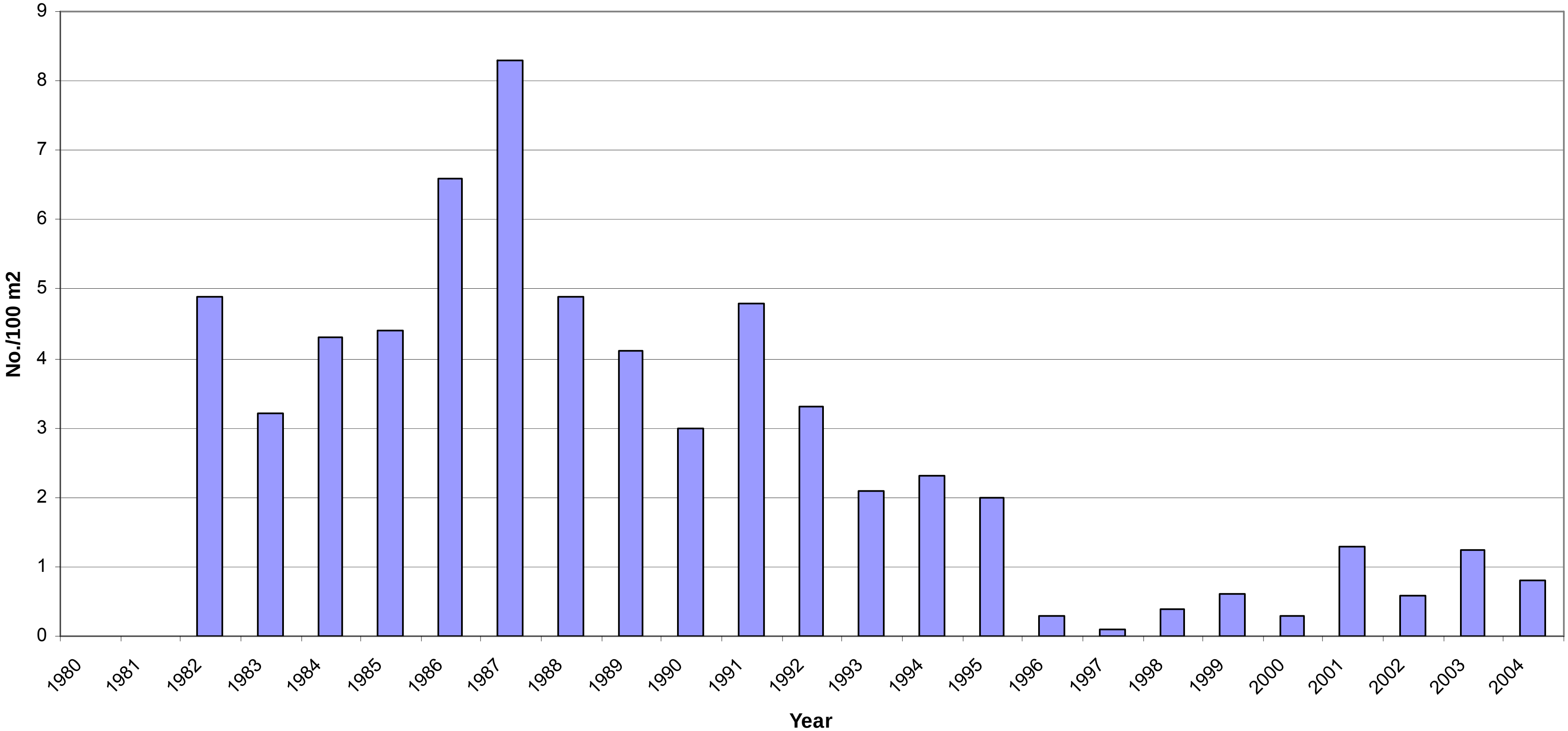
The Coal Creek fish abundance section is located just downstream from the crossing of Forest Road 1693, locally known as Dead Horse Bridge. Field crews have electrofished this section annually since 1982. Throughout this area the channel is occasionally confined and stream gradient is less than 1.0 percent. The substrate is dominantly large gravel with some cobble. The habitat type here is generally riffle/run with occasional pools formed by large woody debris. The channel is relatively stable; no major changes have occurred during the period of record. This section is midway in the bull trout spawning reach. We have observed redds in or near this section.

Over the past 23 years estimates of Age I and older bull trout abundance in the Dead Horse section have ranged from a high of 115$\pm$55 during 1987 to a low of 17$\pm$3 in 2001 (Figure 4, Appendix C-2). During several years the electrofishing crew did not capture enough juvenile bull trout to calculate valid estimates. The values reported for $\hat{N}$ in Appendix C-2 during these years are the total numbers of juvenile bull trout captured during the first electrofishing pass. During the years when estimates could be calculated, the average estimated abundance is 55.8 Age I and older bull trout. Juvenile bull trout density during this period has ranged from 8.33 to 0.07 Age I and older bull trout per 100 m^2 of stream surface area (Figure 4). During the 16 years when estimates could be calculated, juvenile bull trout density in the Dead Horse section has averaged 3.79 per 100 m^2. Densities reported in Appendix C-2 for 1996-2000, 2002 and 2004 are expansions from the numbers captured during first pass electrofishing and are underestimates of actual densities.

This section is moderate in size with average wetted widths of approximately 8.0 m and discharges of 25-35 cfs during low summer flows. From 1982-1988 we employed mark-recapture estimators in addition to the standard two-pass estimator. During these years we were able to determine that the two-pass estimator averaged 68 percent of the mark-recapture technique. From 1989 on, we only used two-pass techniques and all values of $\hat{N}$ reported have been standardized for comparison (Appendix C-2). Due to the low $\hat{p}$ values during several years, a third pass was required to produce reliable estimates.

Estimated abundance and densities remained stable during the initial four years of monitoring then increased in 1986 (Figure 4). Numbers and densities peaked during 1987 then we observed a gradual declining trend which continued through the 2000 sampling. No estimates were possible during a five year period beginning in 1996 as well as during 2002 and 2004 due to limited numbers of juvenile bull trout captured. This section has gone from being one of the best in terms of juvenile abundance to the worst. Fine sediment levels in the spawning and incubation environment have chronically been above the recommended threshold and substrate scores show rearing habitat is currently impaired. The current level of juvenile abundance, combined with habitat conditions and low redd numbers, creates a major concern over the future of the bull trout stock inhabiting Coal Creek. This area had no bull trout spawning in 2001 and 2002 and very few redds since then, so this reach of Coal Creek is no longer getting

Figure 4. Densities of Age I and older bull trout calculated from annual electrofishing in the index section of Coal Creek from 1982 through 2004.



seeded. Habitat conditions here have not responded to the natural healing processes as they have in neighboring bull trout streams.

North Fork of Coal Creek

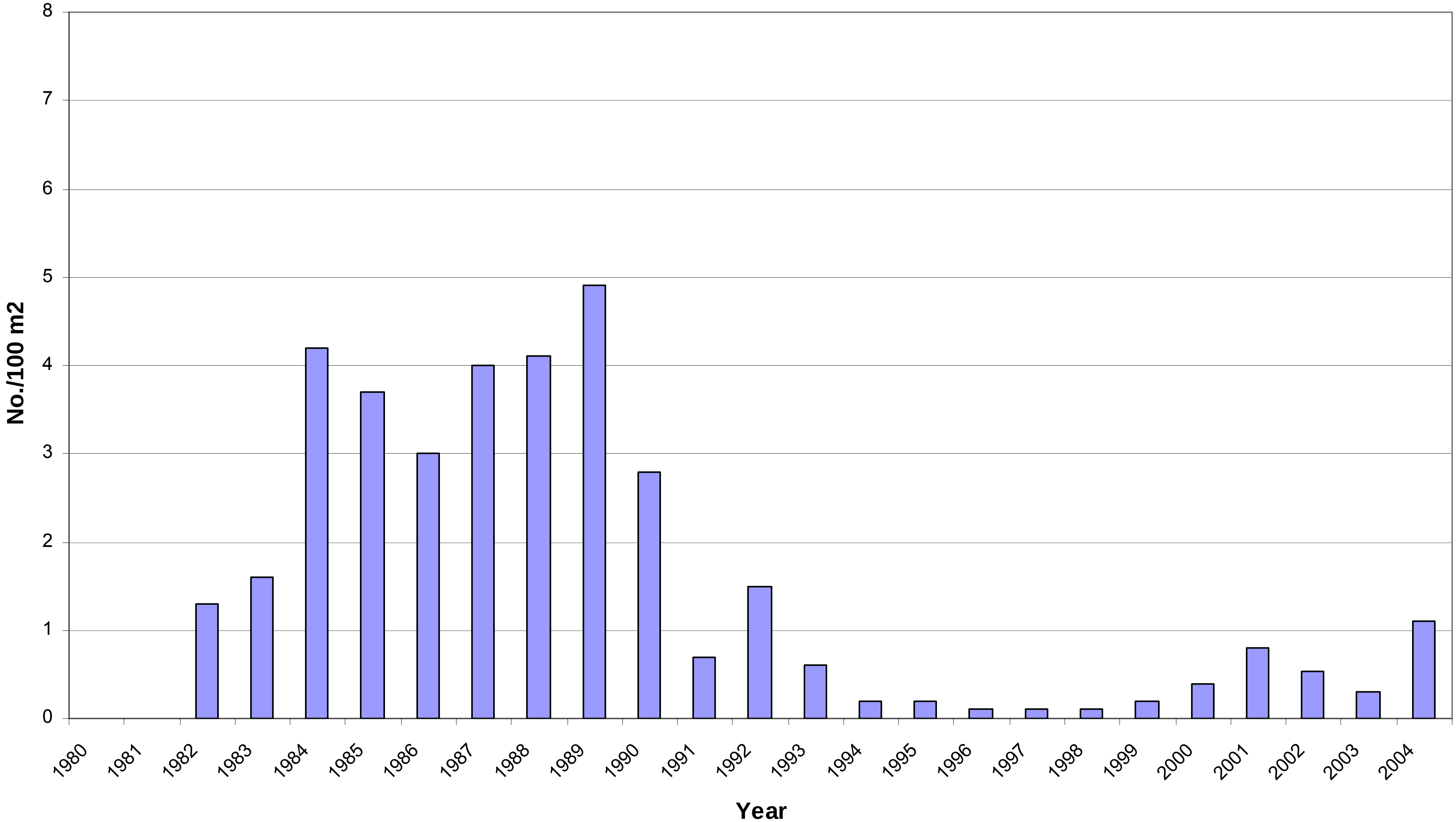
The North Coal electrofishing section is located just upstream from the upper bridge crossing of Forest Road 317. Field crews have electrofished this section annually since 1982. Throughout this area the channel is stable and confined by high banks. Stream gradient is slightly over four percent and the substrate is dominated by large particle sizes. Boulders larger than 1.0 m are common. The most abundant habitat type is pocketwater with little woody debris present. No bull trout spawning occurs within this general area but redds have been documented both up and downstream from here. It is likely this reach supported rearing fish which moved upstream from the Dead Horse spawning area when it was being heavily utilized prior to 1990.

Over the past 23 years, estimates of Age I and older bull trout abundance in the North Coal section have ranged from a high of 48 ± 12 during 1984 to a low of 6 ± 2 during 1993 and 2002 (Figure 5, Appendix C-3). Over the past 11 years the electrofishing crew did not capture enough juvenile bull trout to calculate valid estimates during eight of them. The values reported for $\hat{N}$ in Appendix C-3 during these years are the total numbers of juvenile bull trout captured during the first electrofishing pass. During years when estimates could be calculated, the average estimated abundance is 24.9 Age I and older bull trout. Juvenile bull trout density during this period has ranged from 4.89 to 0.08 Age I and older bull trout per 100 m^2 of stream surface area (Figure 5). During the 15 years when estimates could be calculated, juvenile bull trout density in the North Coal section has averaged 2.32 per 100 m^2. Densities reported in Appendix C, Table 3 for the years when no estimates are available are expansions from the numbers captured during first-pass electrofishing and are underestimates of actual densities.

This section is moderate in size with wetted widths typically from 6.0-8.0 m and discharge of approximately 25 cfs during low summer flows. The higher gradient and large substrate size create some difficulty, but in general electrofishing is relative efficient. Once fish are stunned it is easy to keep them downstream from the positive electrode. Quite a few fish are captured off the block net in this section.

Estimated abundance and densities increased in 1984 and remained relatively stable throughout the following six years (Figure 5). A sharp decline occurred in the early 1990s and during eight years since 1994, the field crew could not capture enough juvenile bull trout in the North Coal section to calculate valid estimates. Habitat indices show that fine sediment in the spawning/ incubation environment downstream in the Dead Horse reach exceeded the recommended threshold level during 19 of the past 23 years. It is likely the decline in juvenile bull trout density in this reach is tied to poor habitat conditions and lack of spawning during recent years downstream in the Dead Horse reach. Substrate scores in North Coal Creek have remained in good to excellent condition since we began monitoring them in 1984 (Appendix B), indicating that rearing potential is there, it’s just not being seeded.

Figure 5. Densities of Age I and older bull trout calculated from annual electrofishing in the index section of North Coal Creek from 1982 through 2004.



South Fork of Coal Creek

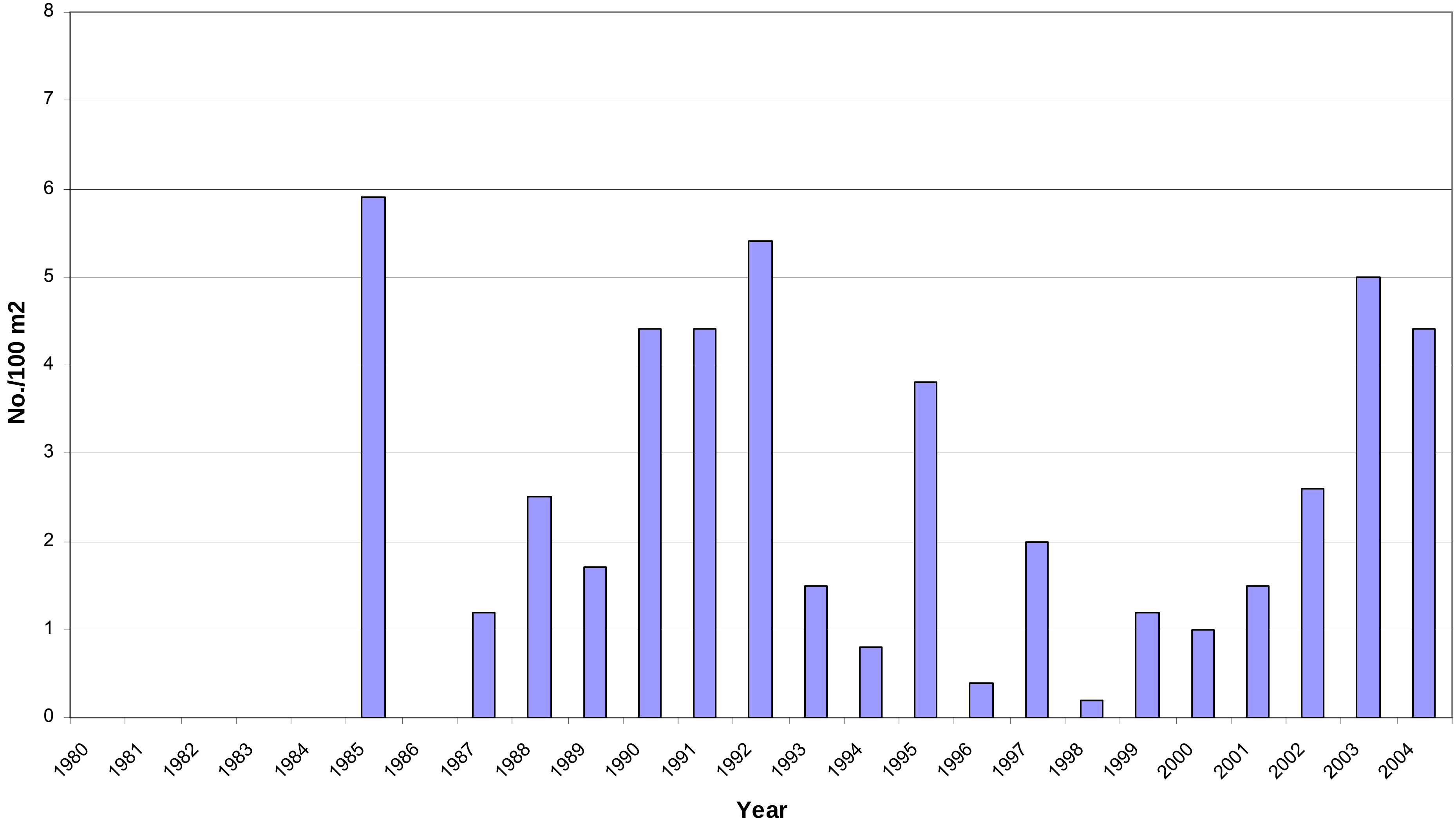
The South Coal fish abundance section is located approximately 2.0 km upstream from the gate on Forest Road 317. With the exception of 1986, field crews have sampled this section annually since 1985. Throughout this area the channel is unconfined and stream gradient is less than three percent. The substrate is dominated by cobble-sized material. The habitat type here is generally riffle/run with low amounts of woody debris. This area was clear-cut during the late 1970s and in several locations the channel was artificially straightened with heavy equipment. This area is highly unstable and extensive bed load movement occurs during high flows. The bull trout spawning area in South Coal Creek is several kilometers in length and is located just upstream from this section.

Over the past 20 years, estimates of Age I and older bull trout abundance in the South Coal section have ranged from a high of 62 ± 8 during 1985 to a low of 9 ± 2 during 1994 (Figure 6, Appendix C-4). No estimates were possible in 1996 and again in 1998 due to the low number of juvenile bull trout captured. The values reported for $\hat{N}$ in Appendix C, Table 4 during these years are the total numbers of juvenile bull trout captured during the first electrofishing pass. During the years when estimates could be calculated, the average estimated abundance is 31.6 Age I and older bull trout. Juvenile bull trout density during this period of record has ranged from 5.91 to 0.16 Age I and older bull trout per 100 m^2 of stream surface area (Figure 6). During the 17 years when estimates could be calculated, juvenile bull trout density in the South Coal Creek section has averaged 2.88 per 100 m^2. Densities reported in Appendix C for 1996 and 1998 are expansions from the numbers captured during the first pass electrofishing and are underestimates of actual densities.

This section is moderate in size with wetted widths from 5.0-7.0 m and discharge of approximately 15-20 cfs during low summer flows. Electrofishing is generally efficient; only one pool with substantial cover creates some difficulty during high flow years. Probability of first-pass capture have generally equaled or exceeded the recommended level of 0.6 assuring valid estimates (Figure 6).

Estimated abundance and densities have fluctuated more in the South Coal section than in the other sections in the Coal Creek Drainage (Figure 6). This may be due to the unstable nature of the channel throughout this area. This instability results from past land management activities in the drainage. Despite this instability our habitat indices have remained at levels suggesting adequate conditions, especially in recent years. Both spawning and rearing habitat indices show that since 1994, conditions have been as good as we have observed since we began monitoring in 1985 (Appendix A and B). The crash and current low level of spawning and juvenile bull trout abundance in other parts of the Coal Creek Drainage suggests this is likely a separate stock whose population statistics fluctuate independently.

Figure 6. Densities of Age I and older bull trout calculated from annual electrofishing in the index section of South Coal Creek from 1985 through 2004.



Red Meadow Creek

The Red Meadow Creek fish abundance section is located at the first crossing of Forest Road 115. The bridge is the center of the section which extends 75 m up and downstream. Field crews have electrofished this section during 16 of the past 23 years. Our initial survey was in 1983. Throughout this area the channel is occasionally confined by steep banks and stream gradient is approximately 2.0 percent. The substrate is dominantly cobble and large gravel. The habitat type is a combination of riffle/run and pocketwater. The channel is relatively stable with moderate amounts of large woody debris. The Red Bench fire burned over this section in 1988 and we saw a substantial increase in woody debris following the fire. This section is located at the downstream end of the bull trout spawning area in Red Meadow Creek.

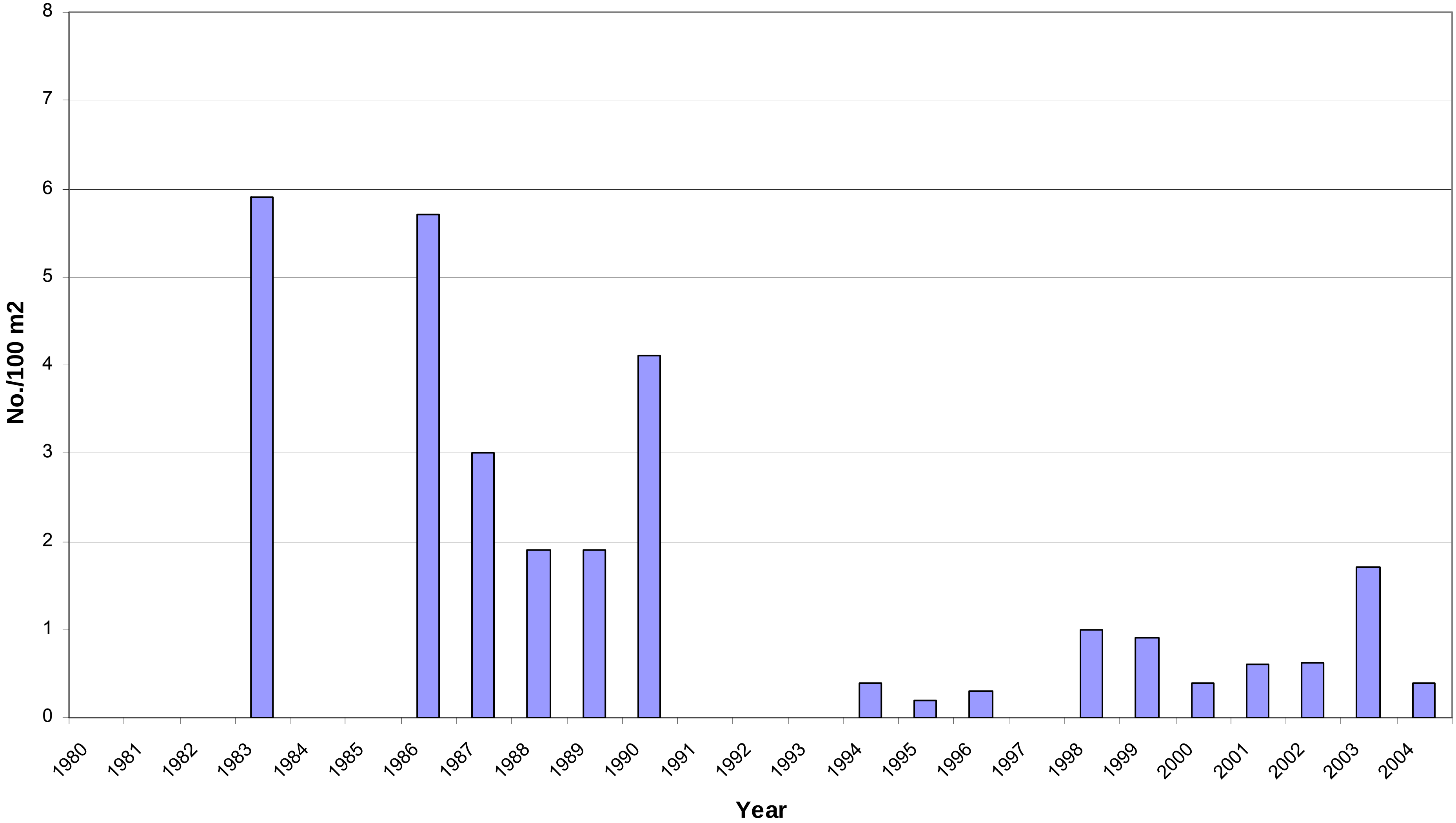
During the years when we surveyed Red Meadow Creek estimates of Age I and older bull trout abundance have ranged from a high of 77$\pm$10 during 1983 to a low of 8$\pm$4 during 1999 (Figure 7, Appendix C-5). During the three year period between 1994 and 1996, again in 2000, 2001 and 2004 the electrofishing crew did not capture enough juvenile bull trout to calculate valid estimates. The values reported for $\hat{N}$ in Appendix C-5 during these years are the total numbers of juvenile bull trout captured during the first electrofishing pass. The average estimated number of Age I and older bull trout in this section is 33.4. Juvenile bull trout density during the period of record has ranged from 5.87 to 0.16 Age I and older bull trout per 100 m^2 of stream surface area (Figure 7). During the ten years when estimates could be calculated, juvenile bull trout density in the Red Meadow section has averaged 2.68 per 100 m^2. Densities reported in Appendix C-5 for years when no estimate is available are expansions from the numbers captured during the first electrofishing pass and are underestimates of total density.

This section is moderate in size with wetted widths of approximately 6.0-8.0 m and discharges of 15-20 cfs during low summer flows. The electrofishing crew failed to obtain first pass capture efficiencies of 0.6 or greater during the three years (1989, 1990 and 2002), so multiple pass techniques requiring additional electrofishing effort were employed during these years (Appendix C-5). This was largely due to the increase in woody debris following the Red Bench fire. We did not conduct electrofishing surveys here in 1991, 1992, or 1993 and by 1994 most of the new woody debris was gone. We did not capture enough juvenile bull trout to calculate valid estimates in 1994, 1995, or 1996. We did not survey this section again in 1997, but the 1998 and 1999 efforts showed that juvenile bull trout abundance had rebounded slightly (Figure 7).Low numbers prevented estimates in 2000, 2001 and 2004. Substrate scores show rearing habitat remains above threshold levels however poor spawning habitat quality and extremely limited spawning in recent years is likely preventing adequate seeding similar to Coal Creek at Dead Horse.

Whale Creek

The Whale Creek fish abundance section is located just downstream from the confluence with Shorty Creek. Field crews have electrofished this section annually

Figure 7. Densities of Age I and older bull trout calculated from electrofishing in the index section of Red Meadow Creek from 1983 through 2004.



since 1981 with the exceptions of 1982, 1984, 1985, 1988, and 1991, or 19 of the past 24 years. The channel in this area is occasionally confined and stream gradient is approximately 2.0 percent. The streambed substrate is dominantly cobble and large gravel. The habitat type is generally riffle/run with occasional pools formed by large woody debris. Following the spring runoff of 1997 the lower half of this section changed from a pool and tail out with large wood to a run. High flows moved most of the wood and the pool filled in with cobble/gravel. Overall this area is relatively stable and is located at the upstream end of the bull trout spawning reach. Whale Creek falls is located 1.0 km upstream and blocks upstream fish migration.

Over the period of record estimates of Age I and older bull trout abundance in the Whale Creek section have ranged from a high of 134 ± 7 during 1998 to 32 ± 10 during 1986 (Figure 8, Appendix C-6). During 1997, the electrofishing crew did not capture enough juvenile bull trout to calculate valid estimates. The value reported for $\hat{N}$ in Appendix C-6 during 1997 is the total number of juvenile bull trout captured during the first electrofishing pass. Average estimated abundance over the period of record is 62.8 Age I and older bull trout (n=18 years). Juvenile bull trout density has ranged from 8.52 to 0.57 Age I and older bull trout per 100 m^2 of stream surface area (Figure 8). Over the 18 years when estimates were completed juvenile bull trout density averaged 3.99 Age I and older fish per 100 m^2. The density reported in Appendix C-6 for 1997 is an expansion from the number captured during first pass electrofishing and is an underestimate of actual density.

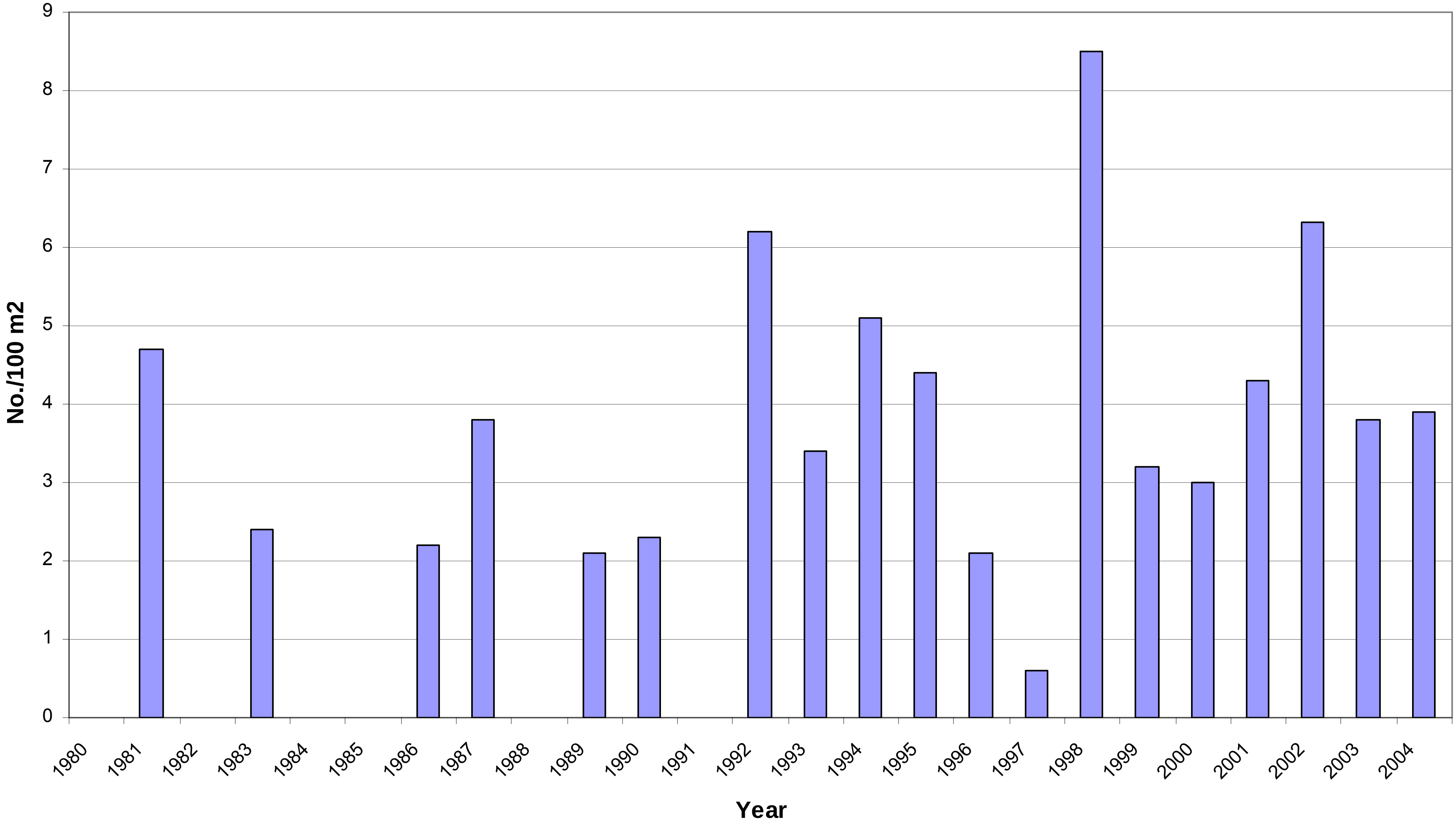
This section is one of the largest of our index areas. Wetted widths can be up to 13.0 m and discharge can be as high as 40 cfs. The electrofishing crew had trouble meeting the first pass capture efficiency of 0.6 during several years. Multiple pass techniques requiring additional electrofishing effort were employed during those years (Appendix C-6). The large pool which formed the downstream portion of this section was extremely difficult to work during high flow years. However, spring flows in 1997 washed out most of the large woody debris and filled in cobble and gravel making it easier to capture fish during recent years.

Estimated abundance and densities have fluctuated since we began monitoring here in 1981 (Figure 8). A decline occurred in 1997 which may have resulted from the channel change in our section. However, the 1998 estimates are the highest on record to date and are encouraging. Habitat quality indices show that fine sediment levels in the spawning/incubation environment reached or exceeded recommended thresholds during two years at the end of the prolonged drought period in the 1980s, but have improved since then (Appendix A). The juvenile rearing habitat index has remained in good condition throughout the period of record (Appendix B).

Morrison Creek

The Morrison Creek fish abundance section is located approximately 1.5 km upstream from the gate on Forest Road 569 below Puzzle Creek. With the exception of 1981 and 1984, field crews have sampled this area annually over a 25-year period between 1980

Figure 8. Densities of Age I and older bull trout calculated from electrofishing in the index section of Whale Creek from 1981 through 2004.



and 2004. The channel meanders through alluvial material deposited during the 1964 flood. Gradient in this portion of Morrison Creek is approximately five percent and the streambed and channel area are comprised mostly of boulder/cobble substrate. Pocketwater habitat is predominant with riffle/run type scattered through the section. Active channel braiding is occurring and in recent years low summer flows have been split into several channels. Prior to 1990, there was only one area where the channel split. This section is at the upstream end of the bull trout spawning reach and bull trout spawning has been documented in the general vicinity of this section.

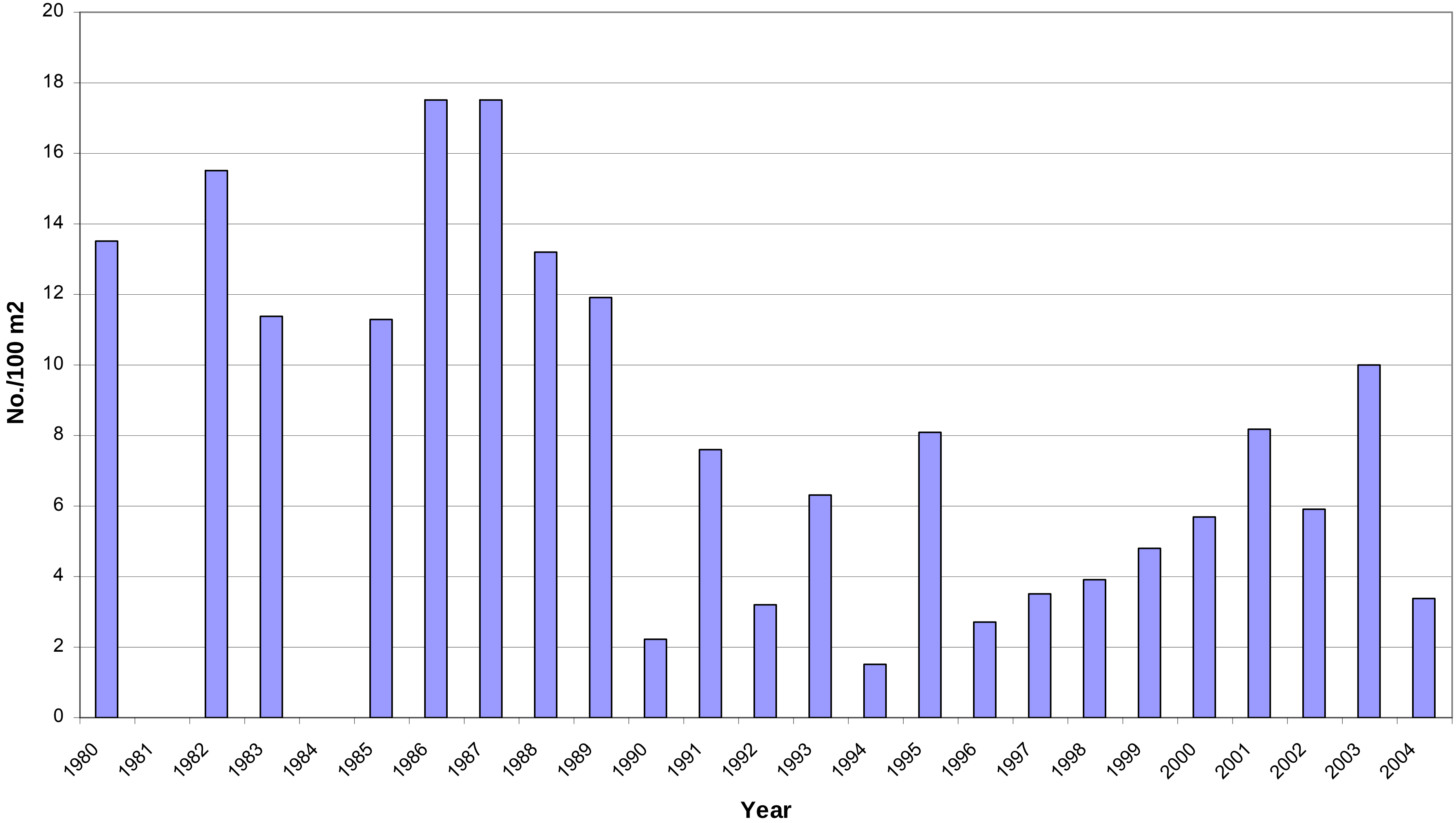
Over the past 25 years, estimates of Age I and older bull trout abundance in the Morrison Creek section ranged from a high of 138 ± 9 during 1987 to a low of 16 ± 3 during 1994 (Figure 9, Appendix C-7). Field crews have captured estimated numbers each year since our efforts began. Annual estimates average 68.2 Age I and older bull trout (n=23). Densities have ranged from 17.54 to 1.46 Age I and older bull trout per 100 m^2 of stream surface area (Figure 9). The average density during the period of record is 8.08 Age I and older bull trout per 100 m^2 surface area.

This section is one of the smaller index areas with wetted widths less than 5.0 m and discharge of less than 10 cfs during low summer flows. This section is easily shocked with a single backpack electrofishing unit and we have typically obtained adequate first pass capture efficiencies. Although the braided sections take longer to work through, we generally have few problems getting valid estimates in this section.

In the past, we observed high estimated numbers and densities in the Morrison Creek section. Strongest populations occurred during the 10-year period between 1980 and 1989 (Figure 9). During the spawning runs in 1987 and 1988 an upstream migration barrier occurred at stream km 5. 5. Progeny from these years would have been Age I and II fish during the 1990 estimate. The estimated number and density of juvenile bull trout in our electrofishing section at stream km 18.5 declined to extremely low levels in 1990 (Figure 9). Estimated abundance rebounded in 1991 then returned to extremely low levels again in 1992. This pattern of high-low-high-low continued through 1996. Estimates during the next two years showed more stability but remain low. However, 1997 and 1998 estimates are higher than the four lowest years following 1990 and the barrier-related decline. The barrier was removed by USFS personnel in 1992. Estimated numbers and densities increased from 1999 through 2003 but the most recent effort (2004) yielded low results. It is possible that adults were unable to reach the upper portion of the spawning reach due to low flow conditions and beaver activity downstream.

Our habitat index of juvenile bull trout rearing shows that in general this portion of Morrison Creek has remained in good to excellent condition over the period of record (Appendix B). We do not index spawning and incubation habitat quality in Morrison Creek.

Figure 9. Densities of Age I and older bull trout calculated from annual electrofishing in the index reach of Morrison Creek from 1980 through 2004.



Ole Creek

The Ole Creek fish abundance section is located just downstream from the Fielding-Coal trail crossing in Glacier National Park. Field crews have electrofished this section during 10 of the last 23 years. This portion of Ole Creek passes through alluvial material deposited during the 1964 flood event. Gradient is three to four percent and the streambed and channel area is comprised of mostly cobble substrate. Riffle/run habitat predominates and there is little large woody debris present. Channel width is greater than 100 m due to the intensity of the 1964 flood and conditions are still largely unstable. This section is about 2.0 km upstream from the main bull trout spawning reach so the juvenile bull trout rearing here likely dispersed upstream after hatching.

Over the ten years when sampling occurred, estimates of Age I and older bull trout abundance ranged from a high of 46 ± 2 in 1989 to a low of 25 ± 12 during our initial sampling in 1982 (Figure 10, Appendix C-8). The field crew failed to capture enough juvenile bull trout to calculate a valid estimate in 1999. The value reported for $\hat{N}$ in Appendix C-8 for this year is the number of Age I and older bull trout captured during the first electrofishing pass. During the nine years when we could calculate estimates, abundance averaged 37.3 Age I and older bull trout. Densities have ranged from 3.85 to 0.78 Age I and older bull trout per 100 m^2 of stream surface area (Figure 10). The average density during the period of record is 2.89 per 100 m^2.

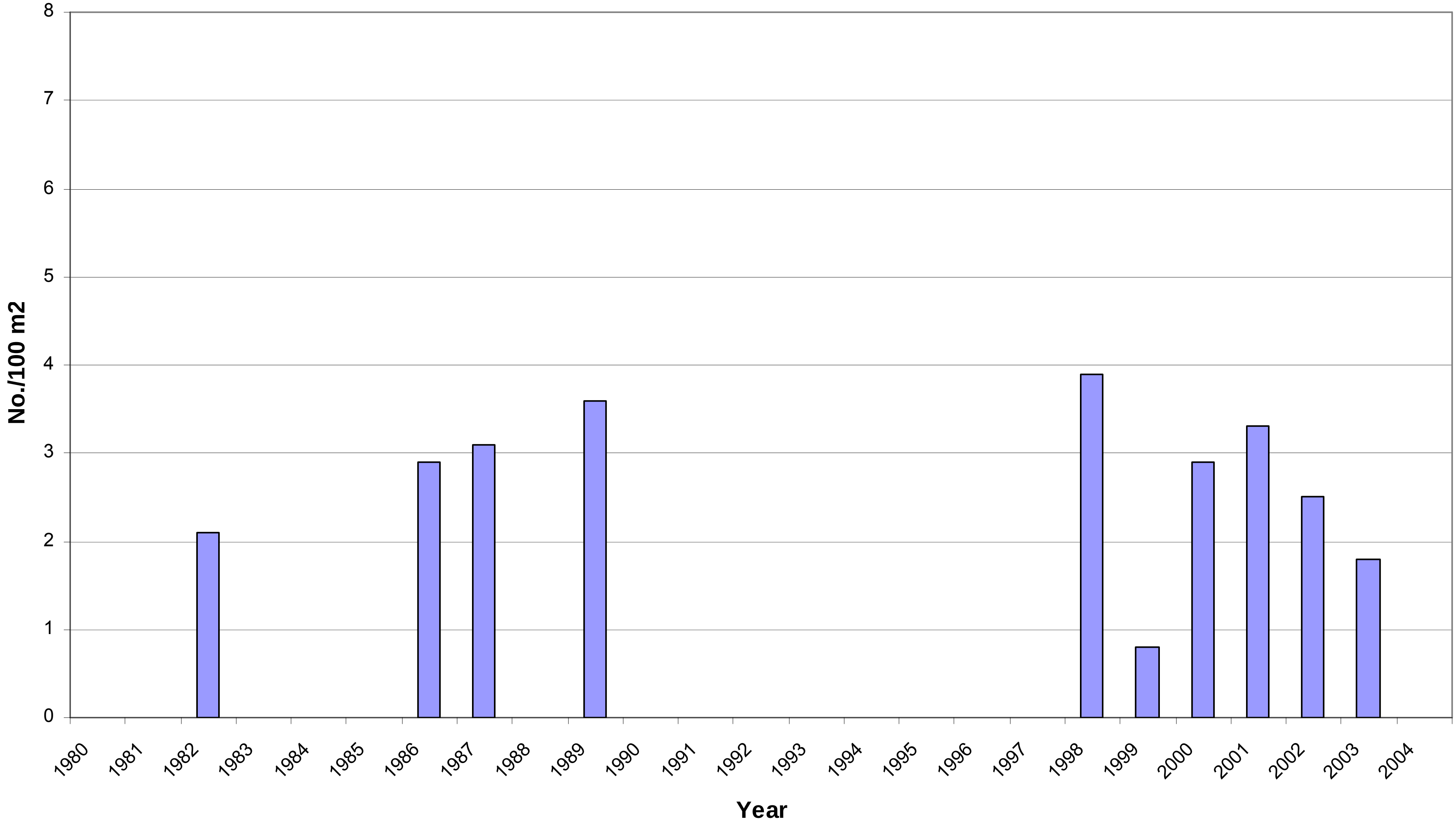
This is a large area section with wetted widths exceeding 15 m and discharge of about 50 cfs. This section is difficult to work during high flow years due to the relatively large substrate size, width and in several runs, depth and undercut banks. We did not attempt to sample this section in 2004 due to extremely high flows from late summer precipitation. Access is by hiking the 4.0 km along the Fielding Coal trail from the railroad near Summit.

Our data set for Ole Creek is not as complete as most of the other index streams. As previously stated, our initial effort in 1982 was the low point in estimated juvenile bull trout abundance (Figure 10). We missed the next three years (1982-1985) but returned in 1986 and 1987 with estimates showing higher abundances. No sampling took place in 1988, but 1989 results were similar to 1986-1987 samplings (Figure 10). From 1990 through 1997 we did not complete fish abundance estimates for this section. Annual sampling began again in 1998 and continued through 2003. Results show fluctuations typical of most of our bull trout index sections (Figure 10). Our index of rearing habitat quality shows that suitable conditions have been present since we began tracking substrate scores in 1986 (Appendix B). It is likely juvenile bull trout densities in this section of Ole Creek are controlled by the fact that the spawning area is some distance downstream and rearing fish must migrate upstream to seed this reach.

Granite Creek

The Granite Creek fish abundance section is located near the end of Forest Road 9684 near the Wilderness boundary. Field crews have electrofished this section annually

Figure 10. Densities of Age I and older bull trout calculated from electrofishing in index section of Ole Creek from 1982 through 2004.



during the past four years. We added this section to better balance our index between North Fork and Middle Fork tributaries. This section of Granite Creek is occasionally confined and gradient is less than two percent. The substrate is mostly gravel and cobble with an occasional bedrock outcrop. The habitat type here is riffle/run with scattered pools formed by large woody debris accumulations. The channel is relatively stable, although evidence of the 1964 flood event can still be seen. This section is at the upstream end of the bull trout spawning reach and we have observed redds in the electrofishing section.

The estimated number of Age I and older bull trout in this section has averaged 43.5 fish ranging from a high of 57 in 2001 to a low of 33 in 2004 (Figure 11, Appendix C-9). Juvenile bull trout density has averaged 4.51 during the four years of sampling with a range from 5.99 to 3.21 Age I and older bull trout per 100 m^2 surface area.

This section is comparatively easy to electrofish. Wetted width is 6 to 8 m and discharge is approximately 15 cfs. The electrofishing crew has had no trouble obtaining first-pass capture efficiencies greater than 0.60. Portions of the drainage upstream from this section burned during the Challenge Fire in 1998 and our index of spawning habitat quality shows sediment levels have increased since 1999. Currently, Granite Creek is at the threshold where embryo survival to emergence is threatened.

<u>Composite Index</u>

To assess overall juvenile bull trout abundance in tributaries to Flathead Lake we developed annual composite densities (Figure 12). This composite is simply the average of all estimates of Age I and older bull trout in the sections electrofished during any given year. From 1986 through 2000 the composite is comprised of four North Fork tributaries (Big, Coal, Red Meadow and Whale) and Morrison Creek. Since 2001 we have included Ole and Granite creeks to better balance our index between the drainages. As previously discussed, juvenile bull trout densities are strongly correlated with substrate scores (Weaver and Fraley 1991, FBC 1991). Densities may also be influenced by fine sediment levels in the spawning/incubation environment. Composite density began to decline during the late 1980s (Figure 12). This trend coincides with the extended drought period when both spawning/incubation and juvenile rearing habitat quality indices showed declining trends. Our indices suggest that habitat responded positively to flushing flows in the early 1990s, however composite juvenile bull trout density continued to decline through 1996 (Figure 12). It is likely that changes in the trophic dynamics of Flathead Lake began to influence bull trout abundance during the early to mid-1990s. Bull trout spawner escapement declined precipitously between 1991 and 1992 then remained stable but low for six years (see next section). Composite density increased even though spawner escapement was extremely low during 1992-1997 (Figure 12). This suggests better survival of these year classes due to improving tributary habitat conditions and possibly some stabilization in the trophic dynamics in Flathead Lake. Since we did not complete an estimate in Ole Creek during 2004, the full data set is unavailable for comparison and high flows during most of the other surveys may have resulted in lower estimates last year. At any rate, the decline in

Figure 11. Densities of Age I and older bull trout calculated from electrofishing in index section of Granite Creek from 2001 through 2004.

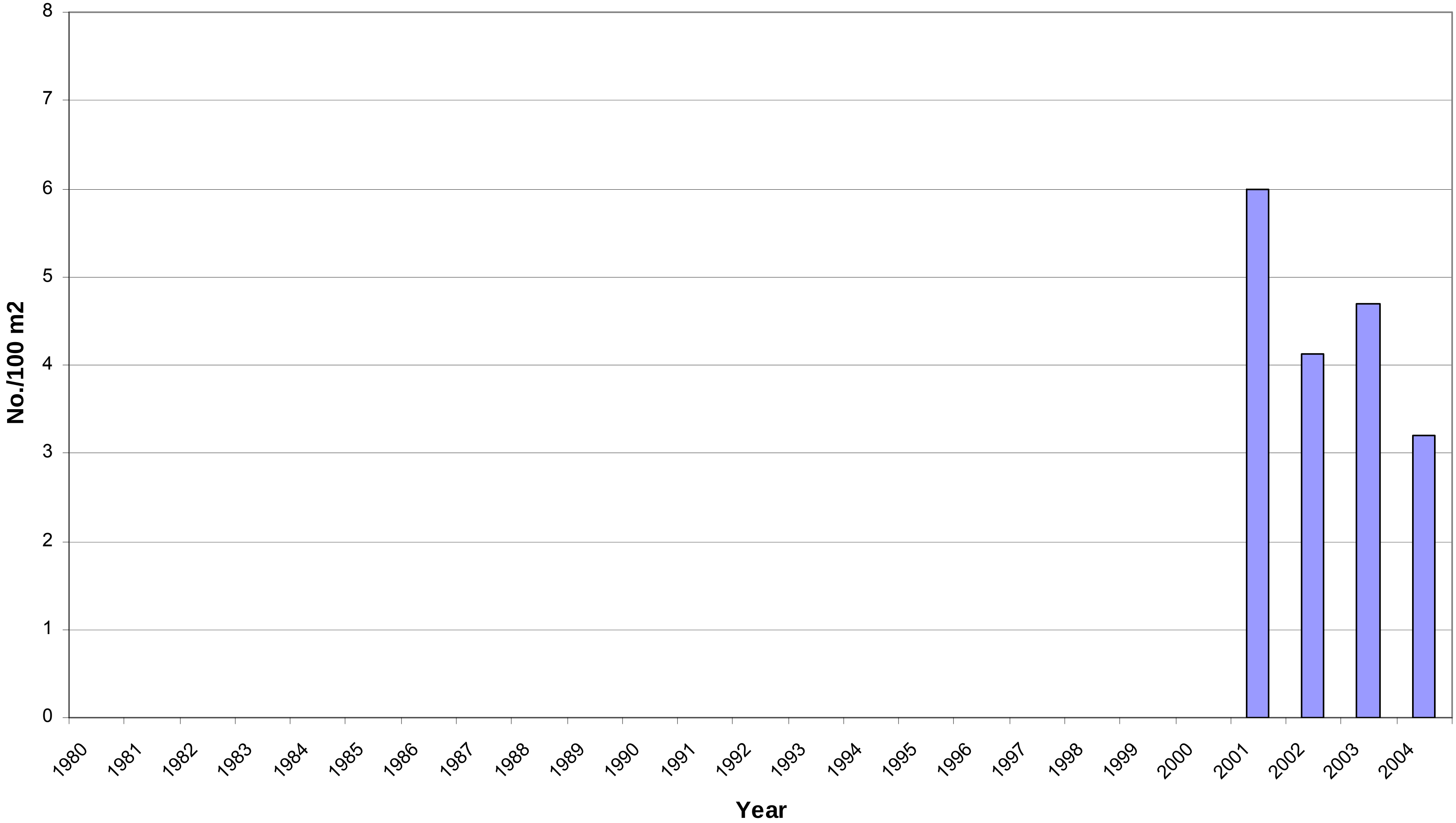
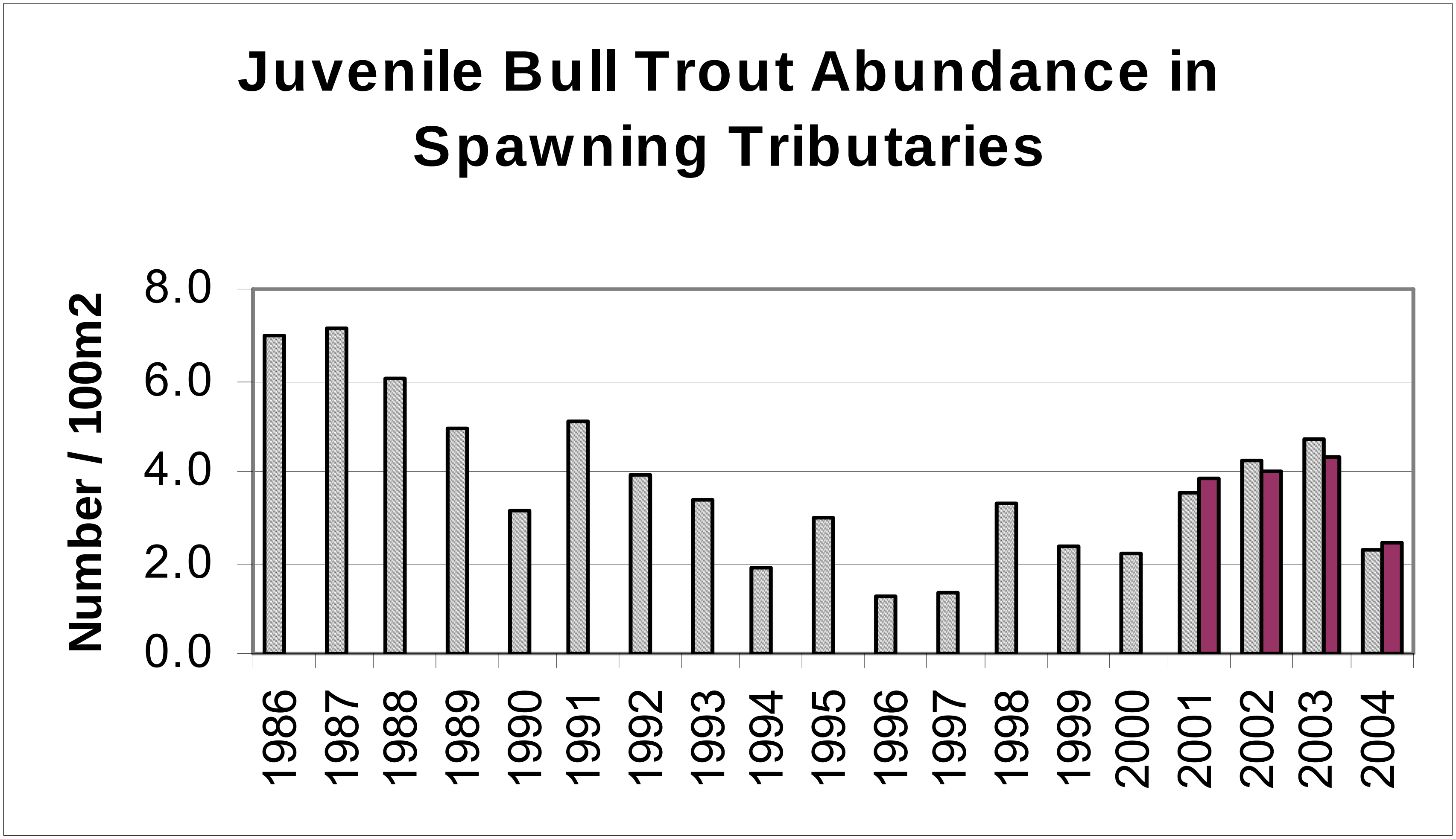


Figure 12. Annual composites of Age I and older bull trout densities calculated from electrofishing in the index sections of Flathead Lake nursery streams (n=5) from 1986 through 2004 (since 2001 n=7).



the 2004 composite density breaks an increasing trend which has been present since the lowest density years in 1996 and 1997 (Figure 12).

Stillwater River

Upper Stillwater Lake supports a disjunct bull trout population which utilize the Stillwater River drainage upstream for spawning and rearing. We believe this population has little or no genetic exchange with the Flathead Lake population. As part of an agreement with DNRC, we began monitoring its status in the early 1990s. This section is located several Km upstream from Emmon's Bridge off Forest Road 900. Large surface area and braiding make it a difficult section to shock efficiently. Wetted width is up to 21 m in the widest places and stream gradient is three to four percent. Substrate is largely cobble with occasional boulder-sized materials mixed in. Riffle/run habitat is the predominant type, with scattered pools formed by large woody debris. Bull trout spawning has been observed in and near this section.

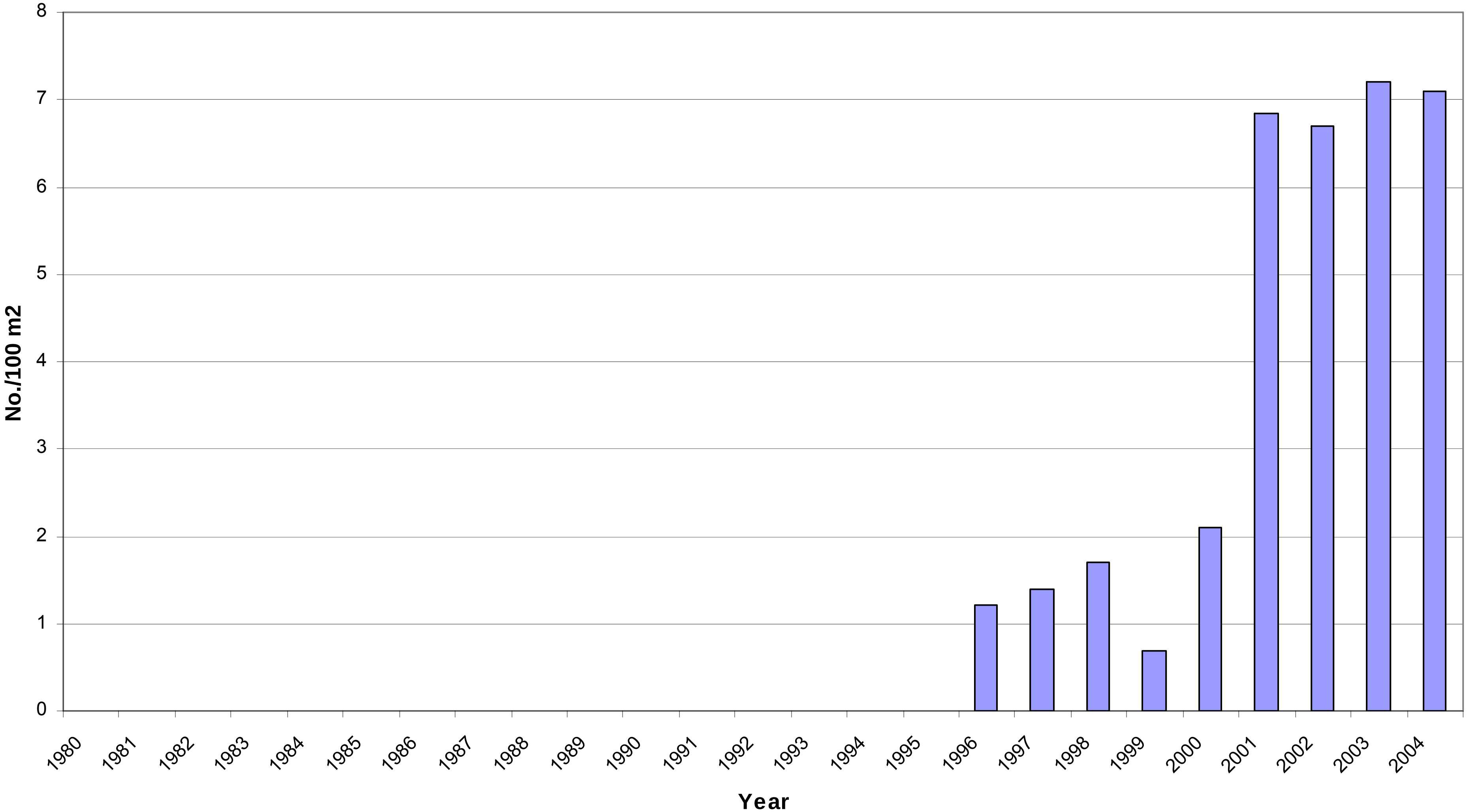
Over the ten years when sampling has occurred, estimates of Age I and older bull trout abundance ranged from a high of 128 in 2004 to a low of 10 in 1999 (Figure 13, Appendix C-10). Age I and older abundance has averaged 55.9 fish over this period. Densities have ranged from 7.18 to 0.68 and averaged 3.64 per 100 m^2 surface area (Figure 13). Juvenile bull trout abundance increased dramatically in 2001 and over the past four years we have handled more juvenile bull trout in this section than anywhere else in the basin. Collections for genetic analysis during the early 1990s showed that a substantial number of the bull trout sampled were full siblings, which means they came from a single pairing. At this point, USFWS personnel reported this population was in imminent danger of extinction. More recent findings clearly show this is not the case. The misinterpretation was likely a sampling artifact which resulted from making the total collection effort in a small length of the stream. Our habitat indices show both spawning and rearing habitat in the upper Stillwater River are in good to excellent shape. We have detected a low level of hybridization with book trout in this section.

West Swift Creek

Whitefish Lake is another Flathead Basin lake which supports a disjunct bull trout population. As with all disjunct populations, we believe there is little or no genetic exchange with the Flathead Lake population. Whitefish Lake bull trout utilize the Swift Creek drainage upstream for spawning and rearing. As part of an agreement with DNRC, we began monitoring in the West Fork of Swift Creek in 1995.

Our electrofishing section in West Swift is located at the lower most crossing of West Swift in the southwest corner of Section 34. This section is relatively simple to shock; wetted width is about 5 m and discharge is approximately 15 cfs. The substrate is cobble and boulder; riffle/run habitat predominates with some areas of pocketwater as well. There is little large woody debris present. The bull trout spawning area is located several Km upstream so we have not observed any redds near this section.

Figure 13. Densities of Age I and older bull trout calculated from annual electrofishing in the index section of the Stillwater River from 1996 through 2004.



We have sampled West Swift annually for the last ten years (Figure 14, Appendix C-11). During the initial three we did not capture sufficient numbers of Age I and older bull trout to calculate estimates. The numbers presented for $\hat{N}$ in Appendix C-11 are the number of fish captured during the first electrofishing pass and densities reported are expansions from these numbers and likely underestimate true densities somewhat. From 1998 through 2002 we were able to calculate estimates, however, three of these years were marginal. No estimates were possible again in 2003 and 2004. In the future, we are considering moving this section closer to the spawning area to obtain a better index for the Whitefish Lake bull trout population.

Westslope Cutthroat Trout

Challenge Creek

Field crews began monitoring the westslope cutthroat trout population in Challenge Creek in 1981 and with the exception of 1984, 1985 and 1988 this section has been sampled annually. Our index section is located just upstream from the crossing of Forest Road 569 near Challenge Cabin. This small stream is easily shocked with a single electrofishing unit, although overhanging vegetation provides considerable cover. Genetically pure westslope cutthroat trout occupy Challenge Creek and spawning by migratory fish has been observed in this section.

Over the period of record, westslope cutthroat trout abundance has ranged from a high of 209 in 1987 to a low of 35 in 1995 and averaged 103.1 Age I and older fish (Figure 15, Appendix C-12). Densities have ranged from 31.19 to 3.68 averaging 14.91 Age I and older fish per 100 m^2 of stream surface area (Figure 15). The Challenge Fire burned most of the Challenge Creek drainage in 1998. Although sampling downstream in Granite Creek showed a decline in spawning habitat quality following the fire, the Challenge Creek sampling results changed little and fish densities during the last two years were well above average.

Langford Creek and Cyclone Creek

We began monitoring Langford and Cyclone creeks in 1983. Both of these streams are small and spawning runs of migratory fish have been documented in both. Early on, the estimates occurred irregularly; 1983 and 1988 in Langford and 1983, 1988 and 1989 in Cyclone. The fish handled during these efforts appeared to be pure westslope cutthroat trout. From 1997 through the present our record is more complete. Many of the fish we are handling now are hybridized with rainbow trout and some appear to be pure rainbow. Genetic analysis is ongoing in these two streams.

Both streams drain areas which burned in the Moose Fire at 2001. Langford Creek burned completely and Cyclone Creek burned partially. Our section in Langford was highly impacted and an attempt to complete the 2001 estimate showed no fish present after the fire (Figure 16, Appendix C-13). The field crew observed dead fish in Langford Creek during post-fire surveys. The 2002 estimate showed that the section had been

Figure 14. Densities of Age I and older bull trout calculated from annual electrofishing in the index section of the West Fork of Swift Creek from 1995 through 2004.

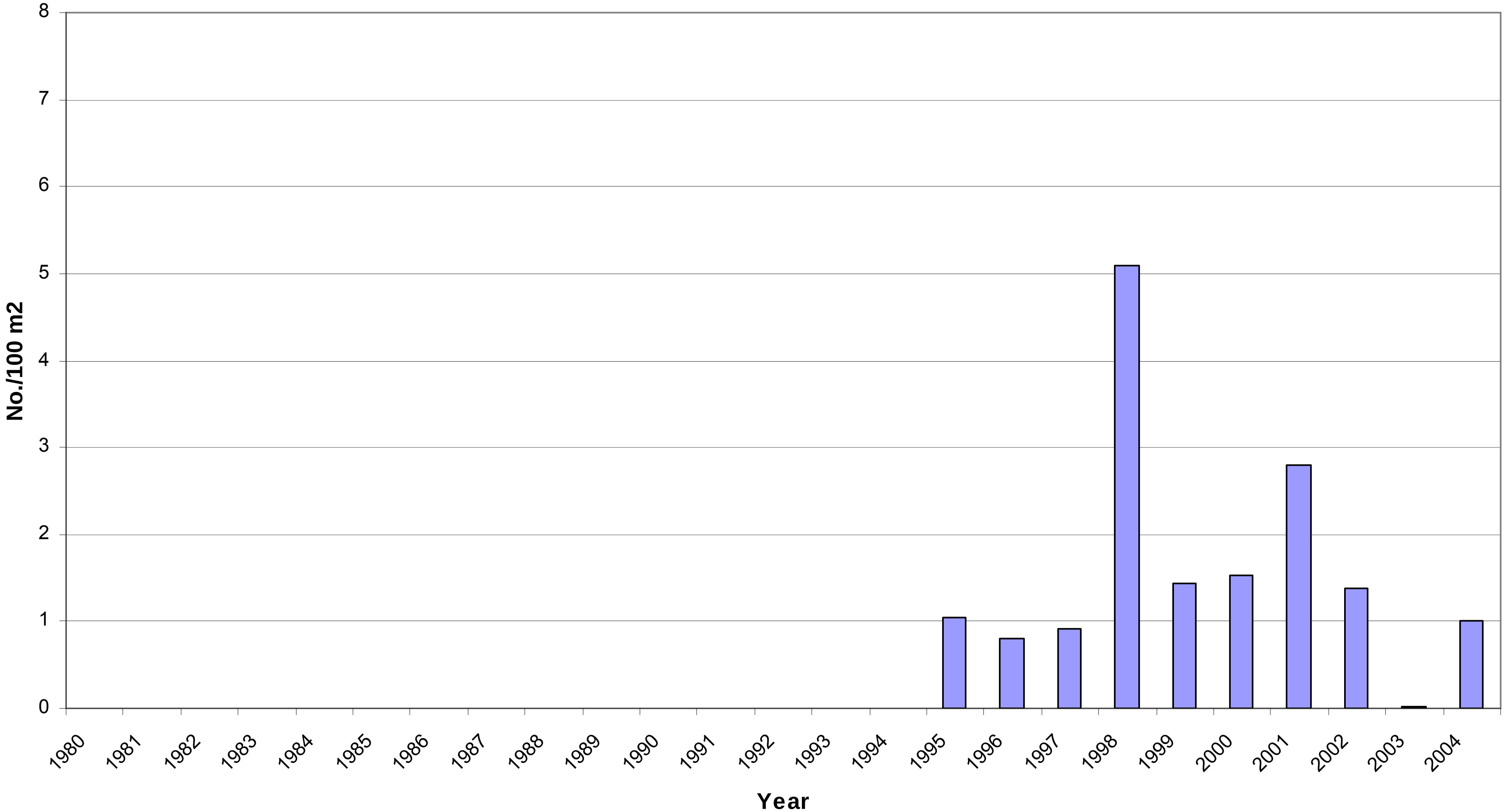


Figure 15. Densities of Age I and older westslope cutthroat trout calculated from electrofishing in the index section of Challenge Creek from 1981 through 2004.

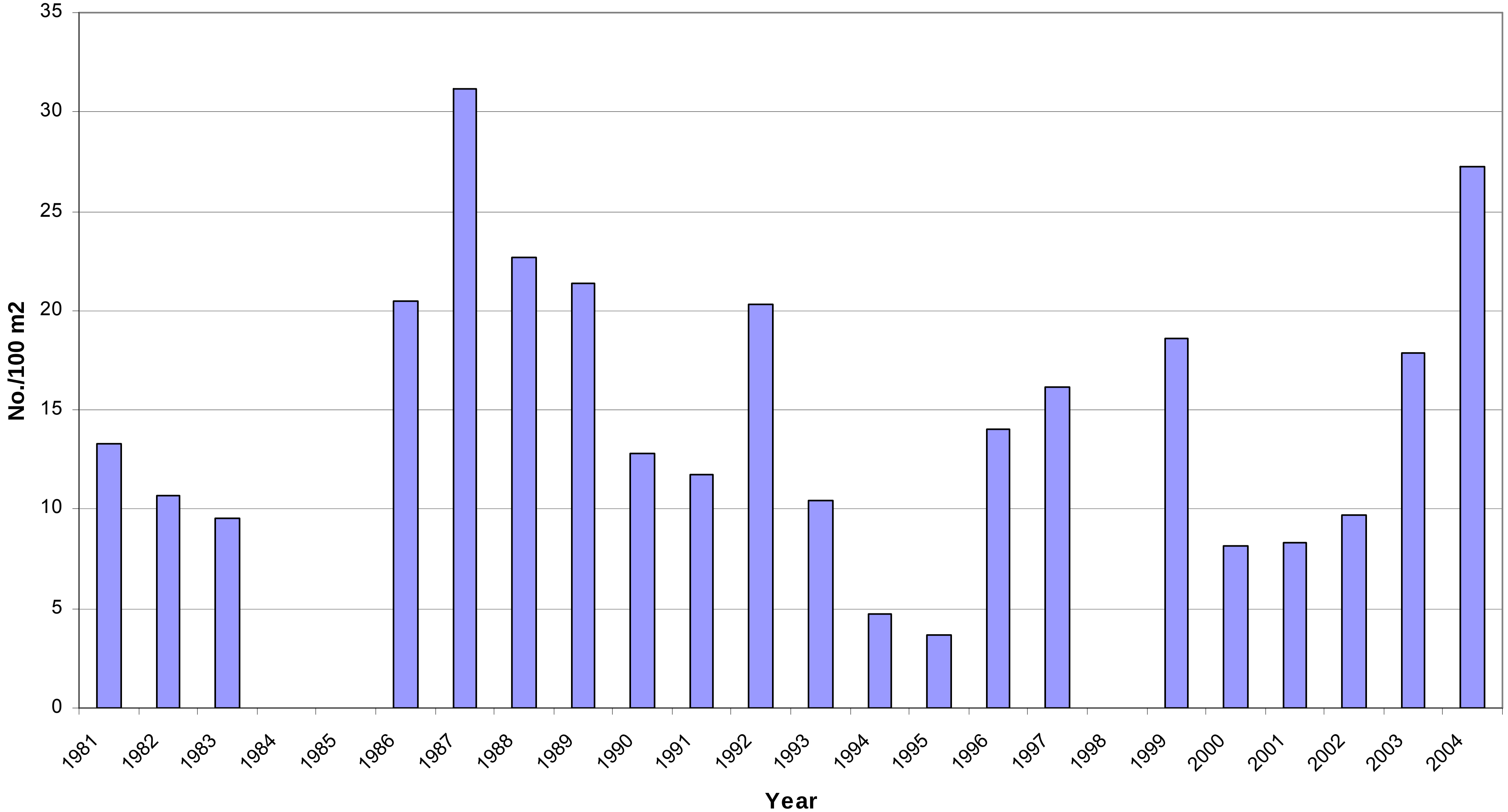
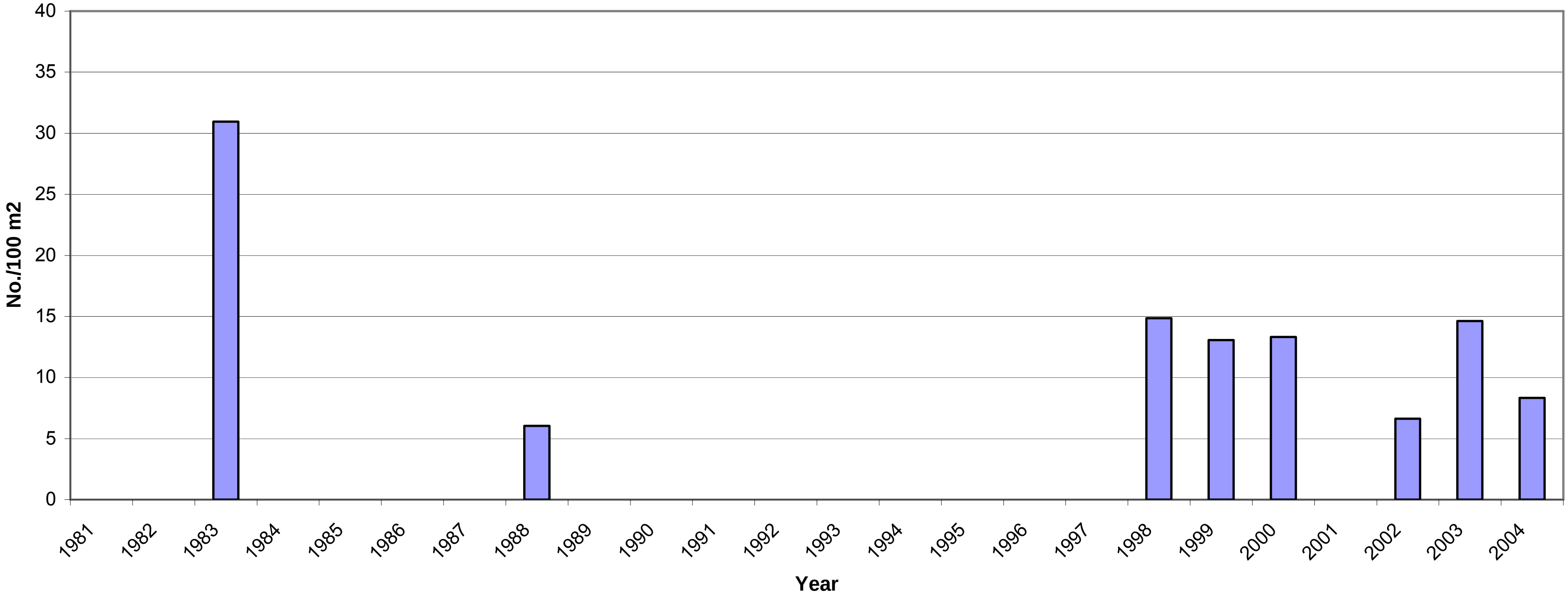


Figure 16. Densities of Age I and older Oncorhynchus sp. calculated from electrofishing in the index section of Langford Creek from 1983 through 2004.



re-colonized, however, one year class was missing. We captured young-of-the-year as well as Age II and III fish, but no Age I's. By the 2003 estimate, things were back within the range of what had been observed pre-fire (Figure 16). The canopy was practically 100 percent pre-fire and it's non-existent now. Instream cover is still available, but greatly reduced.

The Cyclone Creek section is located in Cyclone Meadows and was not influenced by the Moose Fire, although a considerable portion of the drainage upstream was burned. We did not document any fish kill in Cyclone Creek and post-fire estimates have been within the range previously observed (Figure 17, Appendix C-14).

North Coal Creek

This is the same section discussed in the bull trout portion of this report. North Coal is one of four where we get estimates for both bull trout and cutthroat trout. We have sampled here annually since 1982 and estimated numbers of Age I and older cutthroat trout have ranged from 111 in 2001 to 27 in 1983 (Figure 18, Appendix C-15). The average over the 23-year period is 57 fish. Densities have ranged from 9.94 to 2.36 averaging 5.44 Age I and older cutthroat trout per 100 m^2 of stream surface area (Figure 18).

It appears that cutthroat densities have steadily increased in this section while bull trout densities declined sharply in the early 1990s (see the discussion of bull trout abundance). At first glance, one could suggest competition was occurring between these two coevolved species, but closer examination shows that cutthroat densities were increasing even during the years when juvenile bull trout densities were highest. Due to large behavioral differences niche overlap is minimal between these two species and while not totally lacking, competition is likely slight.

We had a gear malfunction in 1999 and could not complete the estimate. The numbers reported for $\hat{N}$ and density in Appendix C-15 are based on the total number of cutthroat captured. Recent genetic testing has shown hybridization with rainbow trout is occurring here.

South Coal Creek

South Coal is another section where annual electrofishing generally yields both a cutthroat and a bull trout estimate. We began sampling here in 1985 and with the exception of 1986, we have sampled annually. We did not capture sufficient cutthroat numbers to calculate estimates in 1996 and 1998 (Figure 19, Appendix C-16). During the 17 years when we could calculate estimates, cutthroat trout abundance has averaged 32.3 Age I and older fish, ranging from a high of 63 in 1985 to a low of 17 in both 1991 and 2004 . Cutthroat trout density has averaged 3.07 Age I and older fish per 100 m^2, ranging from 6.56 to 1.28 (Figure 19). Recent genetic testing has shown slight introgression by rainbow trout in South Coal Creek.

Figure 17. Densities of Age I and older Oncorhynchus sp. calculated from electrofishing in the index section of Cyclone Creek from 1983 through 2004.

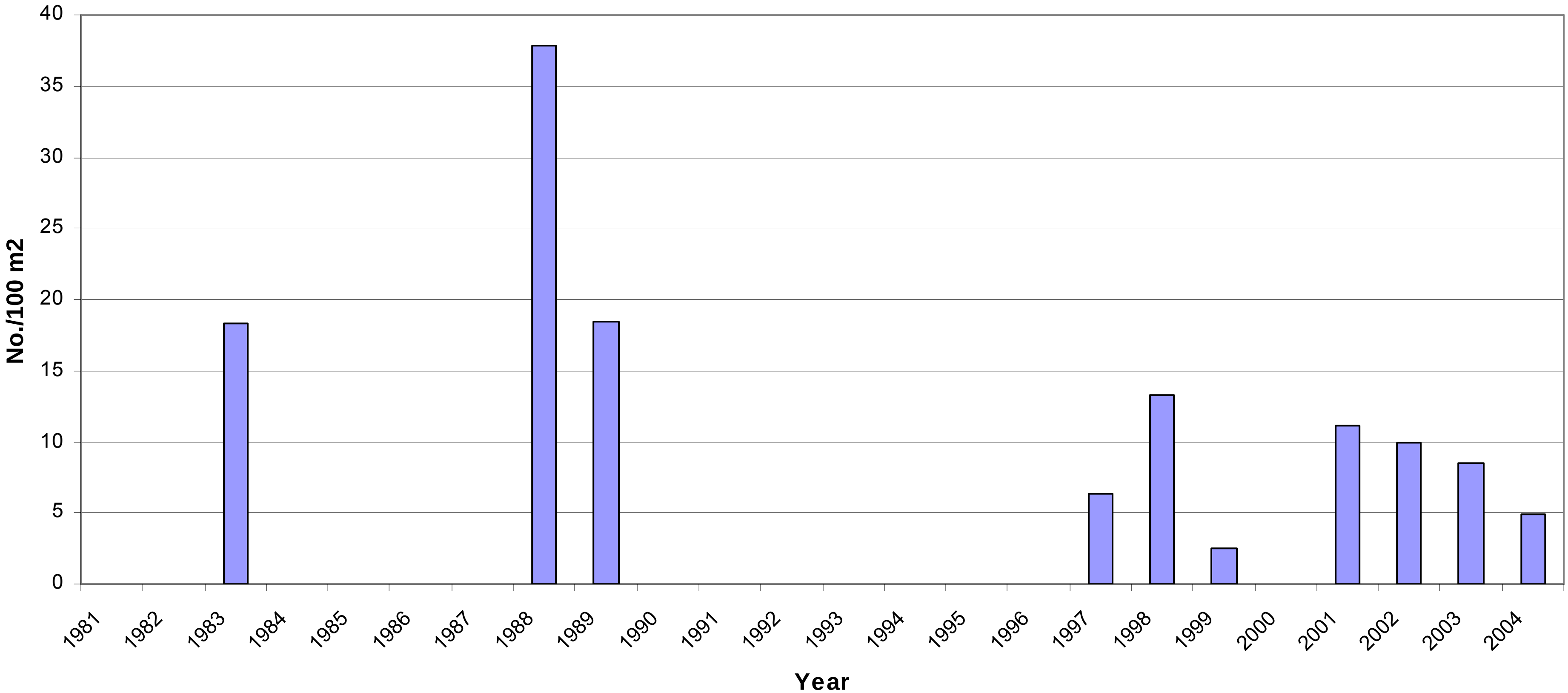


Figure 18. Densities of Age I and older cutthroat trout calculated from annual electrofishing in the index section of North Coal Creek from 1982 through 2004.

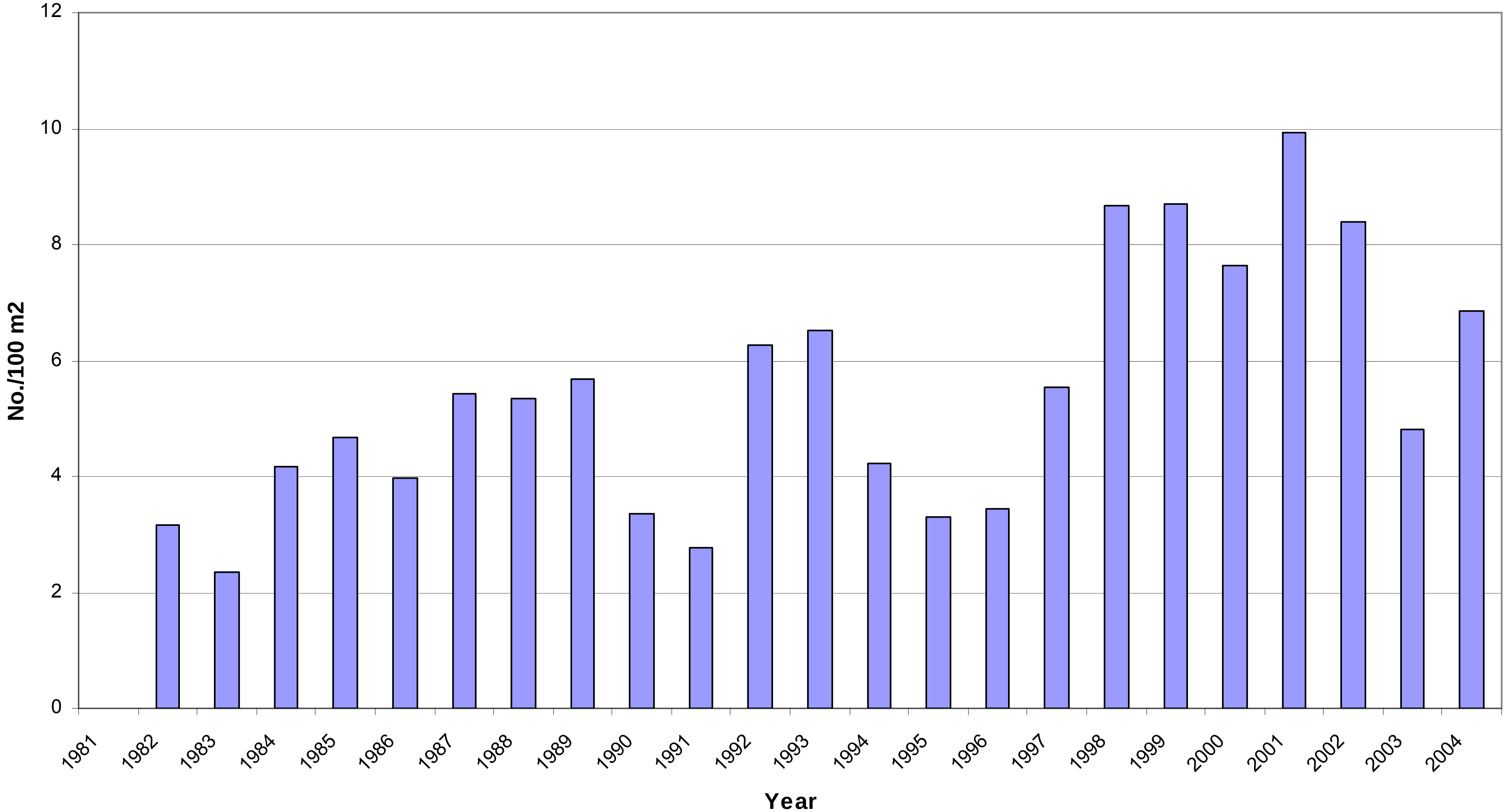
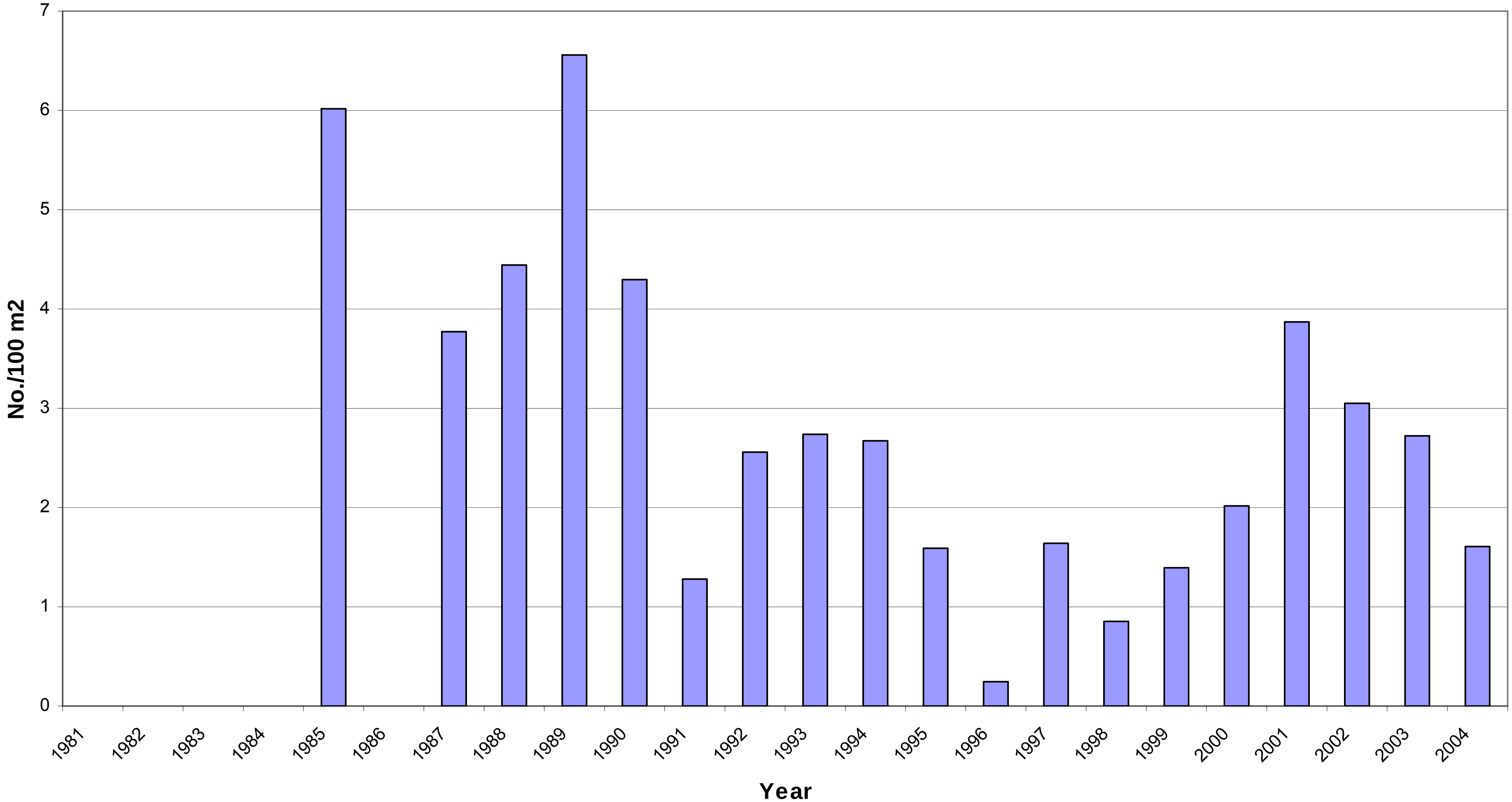


Figure 19. Densities of Age I and older cutthroat trout calculated from annual electrofishing in the index section of the South Fork of Coal Creek from 1985 through 2004.



Red Meadow Creek

The Red Meadow shocking section was previously described (see bull trout abundance discussion) and we have sampled here in 16 of the past 22 years (Figure 20, Appendix C-17). Our gear malfunctioned during the 1989 effort, so the data reported in Appendix C-17 are based on the total number of cutthroat trout handled. Cutthroat trout numbers have ranged from 136 in 2003 to 43 in 1986 and averaged 86.6 during the period of record. Density has ranged from 12.84 to 3.56 Age I and older cutthroat trout per 100 m^2 of surface area and averaged 7.36 (Figure 20). During the past 7 to 10 years, cutthroat densities have remained near or above average, while juvenile bull trout have declined to extremely low densities. Similar to Coal Creek at Dead Horse Bridge, we have documented very little bull trout spawning in Red Meadow Creek in recent years. It is likely the available bull trout habitat is not being seeded. Recent genetic testing has shown introgression by both rainbow and Yellowstone cutthroat trout here.

Stillwater River

The electrofishing section in the Stillwater River yields both a bull trout estimate and a cutthroat trout estimate. A description of this section was presented in the bull trout abundance discussion. Actually, brook trout are also present in the Stillwater River. Our sampling shows that fish populations in this reach of the Stillwater River have increased markedly in recent years. Cutthroat trout numbers ranged from 113 Age I and older fish in 2002 to 5 in 1991, averaging 60.4 over the ten years when sampling was conducted (Figure 21, Appendix C-18). Cutthroat trout densities have ranged from 7.58 to 0.30, averaging 3.97 Age I and older fish per 100 m^2 surface area (Figure 21). Our indices of spawning and rearing habitat quality show both to be in good to excellent shape (Appendix A and B). Genetic testing shows pure westslope cutthroat trout are present in Chepat and Fitzsimmons creeks upstream from our shocking section. Currently, the upper Stillwater River is coded as potentially unaltered with no record of stocking.

East Swift Creek

Field crews have sampled the East Fork of Swift Creek sporadically since 1989. Our most recent effort in 2002 resulted in only three cutthroat trout captured, so no estimate was possible (Figure 22, Appendix C-19). Prior to 2002, estimate cutthroat abundance averaged 31.8 Age I and older fish ranging from 68 to 16. Average density is 4.18 during the six years of sampling and we observed a range of 7.69 to 1.80 Age I and older cutthroat trout per 100 m^2 of stream surface area (Figure 22). Genetic status in East Swift Creek is currently listed as potentially unaltered with no record of stocking, however, rainbow trout were stocked in main Swift Creek downstream from upper Whitefish Lake in 1949. The section is located upstream from upper Whitefish Lake at what is locally known as the “grave site” crossing off Forest Road 115.

Figure 20. Densities of Age I and older cutthroat trout calculated from electrofishing in the index section of Red Meadow Creek from 1983 through 2004.

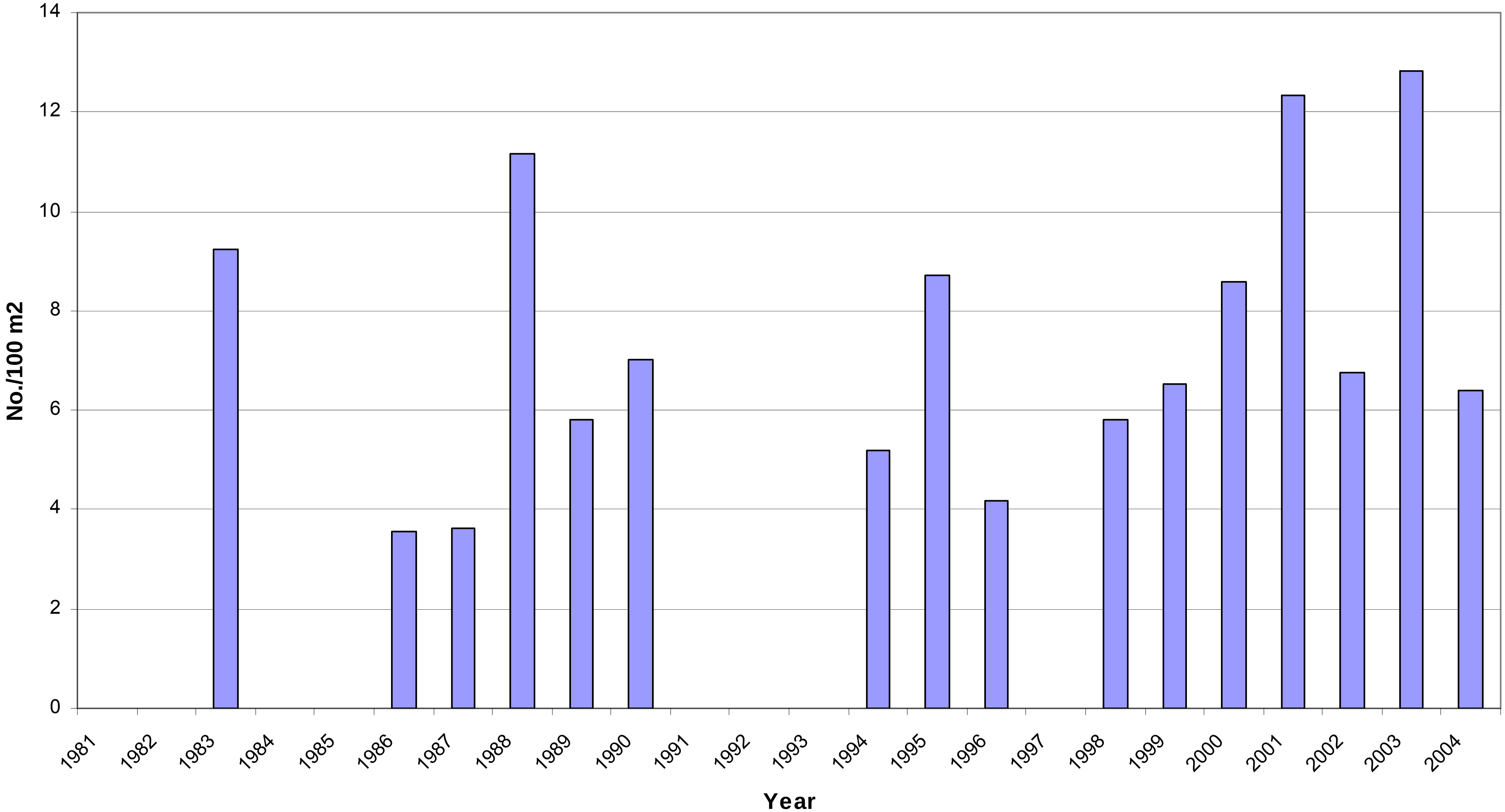


Figure 21. Densities of Age I and older westslope cutthroat trout calculated from electrofishing in the index section of the Stillwater River from 1991 through 2004.

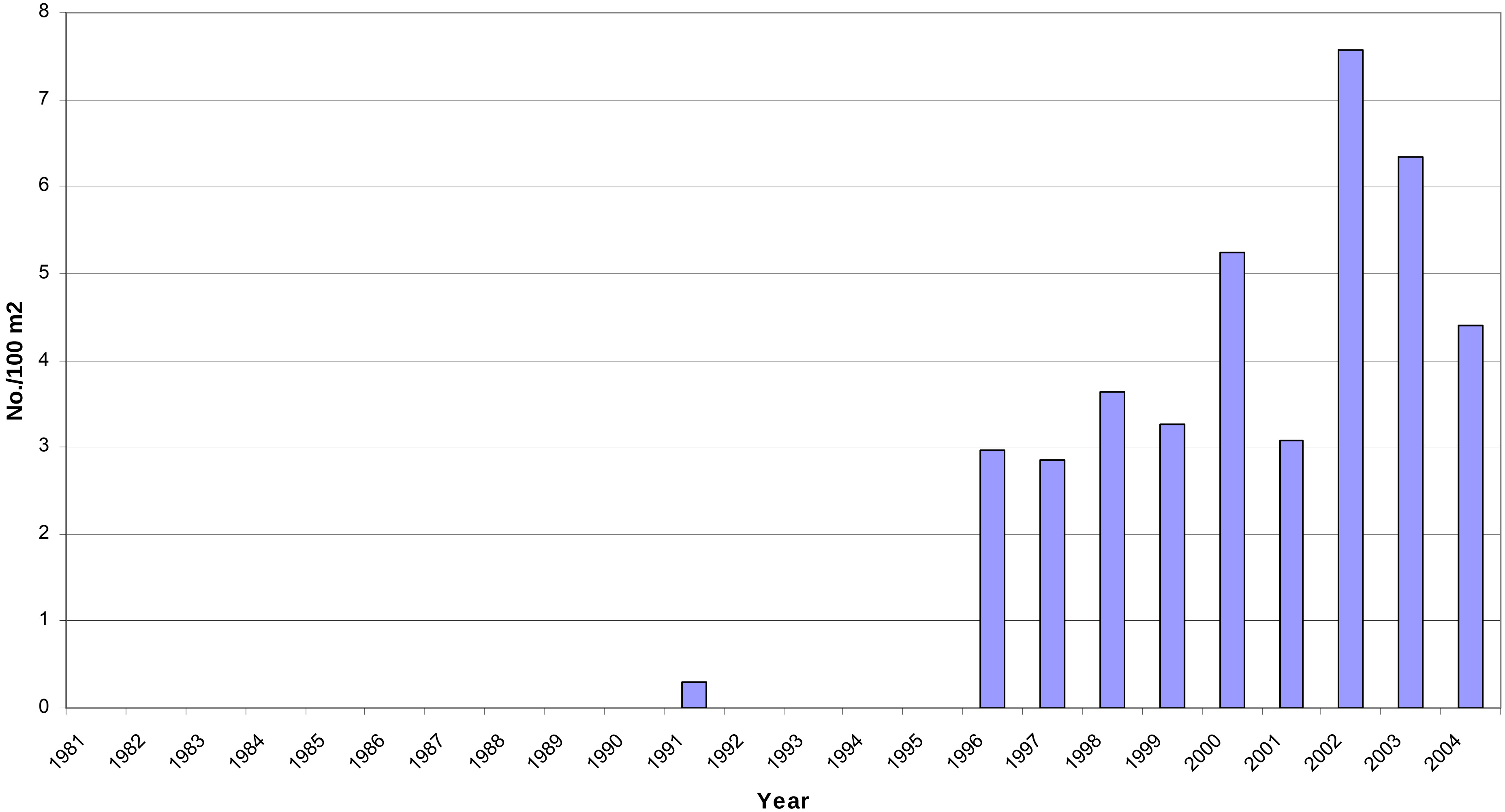
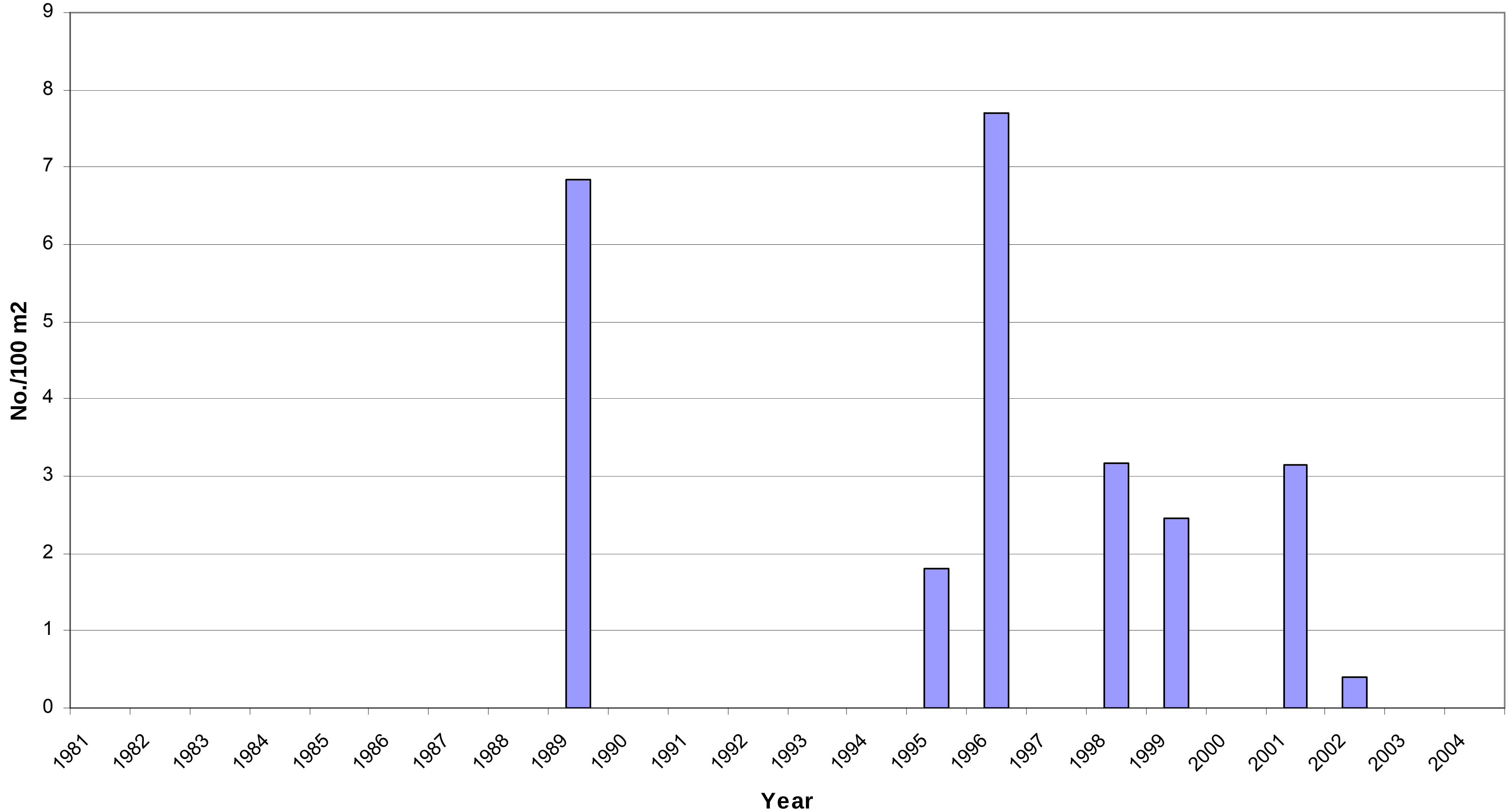


Figure 22. Densities of Age I and older westslope cutthroat trout calculated from electrofishing in the index section of the East Fork of Swift Creek from 1989 through 2004.



Population Fluctuations

The combined 176 sampling years of time trend information collected during our 25-year study period demonstrate clearly that Flathead Basin bull trout populations normally exhibit large annual fluctuations. Maximum relative fluctuation (M_s) as described by Platts and Nelson (1988) relates the highest observed density to the lowest observed value during the study period and gives an indication of the magnitude of volatility in juvenile bull trout density for each section. Average relative fluctuation (A_s) describes the magnitude of change in density with respect to the average density over the course of the study for each section.

The largest maximum relative fluctuation occurred in the Morrison Creek section, at just over 1100 percent. Red Meadow followed at 832 percent, with North Coal at 822 percent, South Coal at 688 percent and Coal-Dead Horse at 566 percent. Maximum relative fluctuation in Big and Whale are considerably lower at 326 and 300 percent, respectively. Ole Creek showed maximum change of 109 percent with nine years of data available, while with only four years of data, Granite Creek showed a maximum relative fluctuation of 87 percent. These are our index streams for the Flathead Lake bull trout population, although North and South Coal are not included in calculation of the annual composite density (Figure 12).

The Stillwater River showed a maximum relative fluctuation of 493 percent with 10 years on record, while West Swift Creek's maximum change is 269 percent, with only five years of data. As previously discussed, these areas provide the juvenile bull trout rearing habitat for the disjunct populations occupying upper Stillwater and Whitefish Lake, respectively.

When examining the average relative fluctuation it appears that all the sections with substantial data sets are approaching a 200 percent average fluctuation. Morrison is at 199 percent, Big is at 197 percent, Red Meadow is at 195 percent, North Coal is at 188 percent. Coal-Dead Horse is at 187 percent, South Coal is at 179 percent and Whale is at 160 percent. Ole and Granite creeks with shorter data set lengths are at 70 and 62 percent, respectively. The average relative fluctuations in the Stillwater River and in West Swift Creek are 178 and 152 percent, respectively.

The combined 115 sampling years of time trend information collected over the 25-year study period clearly demonstrate that cutthroat trout populations also exhibit very large annual fluctuations in density. The largest maximum relative fluctuation occurred in the Stillwater River section at 2,427 percent. East Swift followed at 1,610 percent, with Cyclone at 1,395 percent, Challenge at 748 percent, Langford at 413 percent, South Coal at 412 percent, North Coal at 321 percent and Red Meadow at 261 percent.

SPAWNING SITE INVENTORIES

Introduction

A reliable index of annual spawner escapement is a valuable element of any fisheries monitoring program. These data are frequently used as measures of anticipated production in succeeding generations. They also provide an assessment of success in regulating the fishery. Observations during past studies indicate that native fish populations in the Flathead System consistently use the same stream sections for spawning. The available genetic information strongly suggests that both migratory westslope cutthroat and bull trout faithfully return to natal tributaries to spawn.

Flathead Lake bull trout spawned in 28 percent of the 750 km of available stream habitat surveyed in 1978-1982 (Fraley and Shepard 1989). In the Swan River drainage, 75 percent of all bull trout spawning during 1983 and 1984 took place in 8.5 percent of the available habitat (Leathe and Enk 1985). About 70 percent of spawning in the Swan drainage during 1995, 1996, and 1997 occurred in portions of four streams, which amounted to less than 10 percent of available stream habitat (Montana Fish, Wildlife & Parks, Kalispell, unpublished data). Bull trout spawned in 14 of 37 streams surveyed in the South Fork of the Flathead River drainage upstream from Hungry Horse Dam during 1993. Portions of eight of these, totaling less than 10 percent of the total habitat, supported 80 percent of the spawning (MBTSG 1995a, 1995b). As a result of specific spawning habitat requirements, the majority of bull trout spawning is clustered in a small portion of the available habitat, making these areas critical to bull trout production and relatively simple to monitor.

Conversely, several aspects of westslope cutthroat trout make inventories of their spawning sites much more difficult. First, they are more widely distributed in the Flathead than bull trout. Shepard et al. (2003) estimated over 5,600 km of habitat historically occupied by westslope cutthroat trout in the Flathead drainage. Westslope cutthroat trout exhibit multiple life histories; some are stream residents while others are migratory with movements of up to 250 km (Shepard et al. 1984). Since these fish are spring spawners our counts are highly dependent on annual runoff intensity. If the snow pack melts off gradually accurate counts are possible, but only in the smaller, lower order streams. In high runoff years spawning sites become difficult or impossible to identify even in these small streams. So even under optimal conditions, we are only able to complete accurate counts for migratory cutthroat in lower order streams during some years. We do not attempt to track resident cutthroat trout spawning.

Field crews annually monitor the number of spawning sites (redds) in specific stream sections. These counts provide information on trends in escapement into upper basin tributaries and allow us to choose sampling locations for other monitoring activities. Timing of salmonid spawning likely evolved in response to seasonal changes in water temperature (Bjornn and Reiser 1991). Initiation of spawning by westslope cutthroat and bull trout in the Flathead drainage appears to be strongly related to water temperature, although photoperiod and streamflow may also be factors (Shepard et al. 1984.

Bull trout spawn between late August and early November (McPhail and Murray 1979; Oliver 1979; Shepard et al. 1984; Pratt 1985; Brown 1992, Ratliff 1992). Bull trout spawning in the Flathead drainage (Fraley and Shepard 1989) and in Mackenzie Creek, British Columbia (McPhail and Murray 1979) began when daily maximum water temperatures declined to 9-10^{o} C. Spawning takes place primarily at night (Heimer 1965; Weaver and White 1985), but has been observed during daylight hours, especially late in the run (Needham and Vaughan 1952; Montana Fish, Wildlife & Parks, unpublished data; Russ Thurow, USFS Intermountain Research Station, personal communication).

Bull trout spawning typically occurs in areas influenced by groundwater (Allan 1980; Shepard et al. 1984; Ratliff 1992, Fraley and Shepard 1989). Such areas tend to remain open in the Flathead drainage during harsh winter conditions, while adjacent stream sections ice over or contain extensive accumulations of anchor ice. Recent investigations in the Swan River drainage found that bull trout spawning site selection occurred primarily in stream reaches that were gaining water from the subsurface, or in reaches immediately downstream of upwelling reaches (Baxter 1997).

Reaches used by spawning adults typically have gradients less than 2 percent (Fraley and Shepard 1989). Water depths at the upstream edges of 80 redds of migratory bull trout in the Flathead drainage ranged from 0.1 to 0.6 m and averaged 0.3 m; water velocities (at 0.6 of the depth below the surface) ranged from 0.09 to 0.61 m/s and averaged 0.29 m/s (Fraley et al. 1981). Similar mean depths (0.3 m) and water velocities (0.31 m/s) at migratory bull trout redds were documented in the Swan River drainage (Kitano et al. 1994).

The large size of migratory bull trout redds can restrict spawning potential in specific locations. Migratory bull trout redds ranged from 1.0 to 3.1 m in length (mean 2.1 m) in tributaries of the North and Middle forks of the Flathead River (n=465); width of these redds ranged from 0.8 to 1.5 m and averaged 1.1 m (Fraley et al. 1981). The largest redd observed in the Swan drainage was 5.1 m long and 3.3 m wide (T. Weaver, Montana Fish, Wildlife & Parks, personal observation).

Westslope cutthroat trout typically spawn from April through June as water temperature reaches 10^{o} C (Scott and Crossman 1973, Liknes and Graham 1988, Behnke 1992). These fish select areas where gravel varies from 2.0 to 50.0 mm in diameter, mean depths range from 17 to 30 cm and mean velocities range between 0.30 and 0.37 m/s (Shepard et al. 1984). Redds of migratory fish are larger than those of resident stocks ranging from 0.6 to 1.0 m in mean length and from 0.32 to 0.45 m in mean width (Shepard et al. 1984). Due to the constraints previously mentioned we only attempt to complete annual index redd counts for migratory westslope cutthroat trout in low order streams.

Areas in which redds are counted on a routine basis are called “index” areas. In some cases these index surveys begin at a barrier to upstream migration. It is important to establish upper and lower limits of index areas. Through repeated annual index surveys we obtain valuable trend information to use in monitoring westslope cutthroat and bull trout populations. Detection of trends often requires at least 10 years of monitoring index areas (Rieman and Meyers 1997).

Methods

We conduct preliminary surveys to determine appropriate timing for final counts. Final inventories begin after we observe numerous completed redds, few adult fish, and little evidence of active spawning during the preliminary surveys. Timing of final counts is critical, because as redds age, they lose the characteristic “cleaned” or “bright” appearance becoming more difficult to identify.

Experienced field crews conduct surveys by walking the channel within these known spawning areas. They visually identify redds by the presence of a pit or depression and associated tail area of disturbed gravel. If timing is proper and for westslope cutthroat trout if spring runoff is not extreme, identification of redds presents little problem. We classify redds based on the following criteria:

1. Definite – no doubt. The area is definitely “cleaned” and pit and tail area are recognizable. The site is not in an area typically cleaned by stream hydraulics.

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

We call the upper boundary of the survey section pace zero and keep track of paces while walking downstream through the section. When the surveyors encounter a redd, they record it’s certainty class along with its location in paces from the start of the survey. Surveyors record distinct landmarks by noting the pace number at the location of each landmark. We include both classes of redds in final totals, which we compare annually as an index of spawner escapement.

During a basin-wide count all habitat which appears suitable for bull trout spawning (as described above) is surveyed. From this basin-wide survey, index areas can be identified for annual surveys. We conduct basin-wide bull trout redd counts every 3-5 years to assure our index areas adequately describe overall trends. We do not attempt to complete basin-wide counts for westslope cutthroat trout.

Results and Discussion

Flathead Lake Population

Bull Trout

Each fall field crews monitor the number of bull trout spawning sites (redds) in specific stream sections. These counts provide information on the number of adult bull trout successfully spawning in upper basin tributaries. Over the past 27 years, we have monitored high density spawning areas in four tributaries to both the North and Middle forks of the Flathead River. Fish spawning in these eight index streams have migrated upstream from Flathead Lake, where they spend their adult lives. In addition to our work in these annual index sections, we have periodically surveyed all known bull trout spawning areas presently available to Flathead Lake bull trout. Over the 27 years on record we have completed basin-wide counts during 9 years. We believe that only a small percentage (<10 percent) of all bull trout spawning is unaccounted for during years when field crews complete basin-wide counts.

Historically, bull trout were one of four native salmonid species distributed throughout the Flathead drainage. The other native salmonids are westslope cutthroat trout, mountain whitefish, and pygmy whitefish. The Flathead Lake bull trout population had access to all three forks of the Flathead as well as the other interconnected streams and rivers both above and below the lake. The downstream extent of this range was likely Metaline Falls below Lake Pend Oreille. Although bull trout had access to all of this area, their preference for colder water temperatures likely restricted their distribution and movement. For example, in larger lakes where there is surface outflow, summer/fall temperatures downstream are higher than bull trout prefer so little movement occurs. This suggests that migration of spawning bull trout from Flathead Lake up into the Swan River's warmer water below Swan Lake was minimal even prior to Bigfork Dam. Similar conditions occur below Flathead Lake, Stillwater Lake, Whitefish lake, Big Salmon lake, and many of the lakes in Glacier National Park. Recent genetic testing has shown the fish in Swan River tributaries are indeed distinct from those in the Flathead. It is likely that fish in Stillwater, Whitefish, Big Salmon, and Glacier Park lakes are also genetically distinct, although little testing has been completed to date in the Glacier Park lakes. These populations are considered to be disjunct and are monitored separately.

Construction of Hungry Horse Dam on the South Fork of the Flathead River in 1953 blocked off an estimated 38 percent of the historic bull trout spawning and rearing areas available to Flathead Lake fish (Zubik and Fraley 1987). Bull trout presently occupying the reservoir as adults utilize tributaries to the reservoir and the South Fork upstream as spawning and rearing areas. No exchange is possible with the Flathead Lake population.

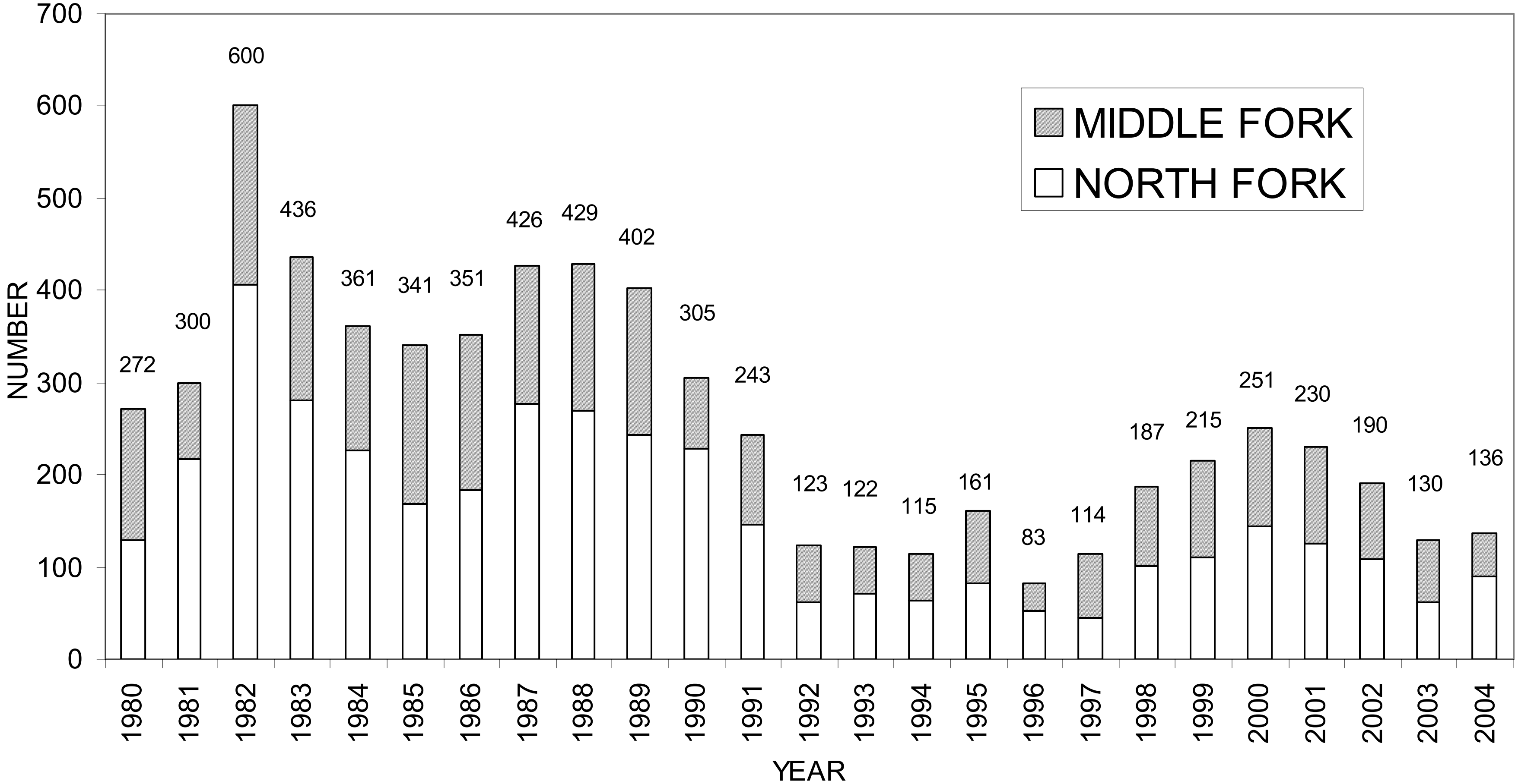
There are limited data on the bull trout spawning run out of Flathead Lake prior to the current monitoring scheme. The earliest and only comparable data on the number of spawning bull trout are from a study in the North Fork during the early 1950s. Personnel from the MFWP operated a two-way weir in Trail Creek during 1954. In addition to stream trapping activities they also conducted a complete redd count survey. Results from this work yielded an estimate of the total number of adult bull trout spawning in Trail Creek during 1954 of 160 fish (Block 1955).

During our initial years of redd counts in 1978 and 1979, field crews attempted to set up standard sections for annual counts. Our intent was to identify high density spawning areas with distinct upper and lower boundaries. Counts in these sections could be duplicated each year, allowing development of an index for comparison over time. We selected sections of four North Fork and four Middle Fork tributary streams for our annual index surveys (Figure 23, Appendix D-1). Counts from 1978 and 1979 are not directly comparable to subsequent years because of differences in the stream sections surveyed; only portions of Trail and Morrison creek's index areas were counted and Ole Creek was not surveyed at all. The total number of redds for these two years is likely lower than the true number, since the entire lengths of present index areas were not surveyed. These numbers are not presented in Figure 23 or Appendix D-1.

Redd numbers reported from 1980 through the present are directly comparable (Figure 23, Appendix D-1). During the 11-year period from 1980 through 1990 the Flathead Lake index count averaged 384 redds with a range from 272 in 1980 to 600 in 1982. In comparing the number of spawners in Trail Creek during this 11-year period to the 1954 estimate for Trail Creek, we see similar numbers. As previously mentioned, the 1954 estimate of total adult bull trout in Trail Creek was 160 fish. The estimated 11-year average for Trail Creek between 1980 and 1990 is 180 fish. To convert our redd numbers to total adult fish we multiplied the number of redds observed by a factor of 3.2 (Fraley and Shepard 1989). This coefficient was developed from trapping the spawning run in several Flathead Basin streams over several years and passing a known number of adults upstream. Then redd counts were completed upstream of each trap site and we calculated an average of 3.2 fish per redd. Field personnel have often observed multiple males with a single female during preliminary surveys when actual spawning was occurring.

A large decline in bull trout redd numbers occurred between 1990 and 1992 with 1991 being a transitional year (Figure 23, Appendix D-1). Indices suggest this change resulted from degraded spawning and rearing habitat conditions likely due to prolonged drought (see sections on Streambed Coring and Substrate Scoring in this report) combined with alterations in the trophic dynamics in Flathead Lake following establishment of *Mysis relicta*. Department personnel first detected *Mysis* in Flathead Lake in 1981. *Mysis* densities increased exponentially through 1985 peaking in 1986. It appears that the presence of *Mysis* enhanced Lake Superior whitefish and lake trout survival and growth. The fish community composition and species abundance changed dramatically from dominance by kokanee, bull trout, and westslope cutthroat trout to dominance by these introduced gamefish.

Figure 23. Bull trout redd numbers in annual index sections of spawning tributaries to the North and Middle forks of the Flathead River.



During the six year period from 1992 to 1997, the Flathead Lake index count averaged 120 redds ranging from a low of 83 in 1996 to a high of 161 in 1995. This represents a reduction by approximately 70 percent from the 11-year period 1980-1990 (Figure 23). The North Fork index counts appear to have declined to a greater degree than Middle Fork streams (Appendix D-1). During the 11 pre-*Mysis* years, North Fork index streams averaged 239 redds or 62 percent of the total Flathead Lake index count. Post-*Mysis* counts show closer to a 50:50 split between North and Middle fork index tributaries (Appendix D-1). This suggests that the prolonged drought period during the mid to late 1980s had a stronger negative influence on stream habitat draining managed lands in the North Fork compared to the largely unmanaged Middle Fork index streams. In addition to degraded tributary habitat, this group of bull trout occupied Flathead Lake during the years when the trophic changes due to *Mysis* establishment were most dramatic. Fish spawning during the six year low but stable period from 1992 through 1997 were progeny of those which spawned from 1985-1990, years of relatively high redd counts.

Field crews documented increasing numbers of bull trout redds in annual index sections beginning in 1998 (Figure 23). Redd numbers continued to increase through 2000 reaching a total of 251, then decreased annually to the current count of 136 in 2004 (Figure 23). Redd numbers averaged 192 during the past six years and although we have seen an annual decline since 2000, current numbers still exceed those observed between 1992 and 1997. The 2004 spawners were largely the progeny from the 1997 year class, one of the weakest years currently on record (Figure 23).

Surveyors have documented bull trout spawning in 30 tributaries in the Flathead Basin (Table 5). During the nine years when we completed basin-wide counts an average of 52 percent of all spawning occurred in 14 Middle Fork tributaries (annual range: 42 percent – 67 percent) while 16 North Fork streams supported an average of 48 percent of the total Flathead Lake spawning run (annual range: 33 percent – 61 percent). The Canadian portion of the North Fork on average supports 17 percent of the Flathead run (annual range: 8 percent – 24 percent) in seven streams. Observed redd numbers have ranged from a high of 1,156 in 1982 to a low of 236 in 1997 (Table 5). The most recent basin-wide survey completed in 2003 documented a total of 297 redds.

When comparing our annual index counts with the basin-wide counts during the nine years on record, we see that our annual index has ranged from 39 to 52 percent of the basin-wide number (Table 6). These data show an average of 45 percent of all Flathead Lake bull trout spawn in the eight stream sections in which we conduct our annual redd count surveys. It appears that the annual index counts accurately reflect basin-wide trends. However, basin-wide counts should be completed at least once every five years to assure that the index counts remain adequate.

The actual proportion of the adult bull trout population in Flathead Lake which spawns in any given year is unknown. This number is likely variable over time. The question is further complicated by the fact that we know some mature fish spawn every year while others spawn every other year. We also have evidence of fish which may only spawn

Table 5. Summary of basin-wide bull trout spawning site inventories for tributaries to the North Fork of the Flathead River. All stream sections know to be utilized by Flathead Lake spawners are included.

	1980	1981	1982	1986	1991	1992	1997	2000	2003
North Fork									
Big	20	24	45	12	32	16	13	32	12
Hallowat	8	14	31	3	27	2	0	32	8
Coal	48	30	95	35	42	7	5	6	4
South Coal	2	24	9	4	8	5	4	1	1
Mathias	10	10	17	10	8	4	0	1	0
Red Meadow	6	19	10	8	15	0	3	1	3
Whale	47	101	236	90	61	12	17	72	34
Shorty	4	17	56	35	6	3	2	12	0
Trail	31	82	101	69	27	26	9	42	14
Cauldrey	15	24	18	7	--	9	5	6	9
Cabin	2	2	3	0	--	3	2	2	1
Howell	47	72	103	22	--	31	7	11	15
Starvation	1	1	--	--	--	--	0	0	--
Sage	6	5	4	5	--	--	2	1	0
Kishenehn	16	13	23	18	--	12	10	23	4
N. Fork River	10	34	17	12	--	14	19	53	60
Total	273	472	768	330	334[1/]	144	98	295	165

Table 5. (con't) Summary of basin-wide bull trout spawning site inventories for tributaries to the Middle fork of the Flathead River. All stream sections know to be utilized by Flathead Lake spawners are included.

Middle Fork									
Nyack	14	14	23	27	22	12	9	13	14
Park	--	13	0	87	19	1	2	10	0
Ole	19	23	51	36	23	16	14	34	21
Bear	9	12	23	21	23	9	2	15	0
Long	8	--	--	--	12	1	15	11	17
Granite	34	14	34	37	20	16	12	28	17
Morrison	75	32	86	52	45	17	39	50	22
Lodgepole	14	18	23	42	9	13	5	3	10
Schafer	10	12	17	30	12	12	5	19	4
Dolly Varden	21	31	36	42	23	13	9	40	5
Clack	10	7	7	16	11	6	1	4	13
Bowl	29	10	19	36	14	8	6	6	0
Strawberry	17	21	39	41	20	14	13	9	9
Trail	31	26	30	53	37	9	6	18	0
Total	291	233	388	520	290	147	138	260	132
Basin Total	564	705	1,156	850	624[1/]	291	236	555	297

[1/]Total redd numbers for 1991 have been adjusted based on averages during other years when complete Canadian counts were made

Table 6. Basin-wide bull trout redd numbers compared with the number of redds observed in the stream sections (North and Middle fork tributaries) where annual monitoring occurs (index areas).

	1980	1981	1982	1986	1991	1992	1997	2000	2003
Basin-wide Redd Numbers	564	705	1,156	850	624	291	236	555	297
Redd Numbers in Index Areas	272	300	600	351	243	123	114	251	130
% of Redds in Index Areas	48.2	42.6	51.9	41.3	38.9	42.3	48.3	45.2	43.8

$\bar{x}$ = 45% of all redds were in index areas
Range: 39% - 52% (n = 9 years)

one out of every three years. Redd count surveys provide a relative abundance index for spawner escapement and over an extended timeframe allow management agencies to assess trends and changes in population status.

In summarizing the information available it appears that between 1980 and 1990 total estimated bull trout spawner escapement fluctuated between 2,000 and 4,000 fish. Limited information from the early 1950s suggests similar numbers of spawners at that time. We do not know whether the population was depressed prior to the early 1950s. Perturbations likely occurred as the spawning and rearing areas in the upper basin were developed and became more accessible. Both legal and illegal harvest influenced the number of spawning fish. In 1981, a Flathead River creel survey estimated that 41 percent of the adult bull trout in the spawning run were harvested by anglers (Fredenberg and Graham 1983). We now believe this 1981 estimate is very high, however, creel limits were reduced in response. Construction of Hungry Horse Dam on the South Fork blocked 38 percent of the population's historic habitat (Zubik and Fraley 1987). Human population growth continues in the basin with associated pressure on the bull trout population and its habitat. A significant decline in redd numbers occurred during the early 1990s due to an extended period of drought, habitat degradation in spawning and rearing areas, and alteration of the trophic dynamics in Flathead Lake. From 1992 to 1997, the number of bull trout redds remained relatively stable (six years), but this level was approximately 70 percent below the average during the preceding 11-year period (1980-1990). Our current counts show an encouraging increase over the previous six years, but are still 50 percent below pre-*Mysis* levels. The mechanisms causing the decline and ongoing fluctuations are not completely clear and there remains considerable uncertainty about bull trout ecology and trophic interactions in Flathead Lake. In a lake as large as Flathead, fluctuations in fish population dynamics brought about by food web alterations and changes in species composition may have long lag times and will likely require several generations to stabilize.

There are separate bull trout populations occupying the Swan and South Fork Flathead drainages which are presently stable or increasing. There are also 19 disjunct bull trout populations in the Flathead Basin. Little is known about some of these populations. We recommend continuing the monitoring program. It provides one of the longest term data sets on bull trout population status available anywhere. Annual index counts adequately reflect basin-wide trends in bull trout redd numbers, but basin-wide counts should be completed every three to five years. Future efforts are focusing on the inter-specific interactions and overall ecology of Flathead Lake and the lower main stem Flathead River, especially subadult bull trout emigration and survival rates. Determination of population genetic structure and status of the numerous disjunct bull trout assemblages in the Flathead Basin should also be a high priority in future work.

Disjunct Populations

In addition to the three main bull trout populations in the Flathead Basin, there are 19 other lakes believed to be supporting reproducing bull trout populations (MTBSG 1996) (Table 7). These smaller lake populations are considered to be disjunct from the main bull trout assemblages in the Flathead Basin. The degree to which bull trout in these lakes are connected to the main migratory populations is unknown, however, it is believed that these populations are functionally isolated. Although downstream movement out of these lakes may occur, biologists believe the thermal preference of adult bull trout returning upstream during late summer spawning runs causes them to avoid comparatively warm water outflows from these lakes. These warm water outflows form thermal barriers to returning spawners, thus the disjunct designation. Recent testing has shown bull trout in several of these disjunct populations to be genetically distinct from the main populations. Information on status and the population genetic structure of each of these disjunct units is a major research need and should be a priority for future efforts.

In general, relatively little is known about these disjunct populations but they represent an important and significant resource. These populations appear to be glacial relics and may possess unique genetic and life history attributes that occur nowhere else in the range of the species.

Table 7. Lakes supporting disjunct bull trout populations in the Flathead Basin.

Lake Name	Drainage	Primary Landowner	Recent Monitoring
Upper Kintla	North Fork	Glacier National Park	Yes
Cerulean	North Fork	Glacier National Park	No
Upper Quartz	North Fork	Glacier National Park	No
Middle Quartz	North Fork	Glacier National Park	Yes
Lower Quartz	North Fork	Glacier National Park	Yes
Akokala	North Fork	Glacier National Park	No
Logging	North Fork	Glacier National Park	Yes
Bowman	North Fork	Glacier National Park	Yes
Arrow	North Fork	Glacier National Park	No
Trout	North Fork	Glacier National Park	No
Cyclone	North Fork	Montana DNRC	Yes

Lake Name	Drainage	Primary Landowner	Recent Monitoring
Frozen	North Fork	Flathead National Forest	Yes
Upper Isabel	Middle Fork	Glacier National Park	No
Lower Isabel	Middle Fork	Glacier National Park	No
Harrison	Middle Fork	Glacier National Park	Yes
Lincoln	Middle Fork	Glacier National Park	Yes
Whitefish	Flathead	Private	Yes
Upper Whitefish	Swift Creek	Montana DNRC	Yes
Upper Stillwater	Stillwater	Montana DNRC/FNF	Yes

Field crews have recently begun tracking several of these smaller populations. Monitoring has occurred on the following lake systems: Whitefish Lake, Upper Whitefish Lake, Cyclone Lake, Frozen Lake and Upper Stillwater Lake.

<u>Whitefish Lake</u> (Table 8)

Bull trout are presently uncommon in Whitefish Lake. This is likely due in large part to the extensive presence of introduced species including brook trout, lake trout, Lake Superior whitefish, northern pike, and *Mysis*, in addition to several others. Road and railroad construction, timber management, municipal and subdivision development that has occurred along the lakeshore and in the Swift Creek Drainage upstream have also contributed to this population's current condition. Historically, the Whitefish River was dammed in association with a sawmill operation. It is unknown how this temporary break in connectivity may have influenced the bull trout population. Whitefish Lake is particularly noteworthy because of its relatively large size (3,350 acres) and its similarity to Flathead Lake. It contains all the same species as Flathead and is subject to similar pressures from human activities.

We completed annual redd count surveys in the Swift Creek Drainage upstream from Whitefish Lake beginning in 1993. Field crews documented limited bull trout spawning in the West Fork of Swift Creek during the past 12 years with an average of 4 redds annually. Surveyors found no redds during the 1997 count, which occurred on October 31. The maximum number observed was 12 in 2001. We have observed limited bull

Table 8. Summary of bull trout spawning site inventories for disjunct populations in the Flathead Basin from 1993 to 2004.

Lake	Year											
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Upper Whitefish	0	0	0	0	0	0	0	0	0	0	0	0
Whitefish	6	4	3	3	0	12	9	10	14	5	6	7[a/]
Upper Stillwater	7	4	3	8	16	47	30	34	12	19	25	nc
Cyclone	3	5	5	5	0	0	0	0	0	0	3	0
Frozen	nc	nc	0	nc	10	nc	nc	nc	nc	nc	nc	nc
Holland	21	19	18	26	19	19	11	12	5	7	7	13
Lindbergh	nc	26	nc	nc	9	nc	nc	nc	16	nc	nc	nc
Big Salmon	92	91	93	61	55	nc	59	nc	75	nc	nc	27[a/]

nc=No counts conducted.
[a/]High flows during survey – minimum count.

trout spawning in main stem Swift Creek to date with an average of five redds annually during the past seven years. The 2004 count may be low due to high streamflow during the survey. As part of an agreement with DNRC, we will continue these surveys. Outlet spawning in the Whitefish River below the lake is possible, so crews should survey for bull trout spawning here as well.

<u>Upper Whitefish Lake</u> (Table 8)

Upper Whitefish Lake at the head of the Swift Creek Drainage, is a small alpine lake (88 acres) with road access and heavy recreational use. It supports a limited bull trout population and is annually stocked with westslope cutthroat trout. Bull trout spawning was documented in the only tributary, East Fork Swift Creek, during 1989. Surveyors recorded four redds at this time. Recent surveys show the East Fork goes dry just above Upper Whitefish Lake so no passage to the spawning area has been possible during the past several years. We found no redds during any surveys since 1993. Outlet spawning is possible and crews surveyed approximately 1.0 km downstream during three years (1998-2000); no definite bull trout redds were found.

<u>Cyclone Lake</u> (Table 8)

Cyclone Lake in the North Fork's Coal Creek Drainage is 145 acres in surface area and supports a disjunct bull trout population. Inlet tributaries are small and flows are extremely low during late summer, so spawning here is unlikely. Field crews surveyed the outlet during 1994, 1995, and 1996 observing five redds each year in the first 1.0 km downstream from the lake outlet. No counts have been completed below this point, but we noted no passage blockages preventing adult spawners from moving further downstream in Cyclone Creek. Redd counts from 1997 through 2002 resulted in no redds observed, but several bull trout ranging from 400 to 550 mm in length were captured by an angler fishing through the ice for westslope cutthroat trout during March, 1998. These fish were released unharmed. The 2003 survey resulted in three redds, however, we observed no redds again in 2004. As part of an agreement with DNRC, we will continue these surveys and check the inlet and immediate shoreline for spawning as well.

<u>Frozen Lake</u> (Table 8)

Field crews surveyed the unnamed inlet stream to Frozen Lake in the North Fork Drainage on the Canadian Border during 1995. Bull trout had been documented in Frozen Lake, but the spawning area had not been identified at this time. Conditions were poor during the 1995 effort and crews were unable to positively identify bull trout redds. We again surveyed Frozen Lake on October 23, 1997 and documented 10 bull trout redds in the outlet stream. The field crew also observed adult fish cruising around in this area. The inlet stream was checked as well and although juvenile bull trout were present we observed no redds. Frozen Lake has not been counted since 1997.

Upper Stillwater Lake (Table 8)

Upper Stillwater Lake (630 surface acres) and the Stillwater River Drainage upstream support a disjunct bull trout population. These fish are presently common in abundance. Perturbations likely occurred as the upper river drainage was developed and became more accessible. Road and railroad construction along the river and lakeshore also contributed to habitat conditions. In the 1970s, northern pike were illegally introduced and have flourished. Recently lake trout have been documented in upper Stillwater Lake. Historically, the Stillwater River was dammed in association with a sawmill operation; this dam no longer exists. Initial surveys during 1989 showed that bull trout spawned in Fitzsimmons Creek and the Stillwater River between Fitzsimmons and Russky creeks. More recent surveys have detected spawning further downstream to just above Emmons Bridge. Complete counts are available since 1997 with an annual average of 26 redds and a maximum of 47 in 1998. We did not complete the 2004 count due to high streamflow conditions.

Westslope Cutthroat Trout

Field crews have attempted annual monitoring of cutthroat trout spawning runs in Flathead tributaries since 1989 (Table 9). Initially, we surveyed Cyclone (North Fork) and Challenge (Middle Fork) creeks. Within the next three years we added Langford and Dodge creeks, giving us two index streams in both drainages. Past stream trapping showed these four streams to be utilized by migratory cutthroat trout (Graham et al. 1980, Fraley et al. 1981, Shepard et al. 1982). Fish spawning in the two Middle Fork tributaries are basically fluvial, living in either Granite Creek downstream from the junction of Challenge and Dodge, or in the Middle Fork as adults. Genetic testing has shown these fish are pure westslope cutthroat trout (MFWP – unpublished data). Fish spawning in Cyclone and Langford creeks are largely fluvial or adfluvial, residing in the North Fork, main stem Flathead or Flathead Lake as adults. Recent genetic testing has shown a substantial degree of introgression by rainbow trout in these two streams (Hitt 2002, Muhlfeld et al. In Prep.). We observed spawning by resident westslope cutthroat trout in all four index streams, however the numbers presented in Table 9 are for migratory redds only. We make this distinction based on the size of the redd (Shepard et al. 1982) but it remains unclear as to whether the redd was constructed by a pure westslope cutthroat trout, a rainbow trout, or a hybrid.

As previously mentioned, annual cutthroat trout redd counts are highly dependent on spring runoff conditions making year to year comparisons tenuous. Our counts do show that migratory fish spawn in the same sections of these four streams annually, allowing us to select sampling locations for other monitoring activities appropriately. All four of these drainages have burned during our period of record. Challenge and Dodge creeks burned in 1998. Cyclone and Langford burned during the Moose Fire in 2001. Both Dodge and Langford had high intensity burns over their entire drainage areas while Challenge and Cyclone burned less intensely over only portions of their drainage areas. While spawning and incubation habitat quality may have been degraded as a result of these fires (See Streambed Coring section in this report) the number of migratory fish spawning after the burns did not show negative impacts (Table 9).

Table 9. Summary of migratory cutthroat trout spawning site inventories in Flathead Basin tributaries from 1989-2003.

Stream	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Cyclone Creek	31	--	29	42	28	17	26	--	--	31	16	19	10	20	16	17
Langford Creek	--	--	--	19	11	8	9	--	--	16	11	9	17	22	15	13
Challenge Creek	19	--	21	11	4	--	16	26	--	23	29	22	18	16	11	9
Dodge Creek	--	--	9	6	15	--	18	19	--	17	12	8	10	9	17	8

LITERATURE CITED

Alderdice, D. F. , W. P. Wickett, and J. R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. Journal of the Fisheries Research Board of Canada 15: 229-250.

Allan, J. H. 1980. Life history notes on the Dolly Varden char (*Salvelinus malma*) in the Upper Clearwater River, Alberta. Manuscript report. Alberta Energy and Natural Resources, Fish and Wildlife Division, Red Deer, Alberta.

Baxter, C. V. 1997. Geomorphology, land-use, and groundwater-surface water interaction: a multi-scale, hierarchical analysis of the distribution and abundance of bull trout (*Salvelinus confluentus*) spawning. Master's thesis. University of Montana, Missoula, Montana.

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society, Monograph 6. Bethesda, Maryland.

Bjornn, T. C. 1969. Embryo survival and emergence studies, Job No. 5, Federal Aid in Fish and Wildlife Restoration. Job Completion Report, Project F-49-R-7. Idaho Fish and Game Department, Boise.

Bjornn, T. C. , and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19:83-138.

Block, D. G. 1955. Trout migration and spawning studies on the North Fork drainage of the Flathead River. Masters Thesis, Montana State University, Missoula, Montana.

Brown, L. G. 1992. Draft management guide for the bull trout, *Salvelinus confluentus* (Suckley), on the Wenatchee National Forest. Washington Department of Wildlife. Wenatchee, Washington.

Chapman, D. W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society. 117: 1-21.

Cross, D. G. and B. Stott. 1975. The effect of electric fishing on the subsequent capture of fish. Journal of Fish Biology. Volume 7: 349-357.

Crouse, M. R., C. A. Callahan, K. W. Malueg, and S. E. Dominguez. 1981. Effects of fine sediments on growth of juvenile coho salmon in laboratory streams. Transactions of the American Fisheries Society 110:281-286.

Deleray, M., L. Knotek, S. Rumsey, and T. Weaver. 1999. Flathead Lake and River System Fisheries Status Report. DJ Report No. F-78-R-1-5, SBAS Project No. 3131, Montana Fish Wildlife and Parks Kalispell, Montana.

Everest, F. H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Commission, Fishery Research Report 7, Corvallis, Oregon.

Everest, F. H. , and five others. 1987. Fine sediment and salmonid production: a paradox. Pages 98-142 *in* E. O. Salo and T. W. Cundy, editors. Streamside management: forestry and fishery interactions. University of Washington, Institute of Forest Resources Contribution 57, Seattle, Washington.

Flathead Basin Commission. 1991. Flathead basin forest practices water quality and fisheries cooperative program. Final report. Flathead Basin Commission, Kalispell, Montana.

Fraley, J. J., D. Read, and P. J. Graham. 1981. Flathead River fisheries study. Montana Department of Fish, Wildlife and Parks. Kalispell, Montana.

Fraley, J. J. , and B. B. Shepard. 1989. Life history, ecology and population status of bull trout (*Salvelinus confluentus*) in the Flathead Lake and River system, Montana. Northwest Science 63:133-143.

Fredenberg, W. , and P. Graham. 1983. Flathead River fisherman census. Montana Department of Fish, Wildlife and Parks, Kalispell, Montana. 80 pp.

Gooch, B. 1967. An evaluation of the two catch method of population estimation. Montana Department of Fish, Wildlife & Parks, Helena, Montana.

Graham, P. J. , D. Read, S. Leathe, J. Miller, and K. L. Pratt. 1980. Flathead River Basin fishery study. Montana Department of Fish, Wildlife & Parks, Kalispell, Montana.

Graham, P. J. 1980. Flathead River Basin Fishery Study. Environmental Protection Agency, Region VIII, Water Division, Denver, Colorado.

Hanzel, D. A. , and T. Weaver. 1991. Survey and inventory of coldwater and warmwater ecosystems: Flathead Lake - River system study. Project Number F-46-R-4. Job Number V-a. Montana Department of Fish, Wildlife and Parks. Kalispell, Montana. 32 pp.

Heimer, J. T. 1965. A supplemental Dolly Varden spawning area. Master's thesis, University of Idaho, Moscow, Idaho. Cited in: Goetz 1989. Biology of the bull trout *Salvelinus confluentus*: a literature review. U. S. Forest Service, Willamette National Forest, Eugene, Oregon.

Hitt, N.P. 2002. Hybridization between westslope cutthroat trout (*Oncorhynchus clarki lewisi*) and rainbow trout (*O. mykiss*): distribution and limiting factors. M.S. Thesis. Division of Organismal Biology and Ecology, University of Montana, Missoula.

Junge, C. O. and J. Libovarsky. 1965. Effects of size selectivity on population estimates based on successive removals with electrofishing gear. Zoological Listing 14:171-178.

Kitano, S. , K. Maekawa, S. Nakano, and K. D. Fausch. 1994. Spawning behavior of bull trout in the upper Flathead Drainage, Montana, with special reference to hybridization with brook trout. Transactions of the American Fisheries Society 123:988-992.

Koski, K. V. 1966. The survival of coho salmon (*Oncorhynchus kisutch*) from egg deposition to emergence in three Oregon coastal streams. Master's thesis. Oregon State University, Corvallis, Oregon.

Koski, K. V. 1975. The survival and fitness of two stocks of chum salmon (*Oncorhynchus keta*) from egg deposition to emergence in a controlled stream environment at Big Beef Creek. Doctoral dissertation. University of Washington. Seattle, Washington.

Leathe, S. A. , and M. D. Enk. 1985. Cumulative effects of micro hydro development on the fisheries of the Swan River drainage, Montana. Volume 1. Summary report prepared for the Bonneville Power Administration, Contracts DE-A179-82BP36717 and DE-A179-83BP39802, Project 92-19.

Leider, S. A. , M. W. Chilcote, and J. J. Loch. 1986. Movement and survival of presmolt steelhead in a tributary and the main stem of a Washington river. North American Journal of Fisheries Management 6:526-531.

Lelek, A. 1965. A field experiment on the receptivity of chub, *Leuciscus cephalus* (L.) To the repeated influence of pulsating direct current. Zoological Listing 15:69-78.

Liknes, G. A. and P. J. Graham. 1988. Westslope cutthroat trout in Montana: life history, status and management. American Fisheries Society Symposium 4:53-60.

Mahon, R. 1980. Accuracy of catch-effort methods for estimating fish density and biomass in streams. Biology of Fish 5(4):343-360.

MBTSG (Montana Bull Trout Scientific Group) 1995a. Flathead River drainage bull trout status report (including Flathead Lake, the North and Middle Forks of the Flathead River and the Stillwater and Whitefish rivers). Report prepared for the Montana Bull Trout Restoration Team, Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group) 1995b. South Fork Flathead River drainage bull trout status report (upstream of Hungry Horse Dam). Report prepared for the Montana Bull Trout Restoration Team, Helena, Montana.

McNeil, W. J. and W. H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. U. S. Fish and Wildlife Service, Special Scientific Report 169. Washington, DC

McPhail, J. D, and C. B. Murray. 1979. The early life history and ecology of Dolly Varden (*Salvelinus malma*) in the upper Arrow Lakes. Department of Zoology and Institute of Animal Resources, University of British Columbia, Vancouver, British Columbia.

Megahan, W. , W. S. Platts, and B. Kulesza. 1980. Riverbed improves over time: South Fork Salmon. In: Symposium on watershed management. American Society of Civil Engineers, New York. 1:381-395.

Needham, P. R. , and T. M. Vaughan. 1952. Spawning of the Dolly Varden, *Salvelinus malma*, in Twin Creek, Idaho. Copeia, 1952, Number 3, pp. 197-199.

Oliver, G. 1979. A final report on the present fisheries of the Wigwam River with emphasis on the migratory life history and spawning behavior of Dolly Varden char *Salvalinus malma* (Walbaum). Fisheries investigations in tributaries of the Canadian portion of Libby Reservoir. British Columbia Fish and Wildlife Branch, Victoria, BC.

Phillips, R. W. , R. L. Lantz, E. W. Claire, and J. R. Moring. 1975. Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry. Transactions of the American Fisheries Society 104:461-466.

Platts, W. S. and R. L. Nelson. 1988. Fluctuations in trout populations and their implications for land-use evaluation. North American Journal of Fisheries Management 8:333-345.

Pratt, K. L. 1984. Habitat selection and species interactions of juvenile westslope cutthroat trout (*Salmo clarki lewisi*) and bull trout (*Salvelinus confluentus*) in the upper Flathead River Basin. Master's thesis. University of Idaho, Moscow, Idaho.

Pratt, K. L. 1985. Pend Oreille trout and char life history study. Idaho Department of Fish and Game. Boise, Idaho.

Ratliff, D. E. 1992. Bull trout investigations in the Metolius River-Lake Billy Chinook System. Pages 37-44 *in* P. J. Howell and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Reiser, D. W. , and T. A. Wesche. 1979. In situ freezing as a cause of mortality in brown trout eggs. Progressive Fish-Culturist 41: 58-60.

Rieman, B.E. and D.L. Myers. 1997. Use of redd counts to detect trends in bull trout (*Salvelinus confluentus*) populations. Conservation Biology 11(4):1015-1018.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada. Bulletin 184, Ottawa.

Seber, G. A. F. and E. D. LeCren. 1967. Estimating population parameters from large catches relative to the population. Journal of Animal Ecology 36:631-643.

Shepard, B. and P. J. Graham. 1982. Completion report. Monitoring spawning bed material used by bull trout on the Glacier View District, Flathead National Forest. Montana Department of Fish, Wildlife & Parks, Kalispell, Montana. 37 pp.

Shepard, B. B. and P. J. Graham. 1983. Fish Resource Monitoring Program for the Upper Flathead Basin. Prepared for the Environmental Protection Agency, Contract Number R008224-01-4. Montana Fish, Wildlife & Parks, Kalispell, Montana.

Shepard, B. B. , K. L. Pratt, and P. J. Graham. 1984. Life histories of westslope cutthroat and bull trout in the upper Flathead River basin, Montana. Prepared for Environmental Protection Agency, Contract No. R008224-01-5. Montana Fish, Wildlife & Parks, Kalispell, Montana.

Shepard, B. , S. A. Leathe, T. M. Weaver, and M. D. Enk. 1984. Monitoring levels of fine sediment within tributaries to Flathead Lake, and impacts of fine sediment on bull trout recruitment. Unpublished paper presented at the Wild Trout III Symposium. Yellowstone National Park, Wyoming. On file at: Montana Department of Fish, Wildlife and Parks, Kalispell, Montana.

Shumway, D. L. , C. E. Warren, and P. Doudoroff. 1964. Influence of oxygen concentration and water movement on the growth of steelhead trout and coho salmon embryos. Transactions of the American Fisheries Society 93:342-356.

Silver, S. J. , C. E. Warren, and P. Doudoroff. 1963. Dissolved oxygen requirements of developing steelhead trout and chinook salmon embryos at different water velocities. Transactions of the American Fisheries Society 92:327-343.

Tappel, P. D. and T. C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123-135.

Weaver, T. M. , and J. J. Fraley. 1991. Fisheries habitat and fish populations. Flathead basin forest practices, water quality and fisheries cooperative program. Flathead Basin Commission, Kalispell, Montana.

Weaver, T. M. and J. J. Fraley. 1993. A method to measure emergence success of westslope cutthroat trout fry from varying substrate compositions in a natural stream channel. North American Journal Fisheries Management 13:817-822.

Weaver, T. M. , and R. G. White. 1985. Coal Creek fisheries monitoring study No. III. Quarterly progress report. U. S. Forest Service, Montana State Cooperative Fisheries Research Unit, Bozeman, Montana.

White, G. C. , D. R. Anderson, K. P. Burnham, D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. United States Department of Energy. Contract W-7465-ENG-36. Project Report LA-8787-NERP. Los Alamos National Laboratory, Los Alamos, New Mexico.

Wickett, W. P. 1958. Review of certain environmental factors affecting the production of pink and chum salmon. Journal of the Fisheries Research Board of Canada. 15:1103-1126.

Ziller, J. S. 1992. Distribution and relative abundance of bull trout in the Sprague River sub basin, Oregon. Pages 18-29 In: P. J. Howell and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22(1):82-90.

Zollweg, E. C. 1998. Piscine predation on bull trout in the Flathead River, Montana. Master's Thesis, Montana State University, Bozeman, Montana. 97 pp.

Zubik, R. J. and J. J. Fraley. 1987a. Determination of fishery losses in the Flathead system resulting from the construction of Hungry Horse Dam. Prepared for Bonneville Power Administration, Portland, Oregon by Montana Department of Fish, Wildlife & Parks, Kalispell, Montana.

APPENDIX A

Streambed Coring

Results of annual hollow core sampling in individual spawning areas for the Flathead Lake population from 1981-2003. The bold line at 35 percent less than 6.35 mm indicates the level above which embryo survival to emergence is threatened (FBC 1991). At over 40 percent less than 6.35 mm, survival is considered impaired.

Figure A-1. Results from streambed coring in the Big Creek spawning area from 1981 through 2004.

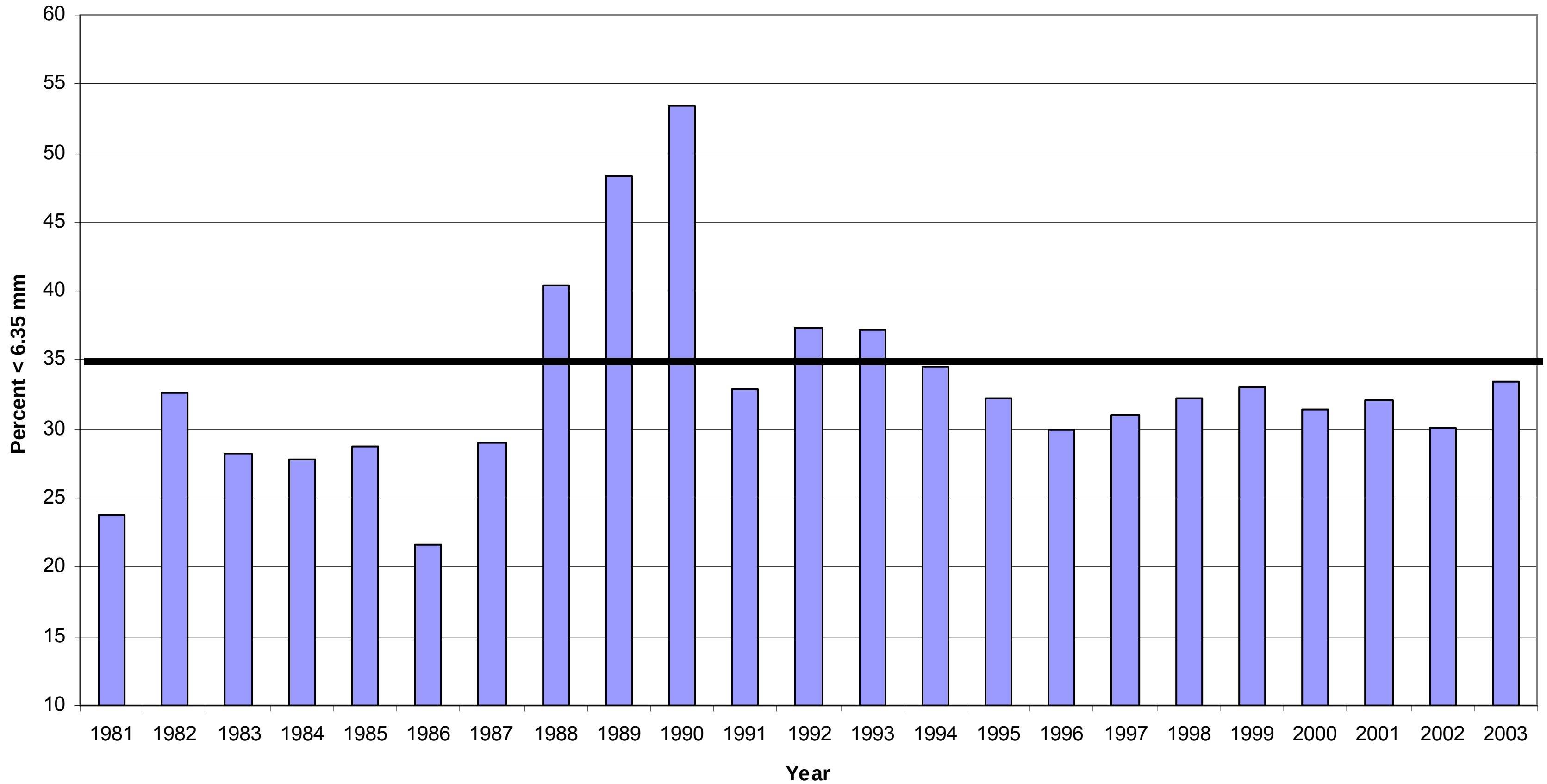


Figure A-2. Results from streambed coring in the Coal-Deadhorse Creek spawning area from 1981 through 2003.

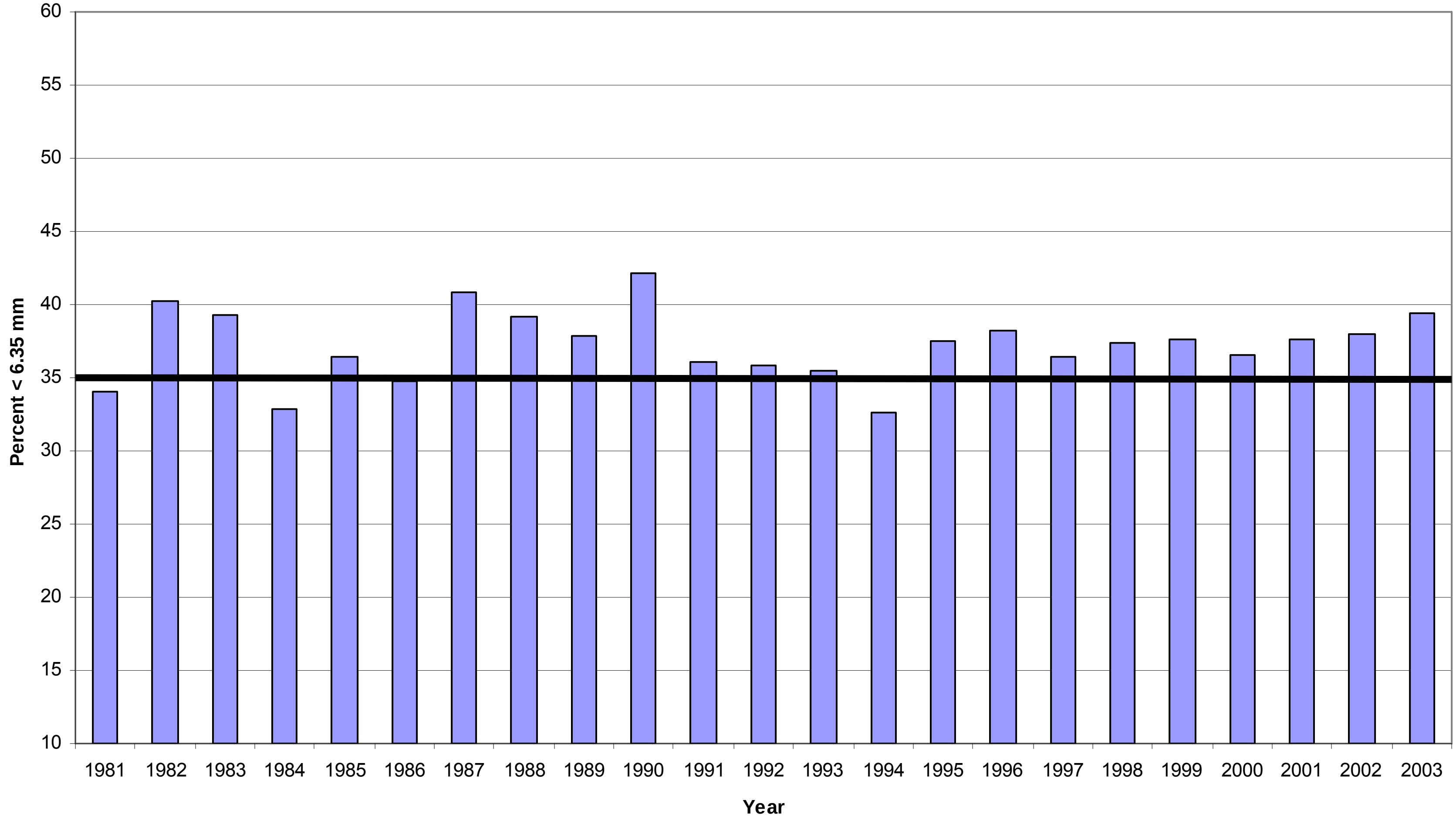


Figure A-3. Results from streambed coring in the North Coal Creek spawning area from 1981 through 2003.

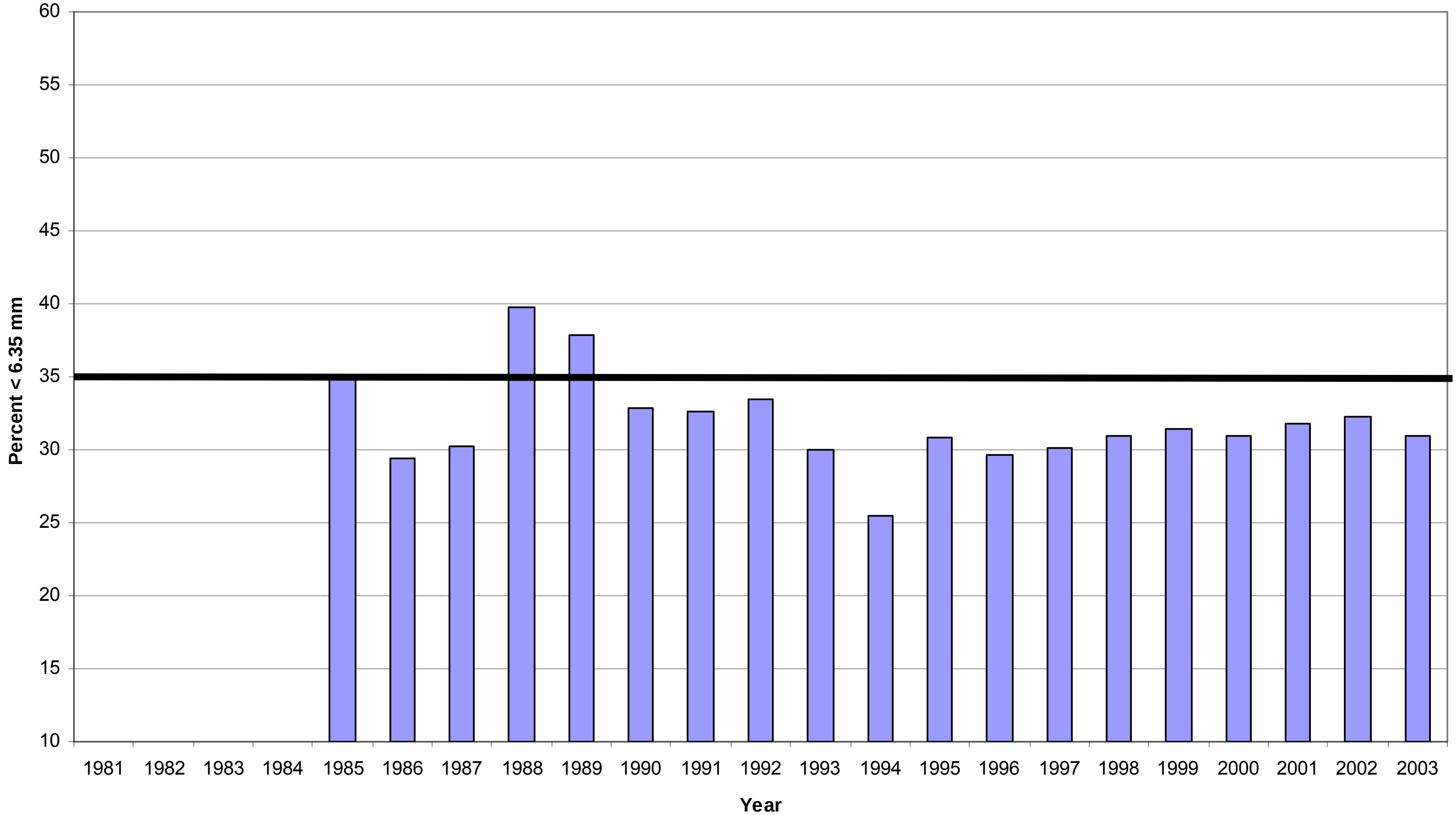


Figure A-4. Results from streambed coring in the South Coal Creek spawning area from 1981 through 2003.

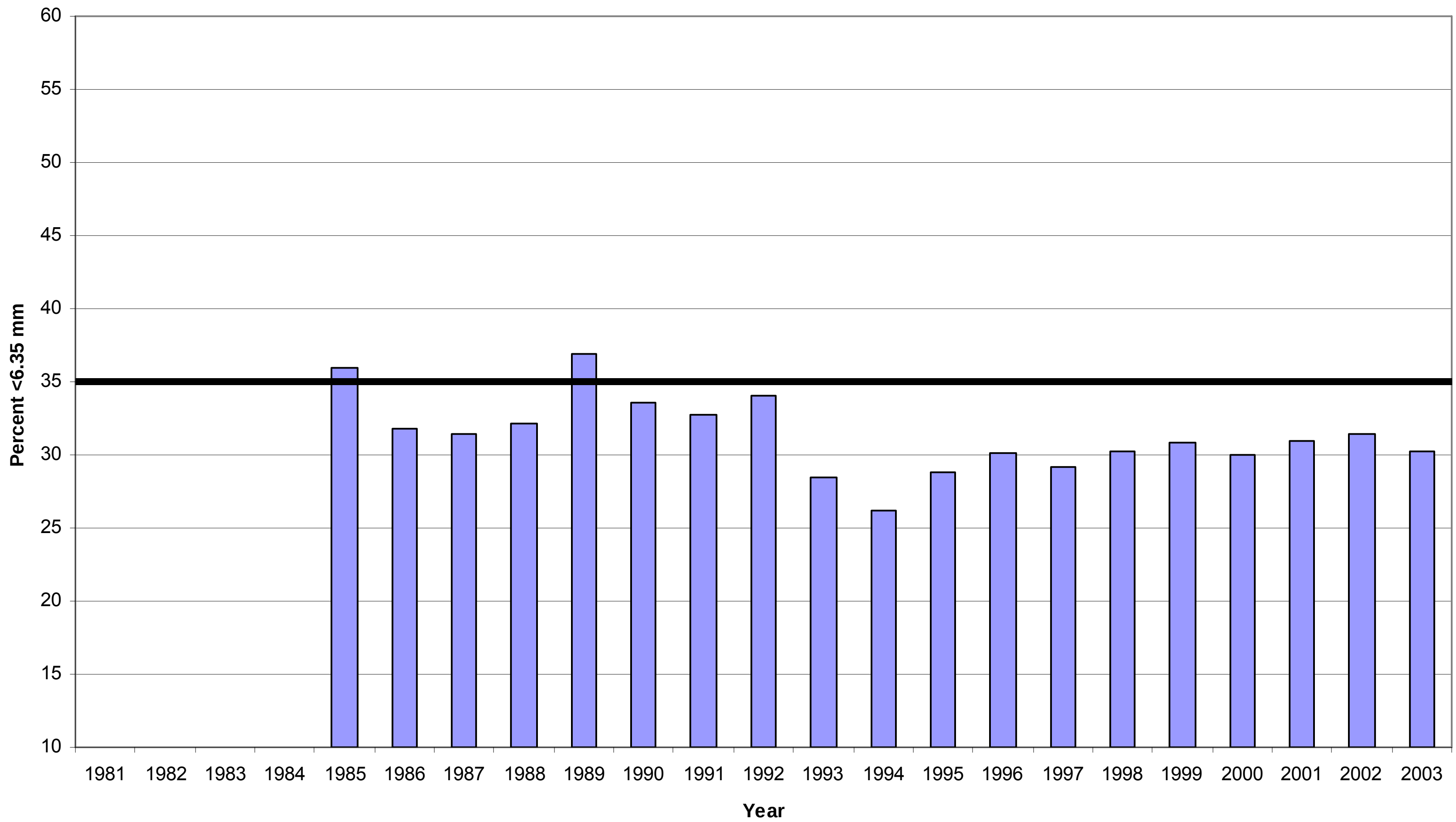


Figure A-5. Results from streambed coring in the Whale Creek spawning area from 1981 through 2003.

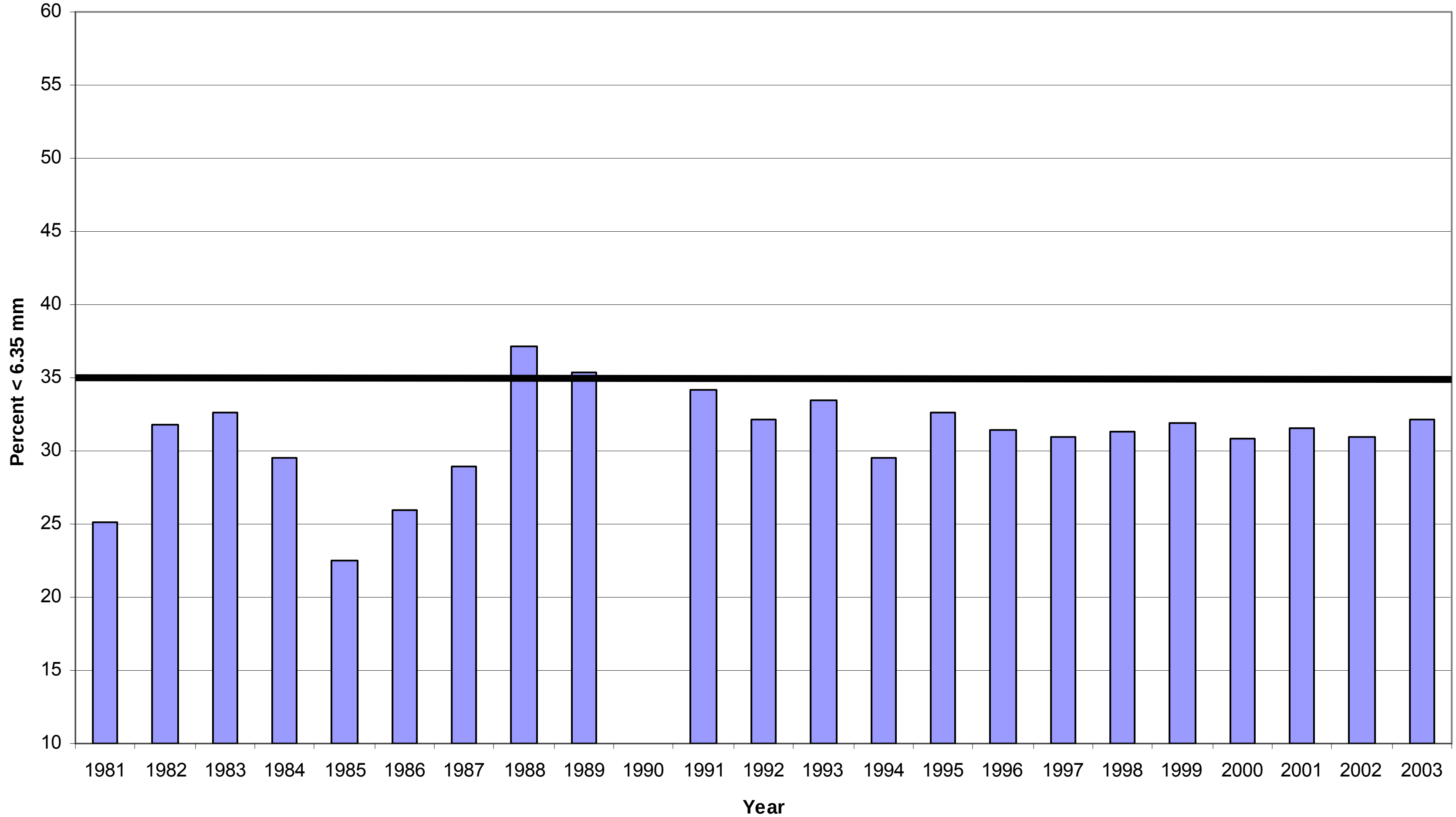


Figure A-6. Results from streambed coring in the Trail Creek spawning area from 1981 through 2003.

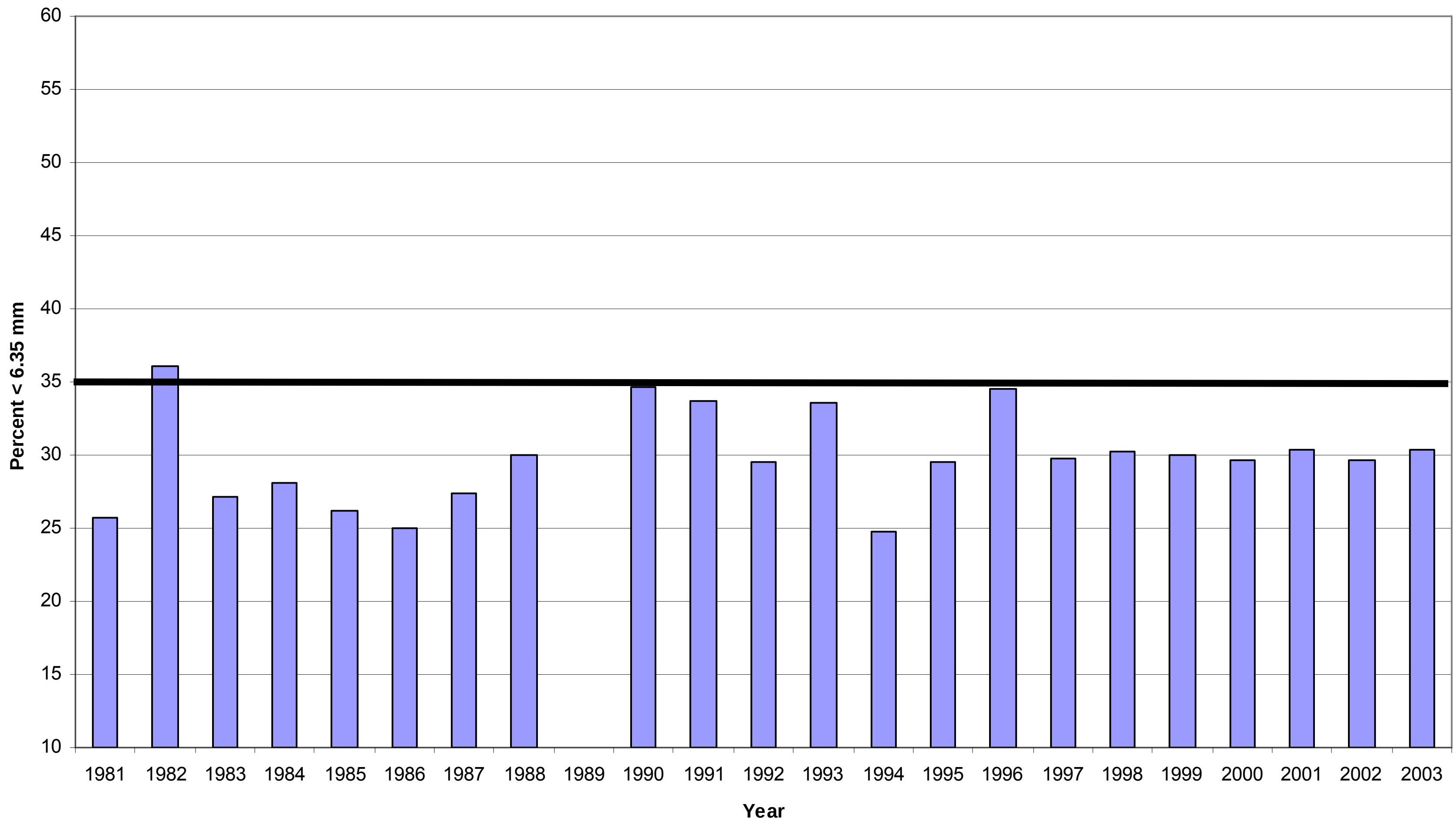


Figure A-7. Results from streambed coring in the Granite Creek spawning area from 1981 through 2003.

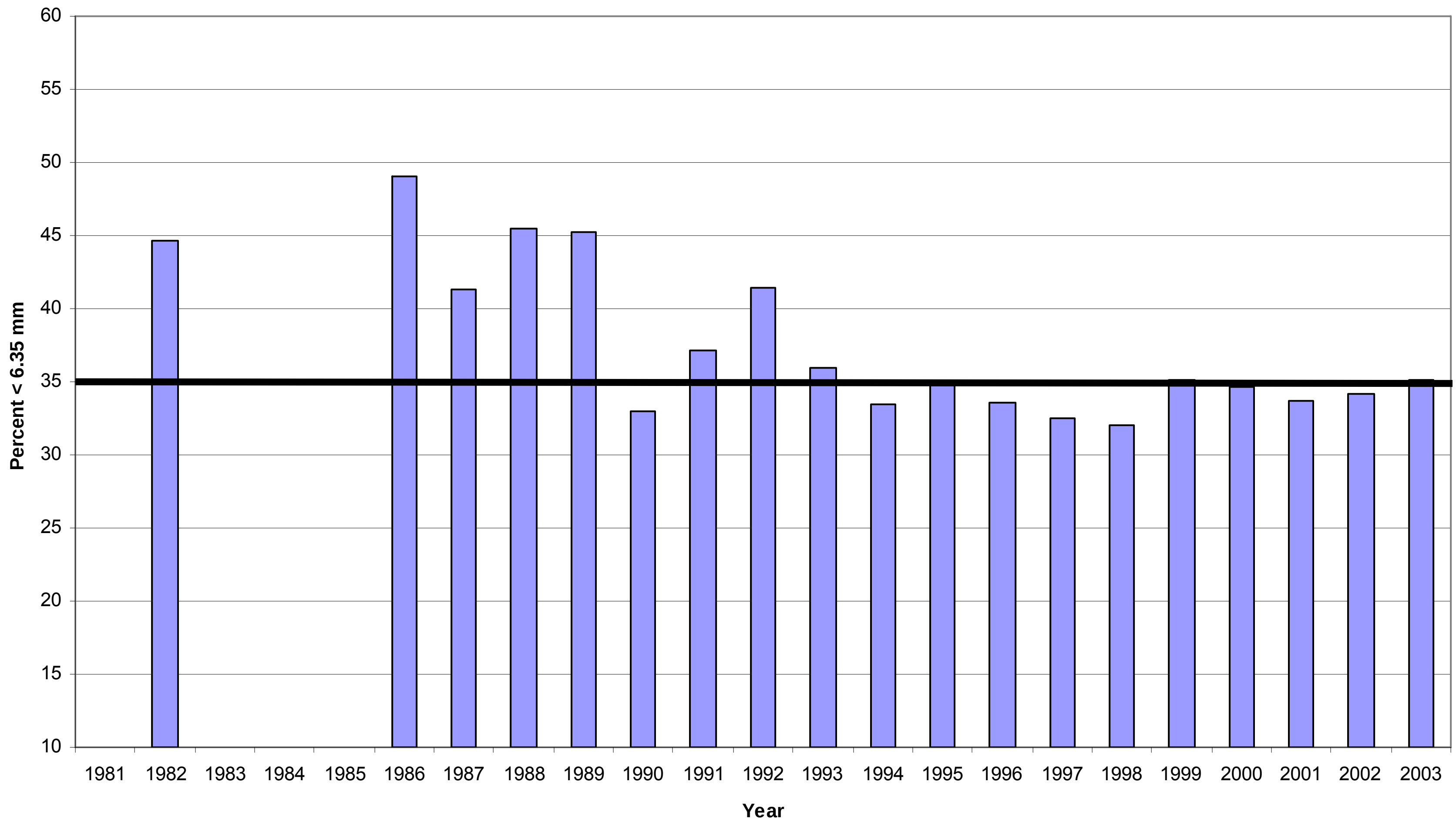


Figure A-8. Results from streambed coring in the Challenge Creek spawning area from 1981 through 2003.

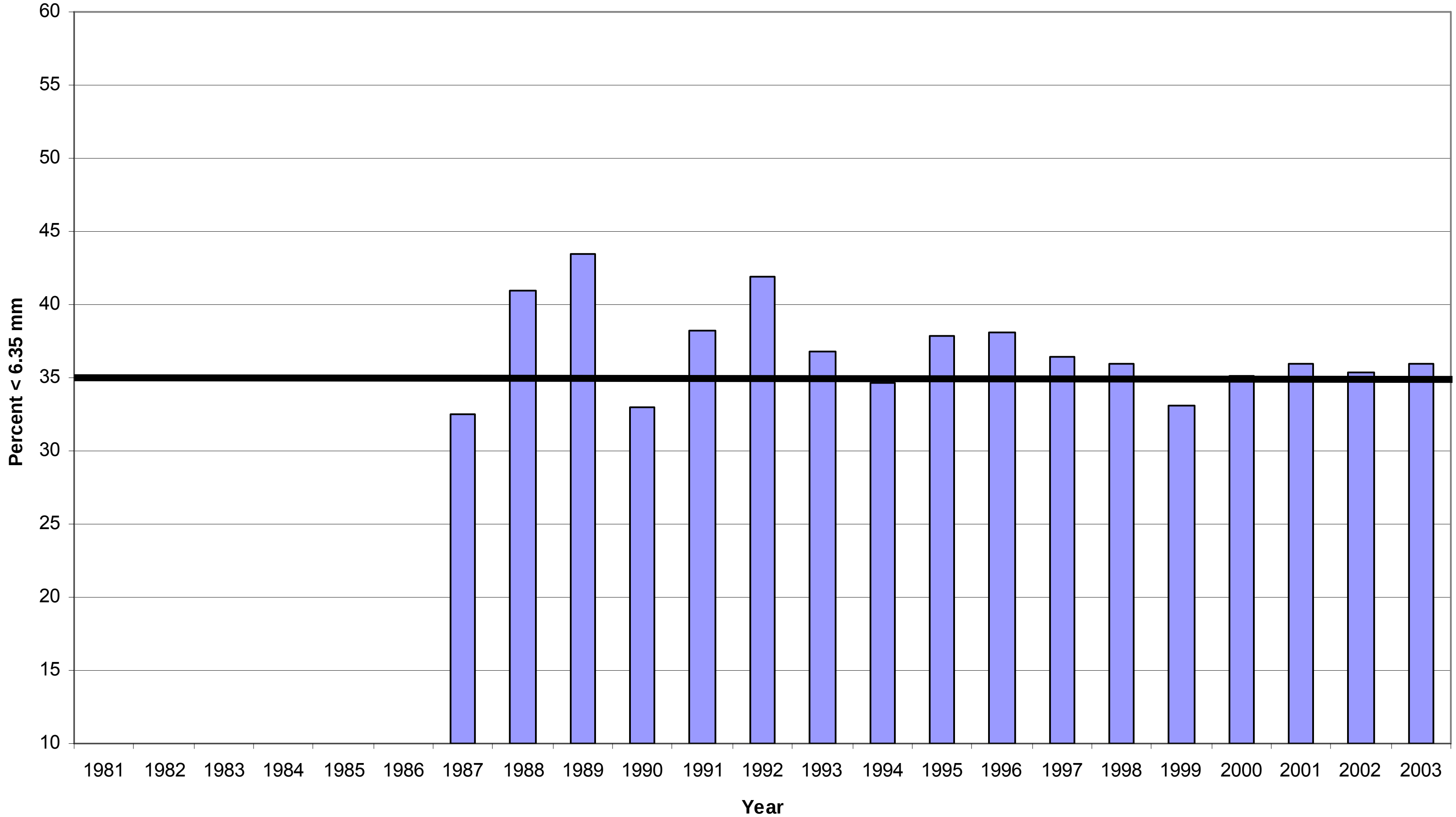


Figure A-9. Results from streambed coring in the Langford Creek spawning area from 1981 through 2003.

Figure A-10. Results from streambed coring in the Cyclone Creek spawning area from 1981 through 2003.

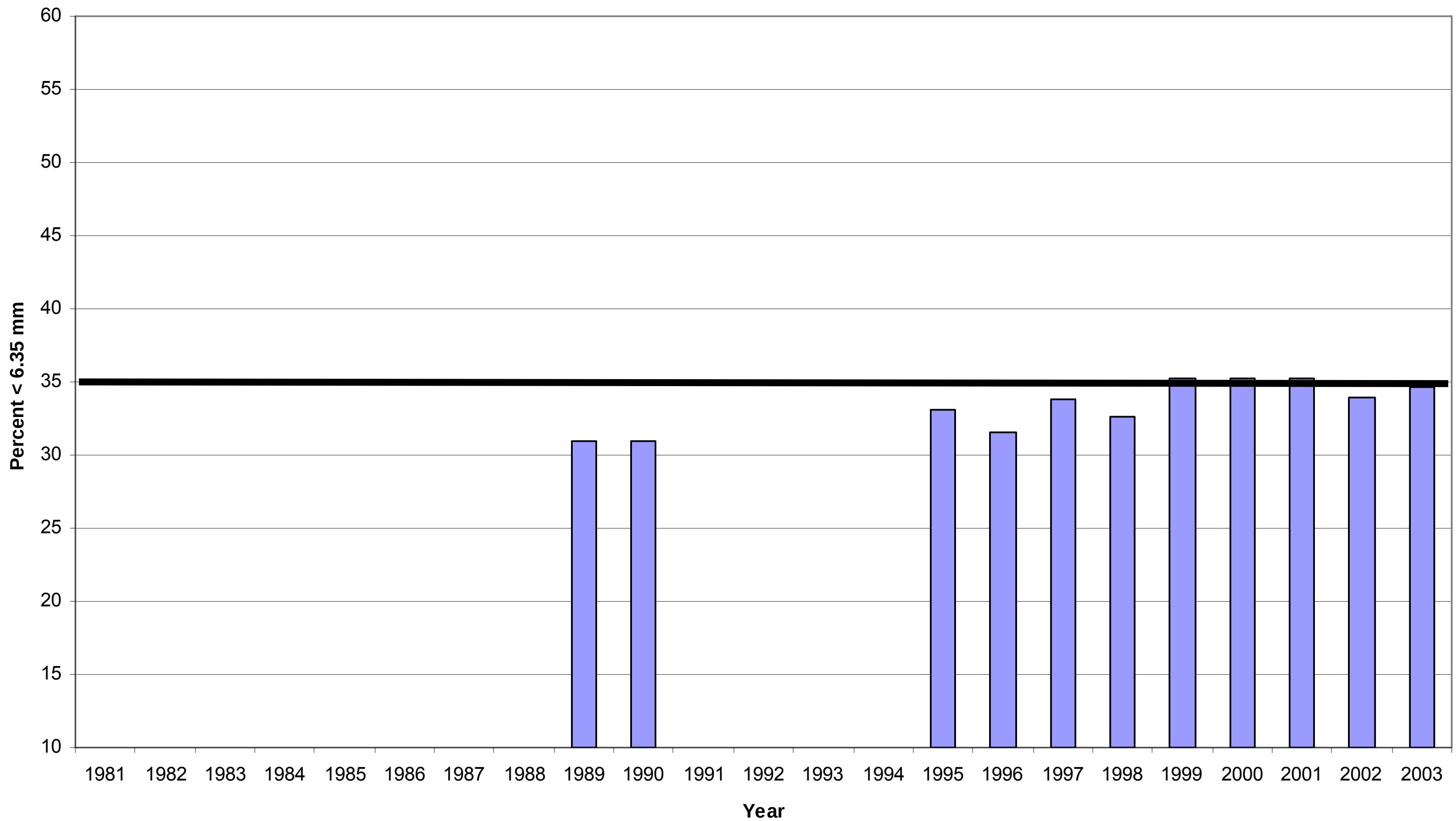


Figure A-11. Results from streambed coring in the Meadow Creek spawning area from 1981 through 2003.

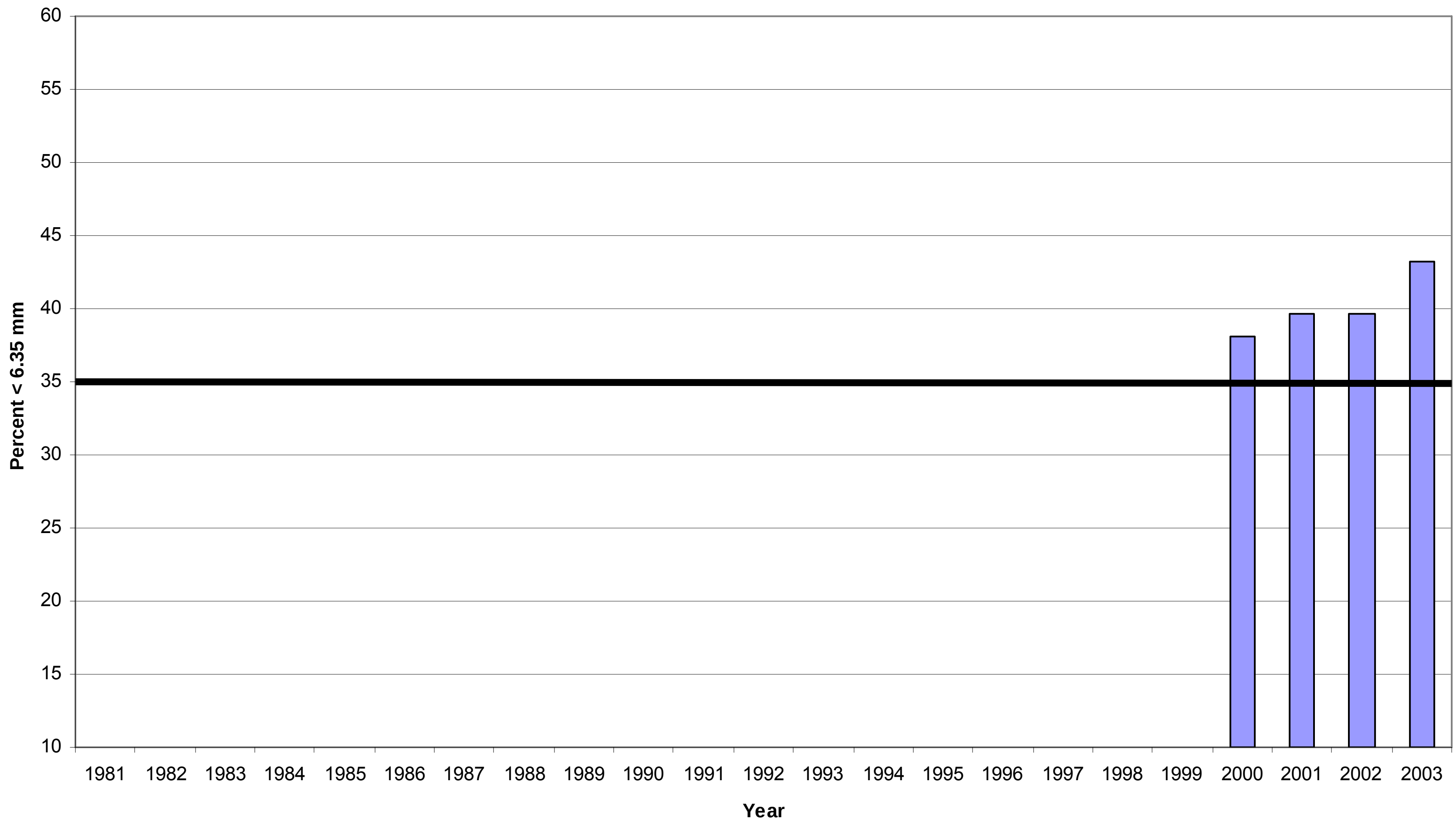


Figure A-12. Results from streambed coring in the Upper Stillwater River spawning area from 1981 through 2003.

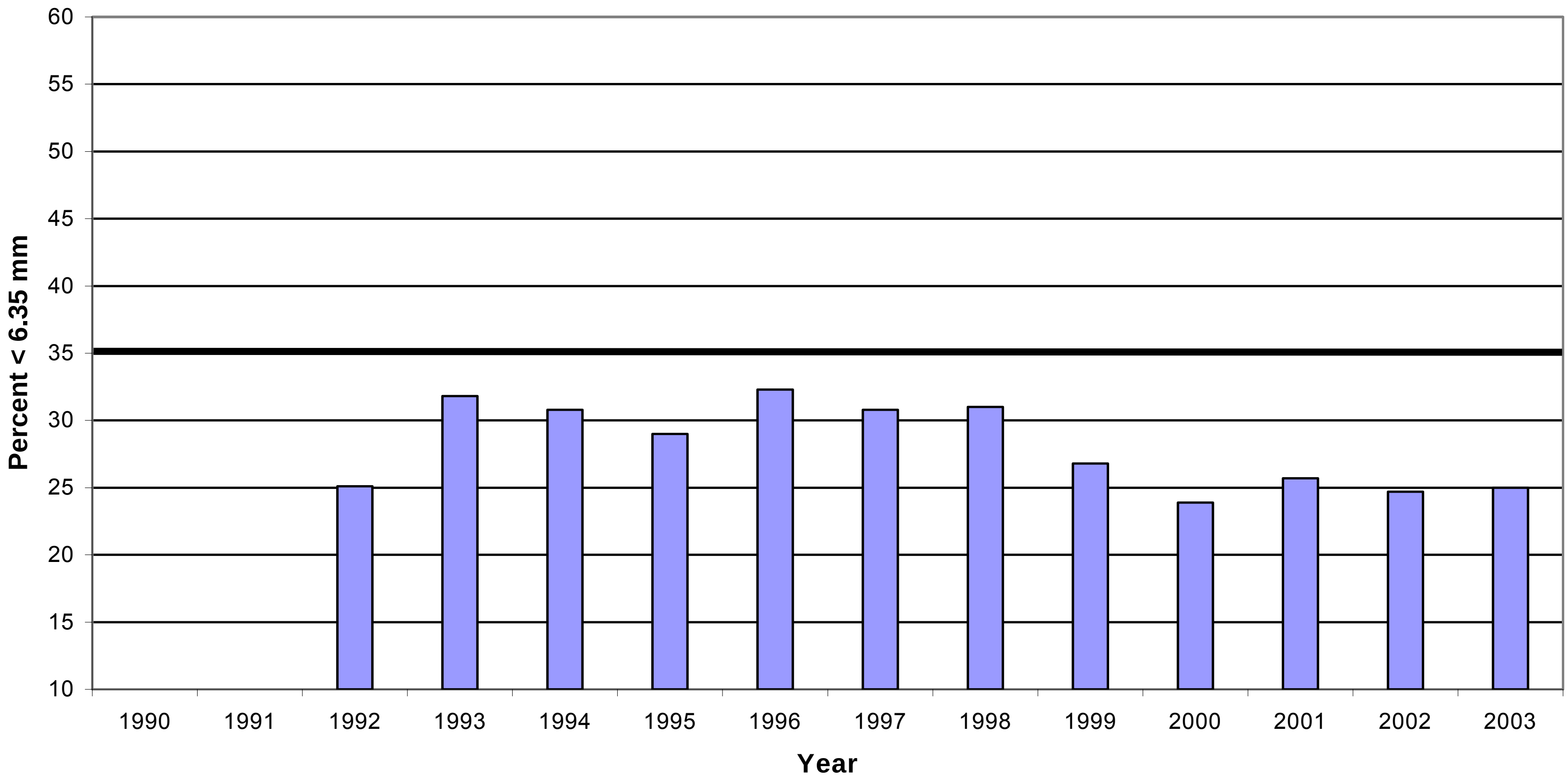


Figure A-13. Results from streambed coring in the Lower Stillwater River spawning area from 1981 through 2003.

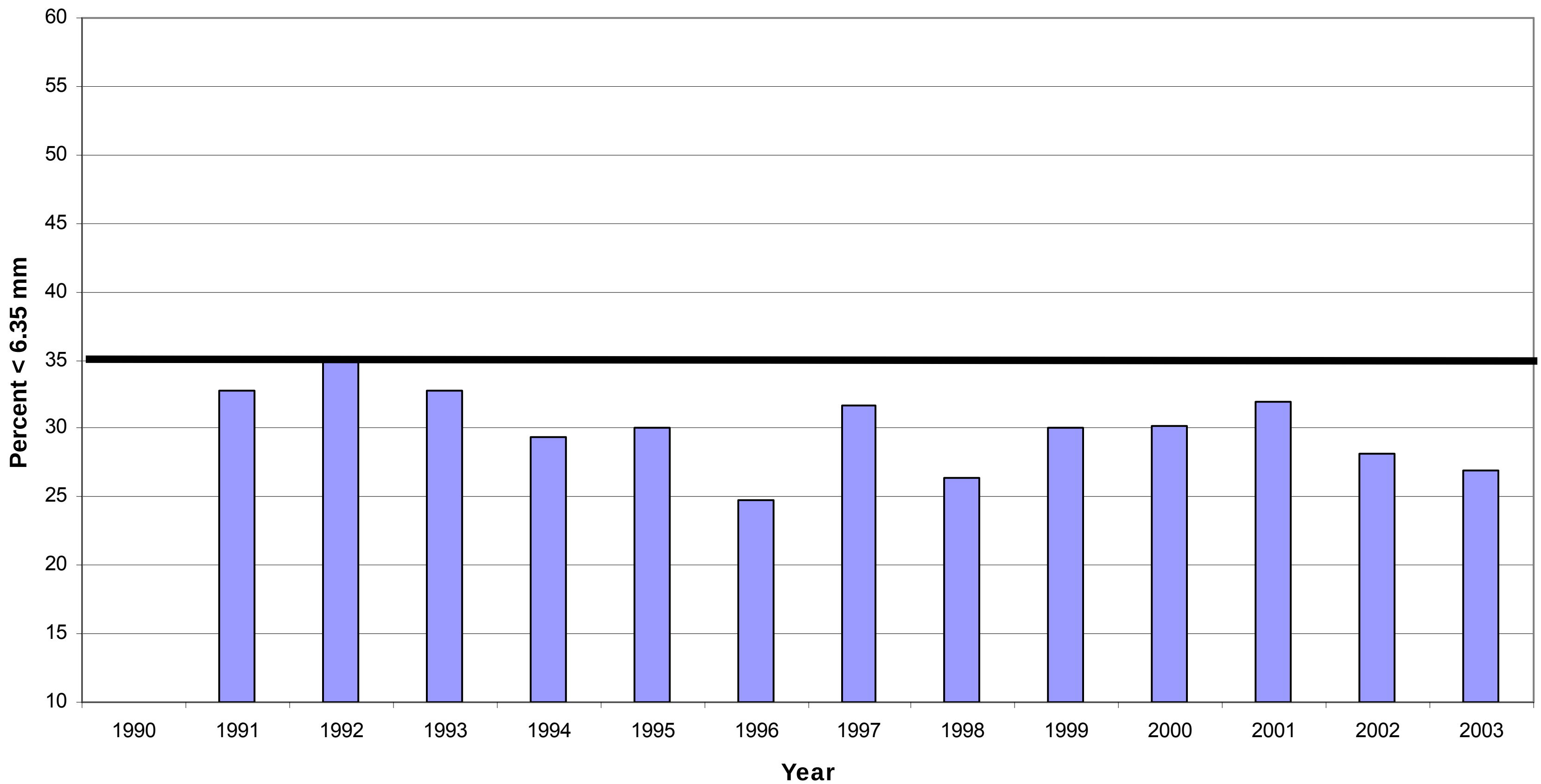


Figure A-14. Results from streambed coring in the Fitzsimmons Creek spawning area from 1981 through 2003.

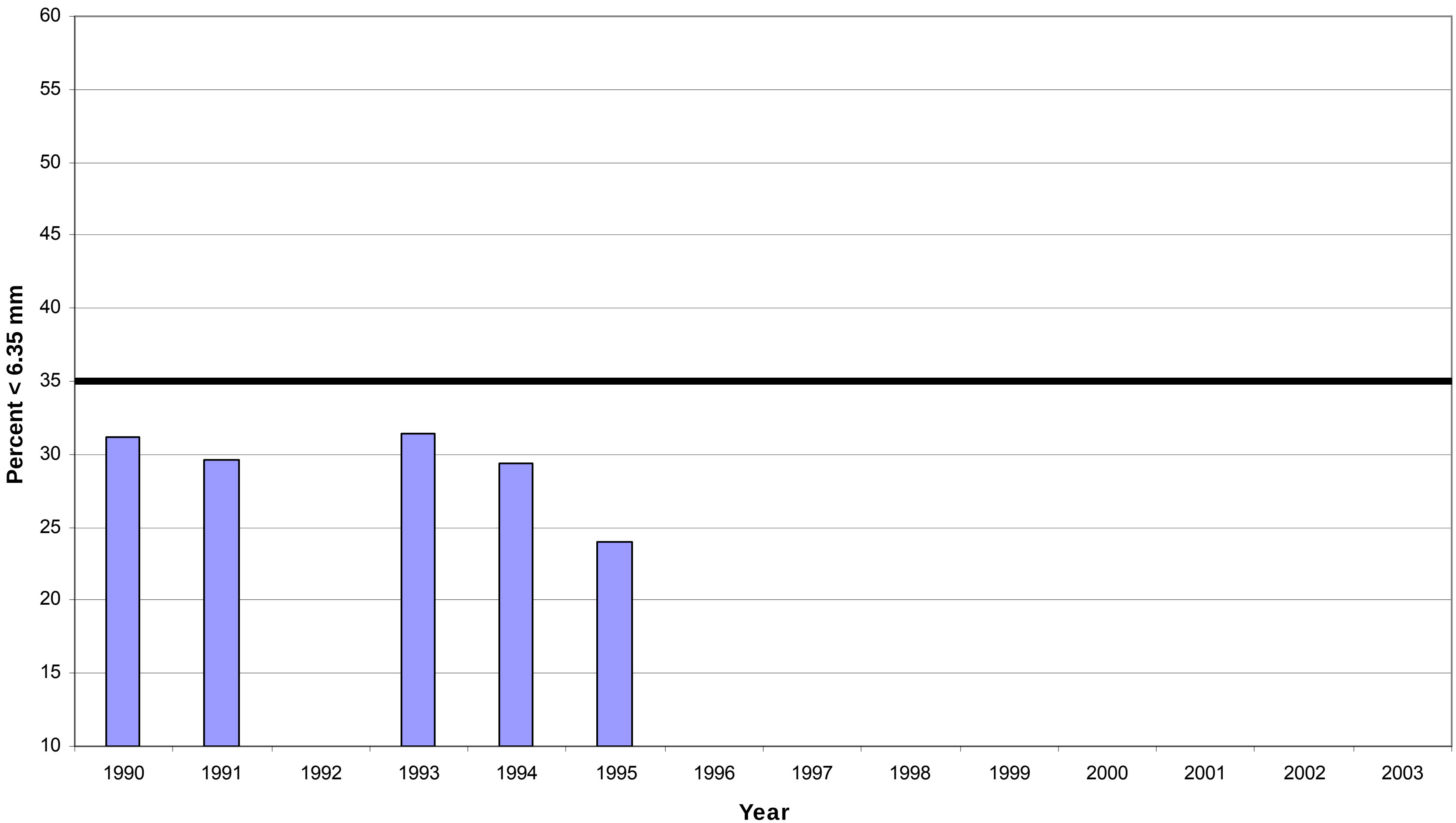


Figure A-15. Results from streambed coring in the Chepat Creek spawning area from 1981 through 2003.

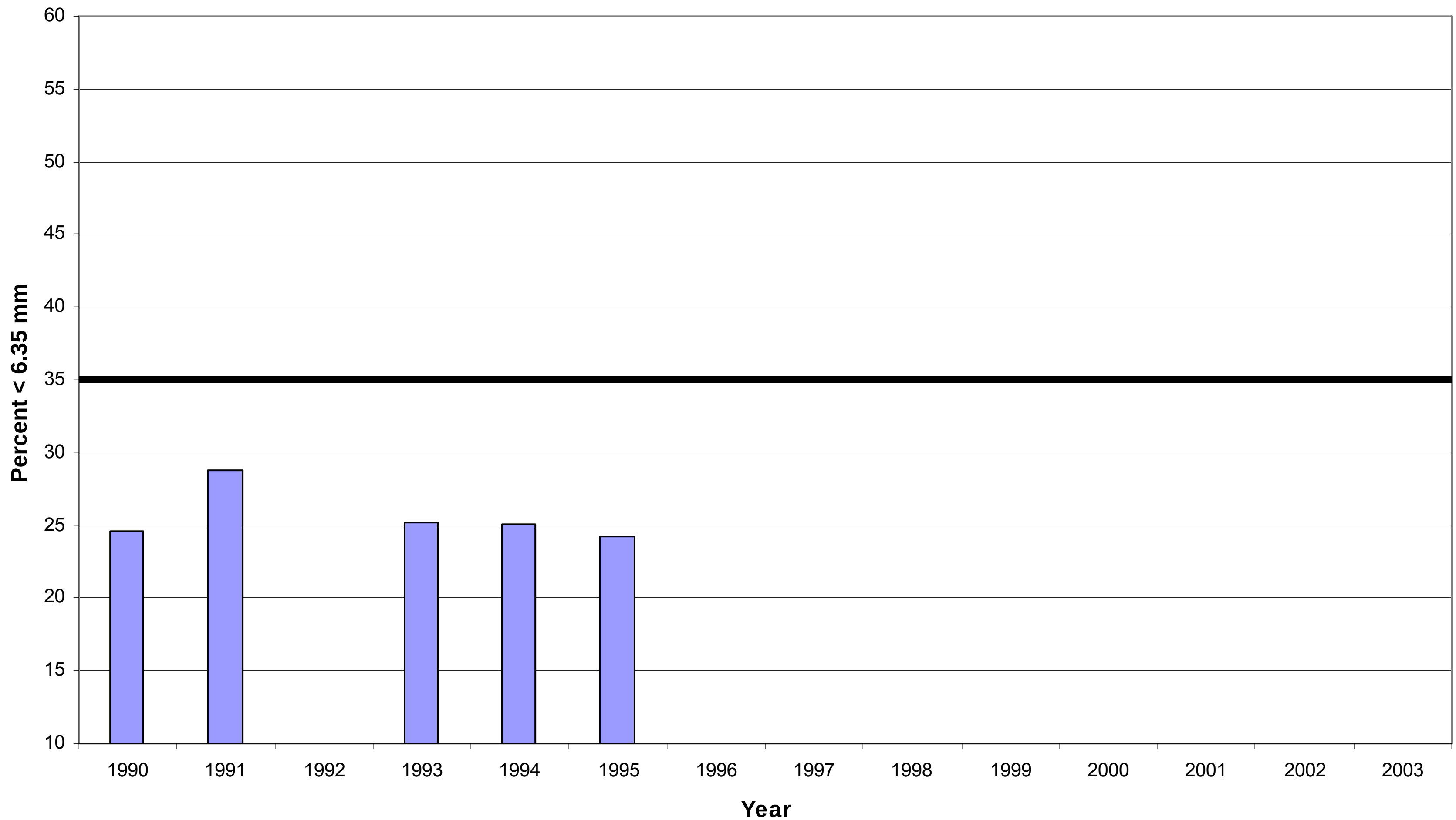


Figure A-16. Results from streambed coring in the West Swift Creek spawning area from 1981 through 2003.

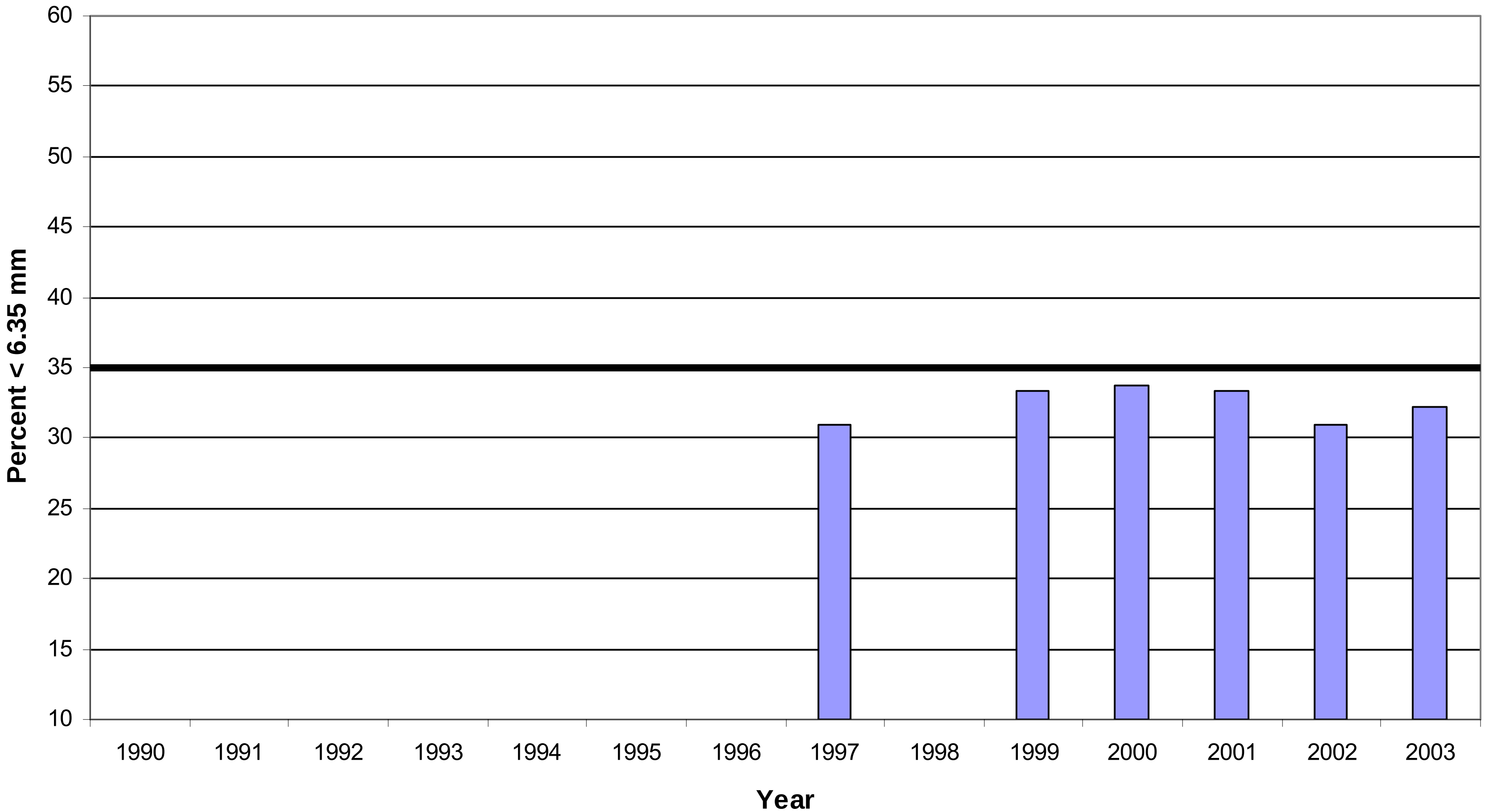


Figure A-17. Results from streambed coring in the Swift Creek spawning area from 1981 through 2003.

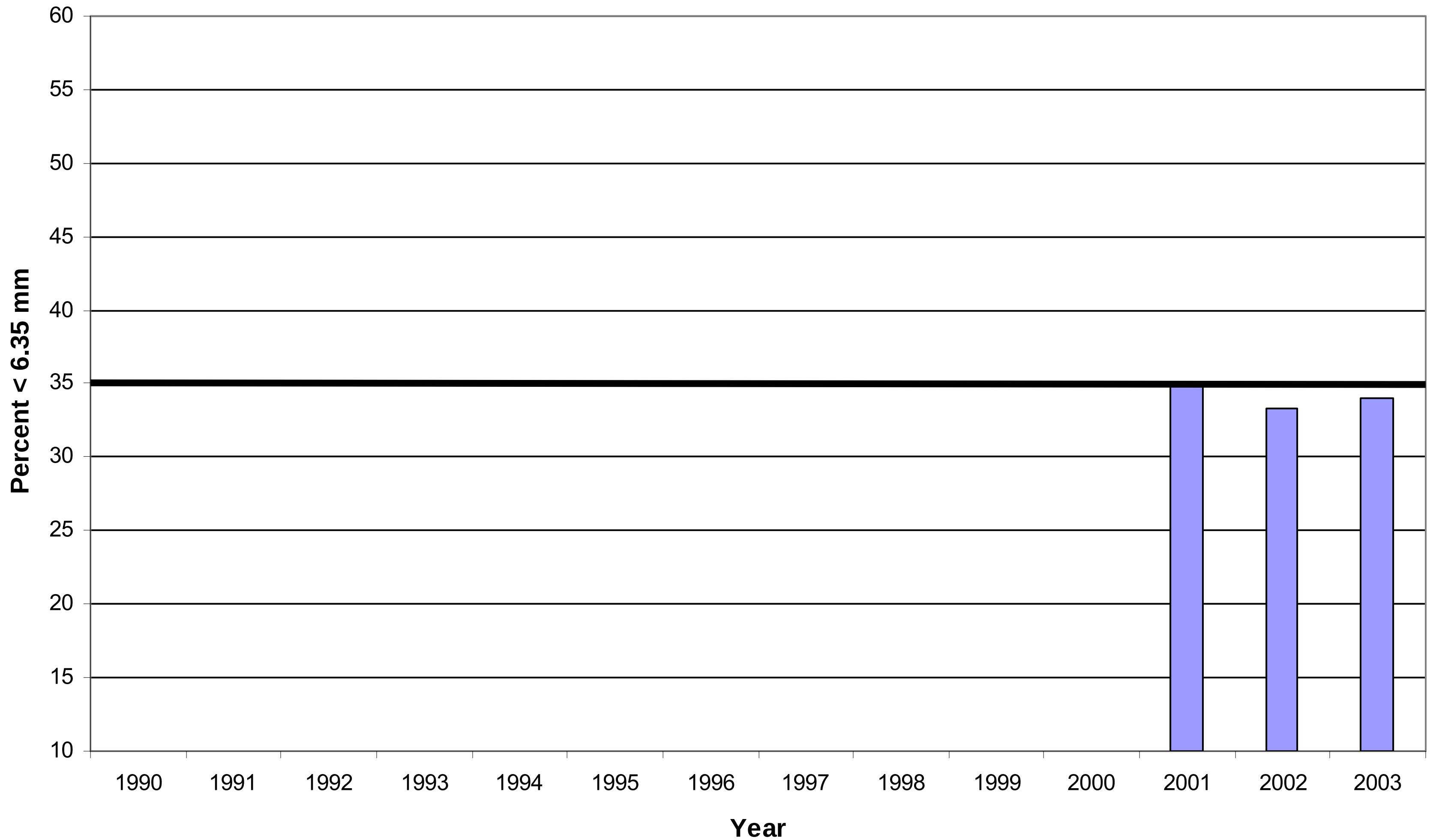


Table A-1. Median percentage of streambed material smaller than 6.35 mm in McNeil core samples collected from bull trout spawning areas in the Stillwater River and Swift Creek drainages from 1990-2003.

Stream	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Stillwater (Upper)	--	--	25.1	31.8	30.8	29.0	32.3	30.8	31.0	26.8	23.9	25.7	24.7	25.0
Stillwater (Lower)	--	--	35.1	32.8	29.4	30.0	24.8	29.6	30.8	30.1	30.2	31.9	28.1	26.9
Fitzsimmons	31.2	--	29.6	31.4	29.4	24.0	--	--	--	--	--	--	--	--
Chepat	24.6	--	28.8	25.2	25.1	24.2	--	--	--	--	--	--	--	--
East Swift	28.4	--	--	--	--	--	31.2	--	--	--	--	--	--	--
West Swift	--	--	--	--	--	--	--	31.0	--	33.4	33.7	33.4	31.0	32.2
Swift	--	--	--	--	--	--	--	--	--	--	--	35.1	33.3	34.0

APPENDIX B

Substrate Scoring

Results of annual substrate scoring for individual stream sections providing juvenile bull trout rearing for the Flathead Lake population. The bold line at the score of 10.0 indicates the level below which rearing capacity becomes threatened (FBC 1991). At scores less than 9.0 rearing capacity is considered impaired.

Figure B-1. Substrate scoring results for the Big Creek index section from 1986 through 2004.

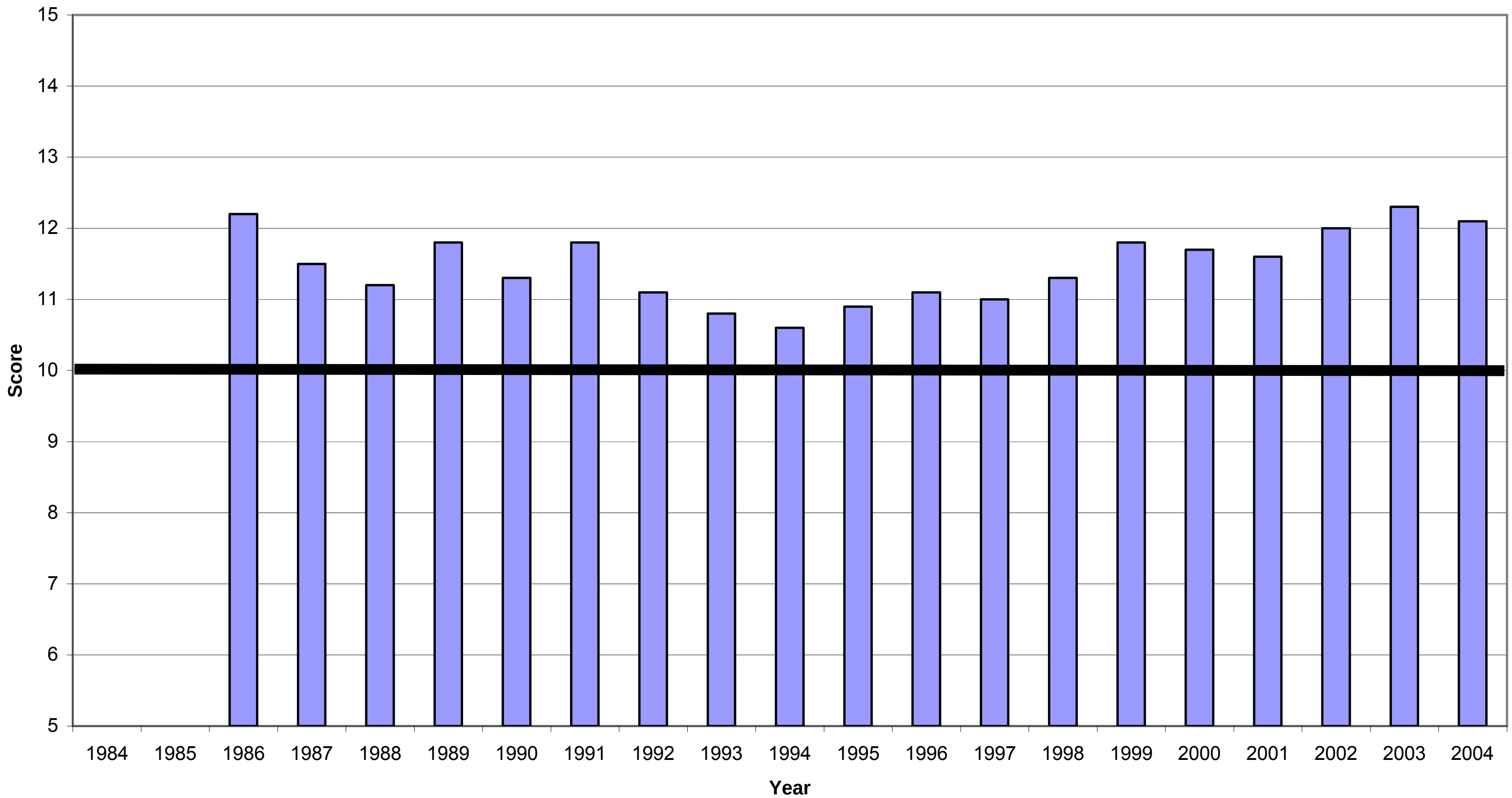


Figure B-2. Substrate scoring results for the Coal Creek index section from 1986 through 2004.

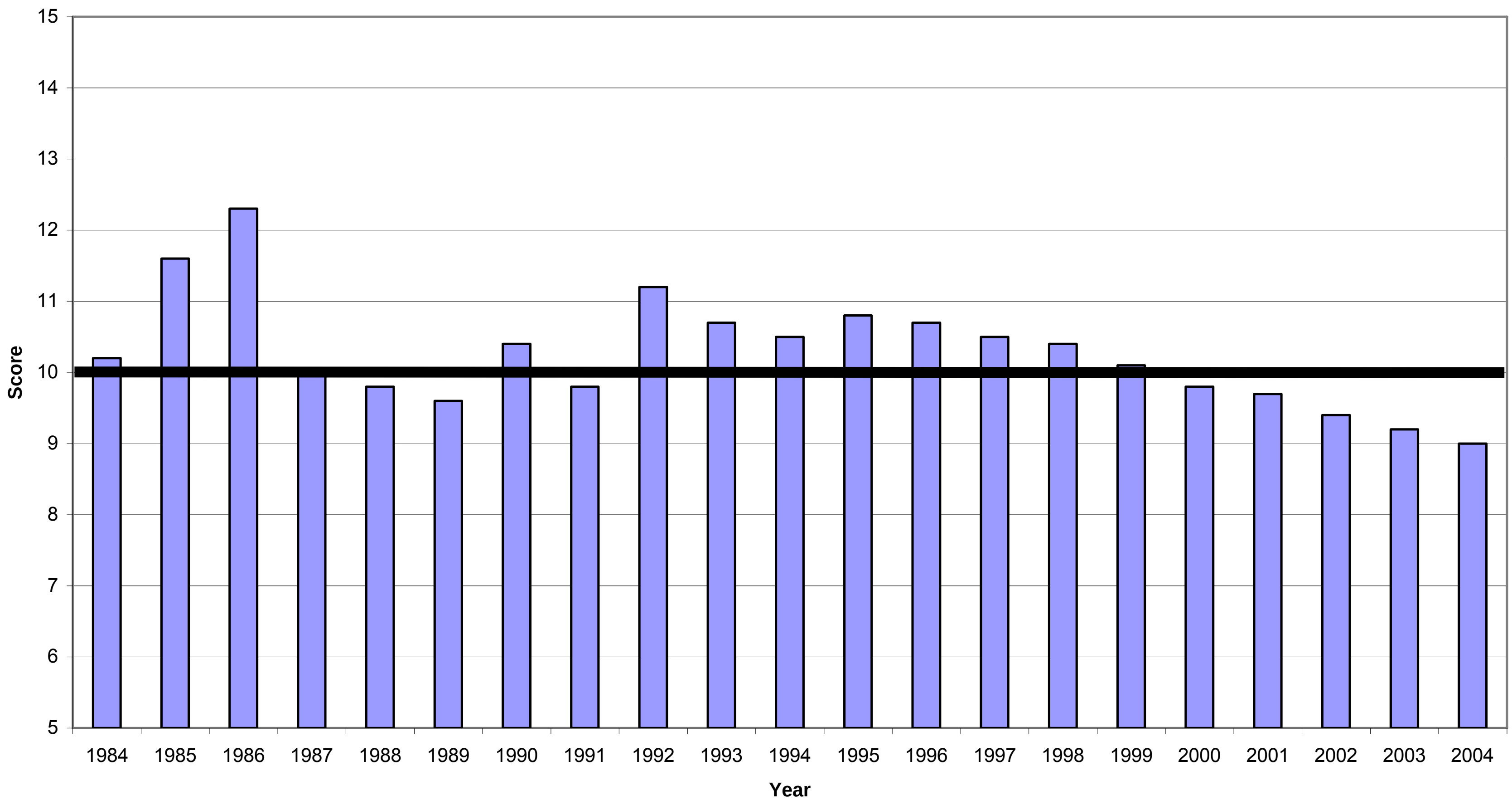


Figure B-3. Substrate scoring results for the Cyclone Creek index section from 1986 through 2004.

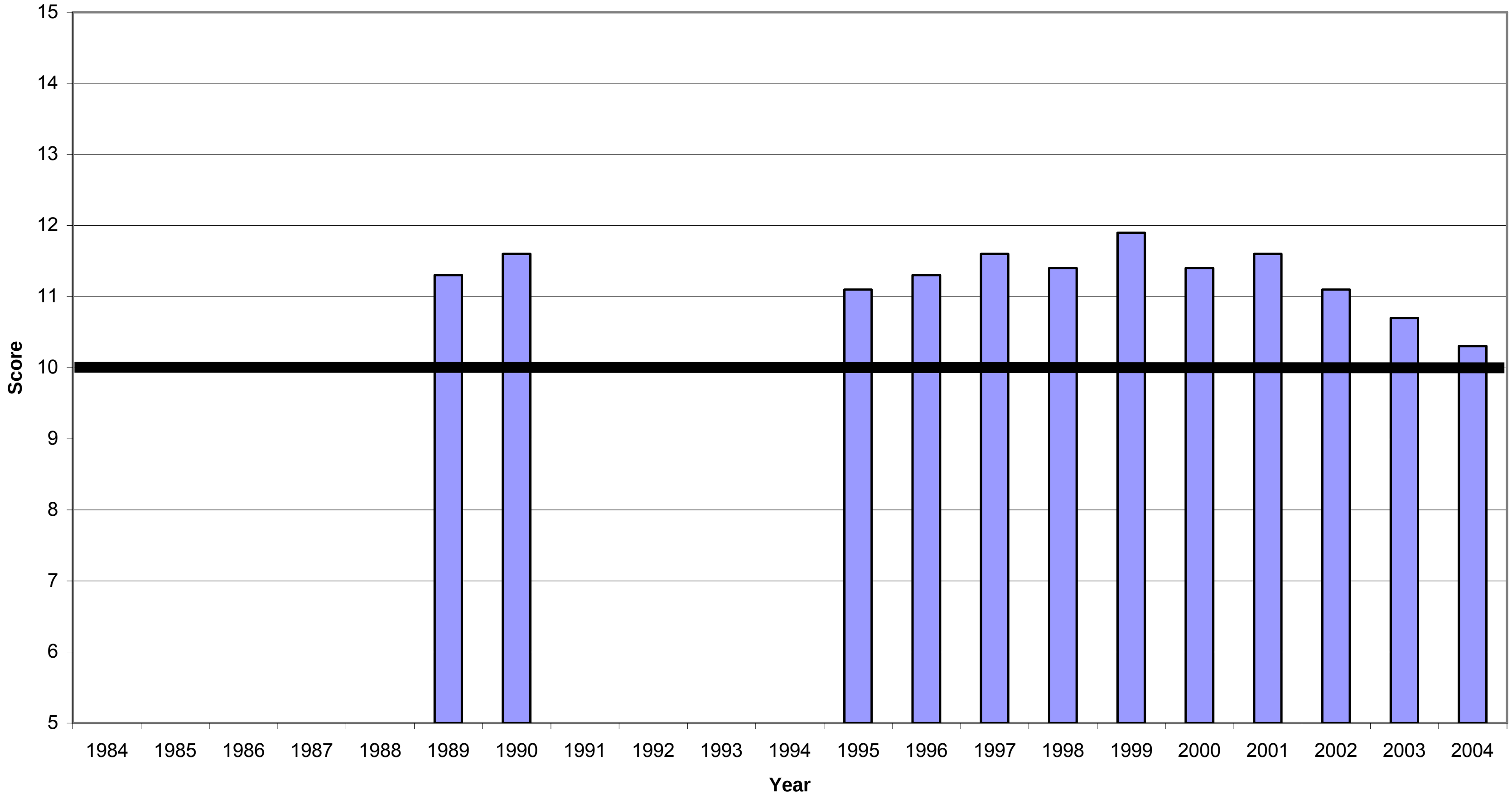


Figure B-4. Substrate scoring results for the North Coal Creek index section from 1986 through 2004.

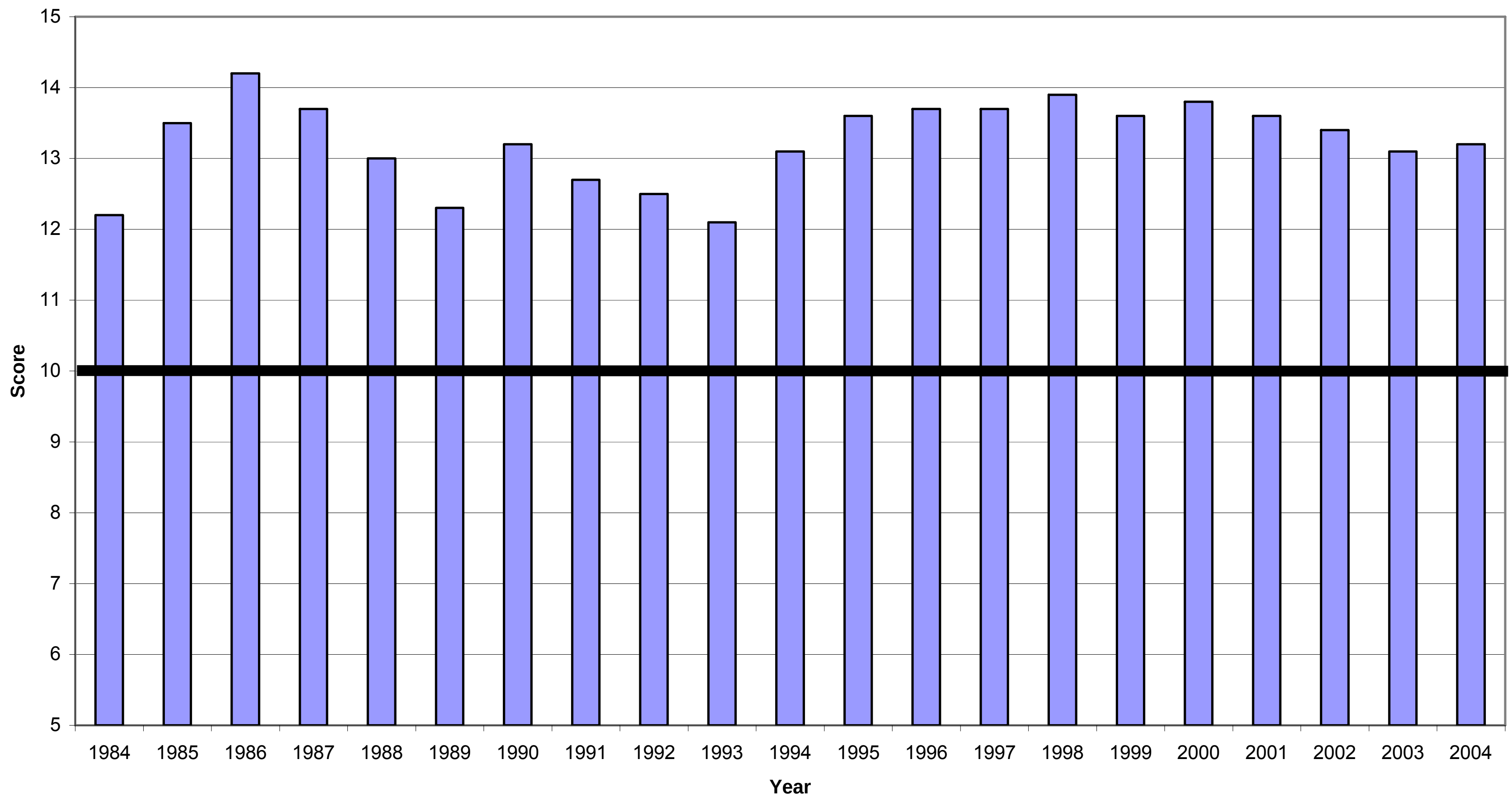


Figure B-5. Substrate scoring results for the South Coal Creek index section from 1986 through 2004.

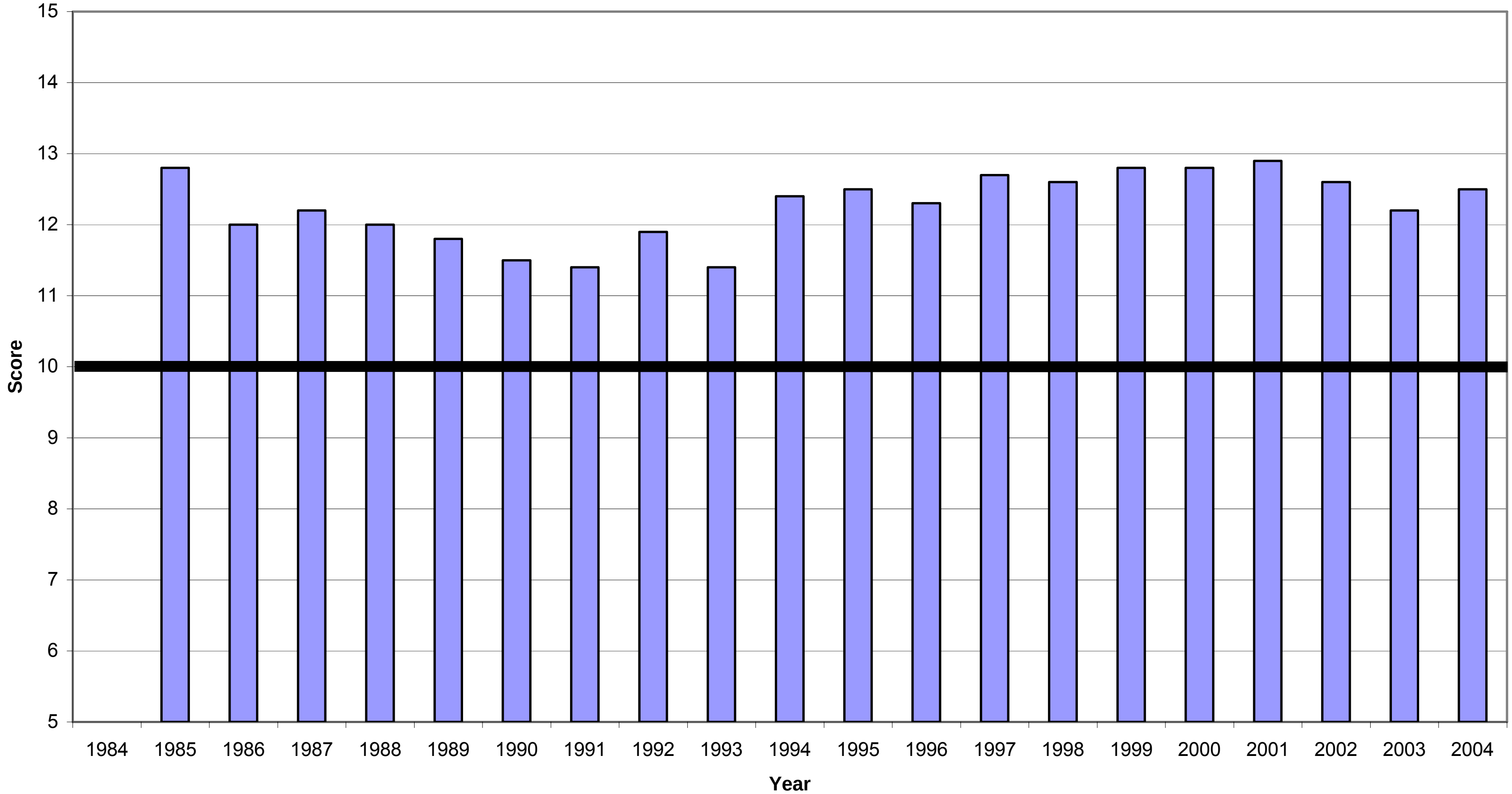


Figure B-6. Substrate scoring results for the Red Meadow Creek index section from 1986 through 2004.

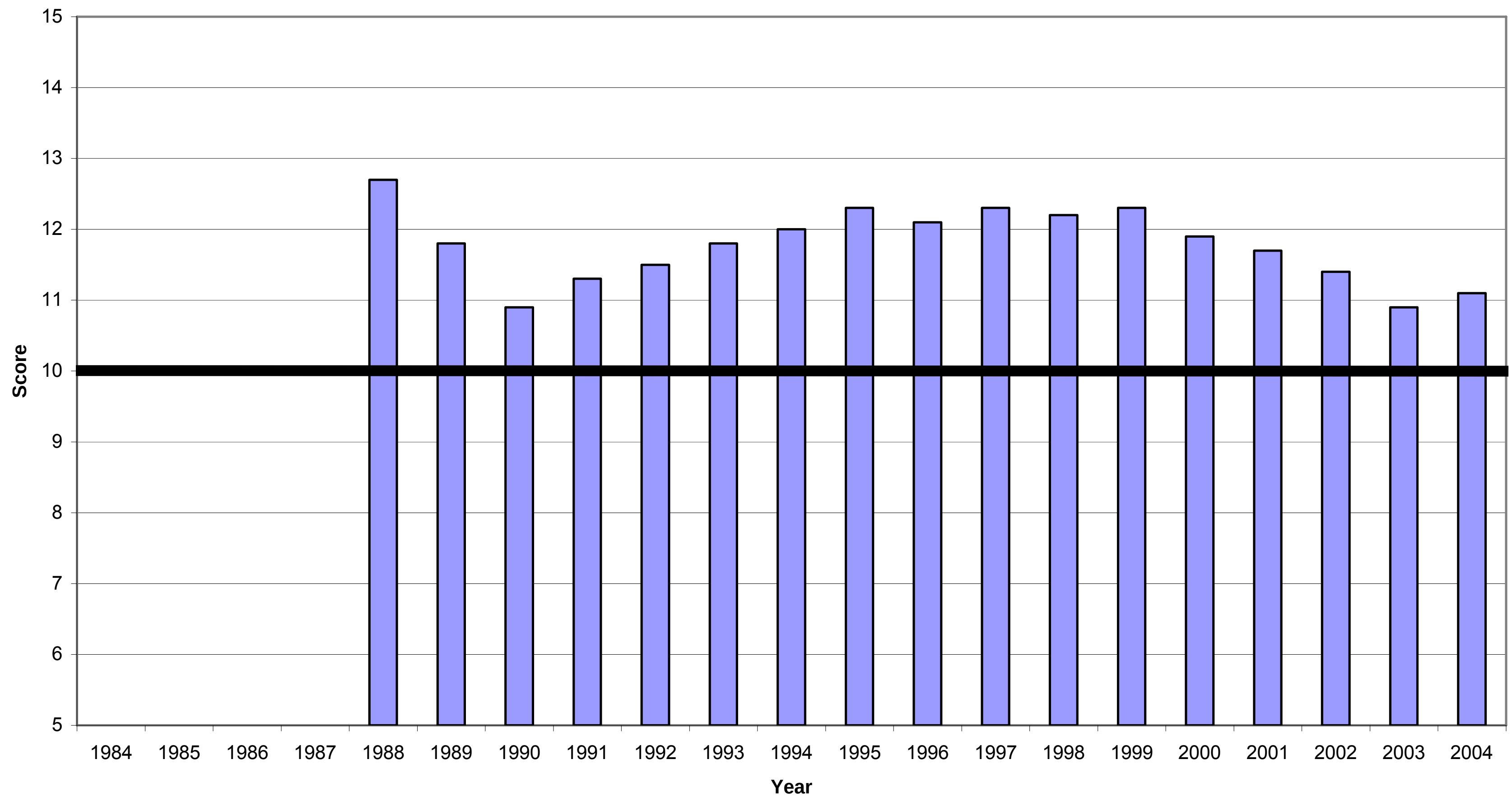


Figure B-7. Substrate scoring results for the Whale Creek index section from 1986 through 2004.

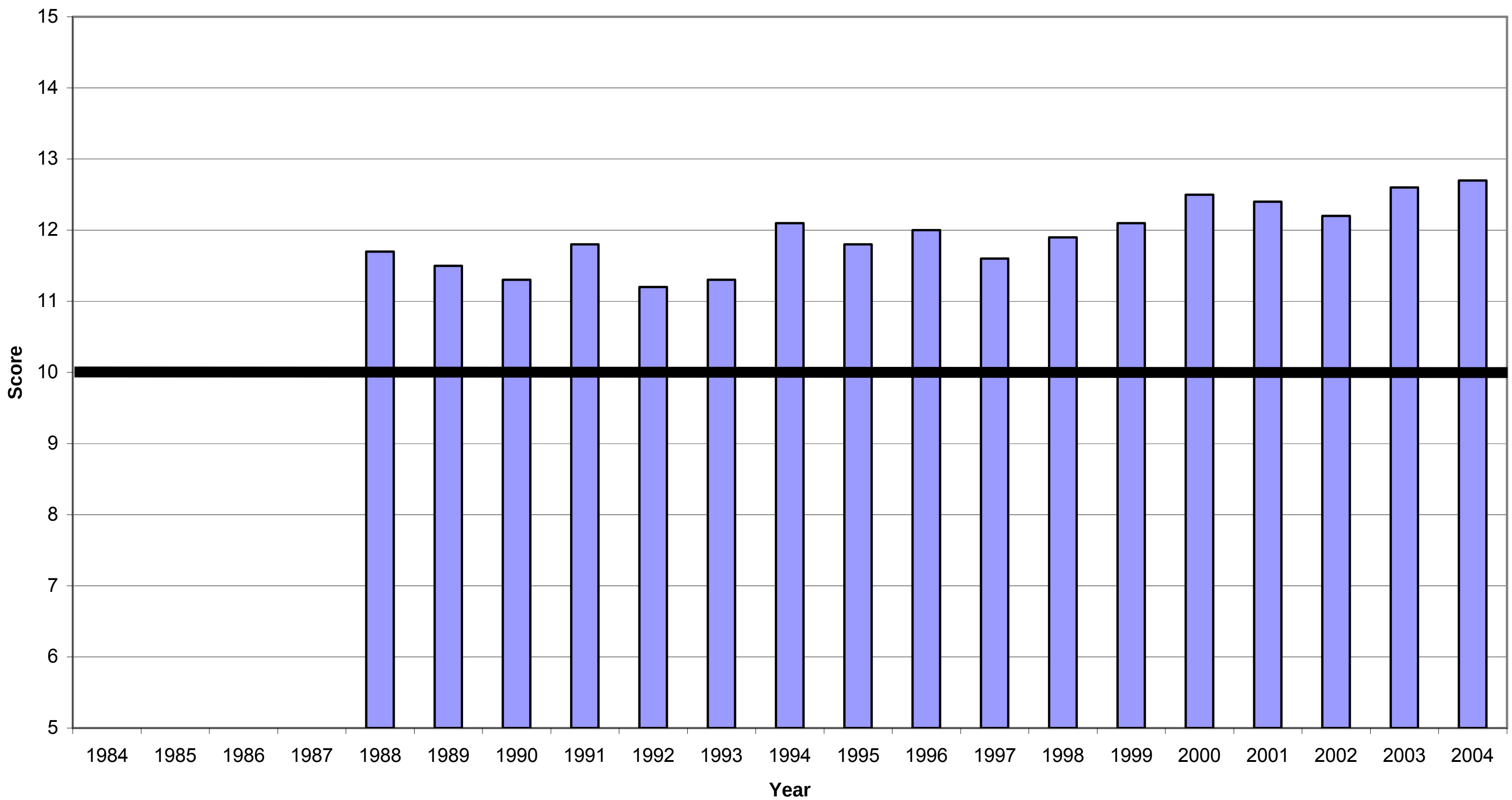


Figure B-8. Substrate scoring results for the Morrison Creek index section from 1986 through 2004.

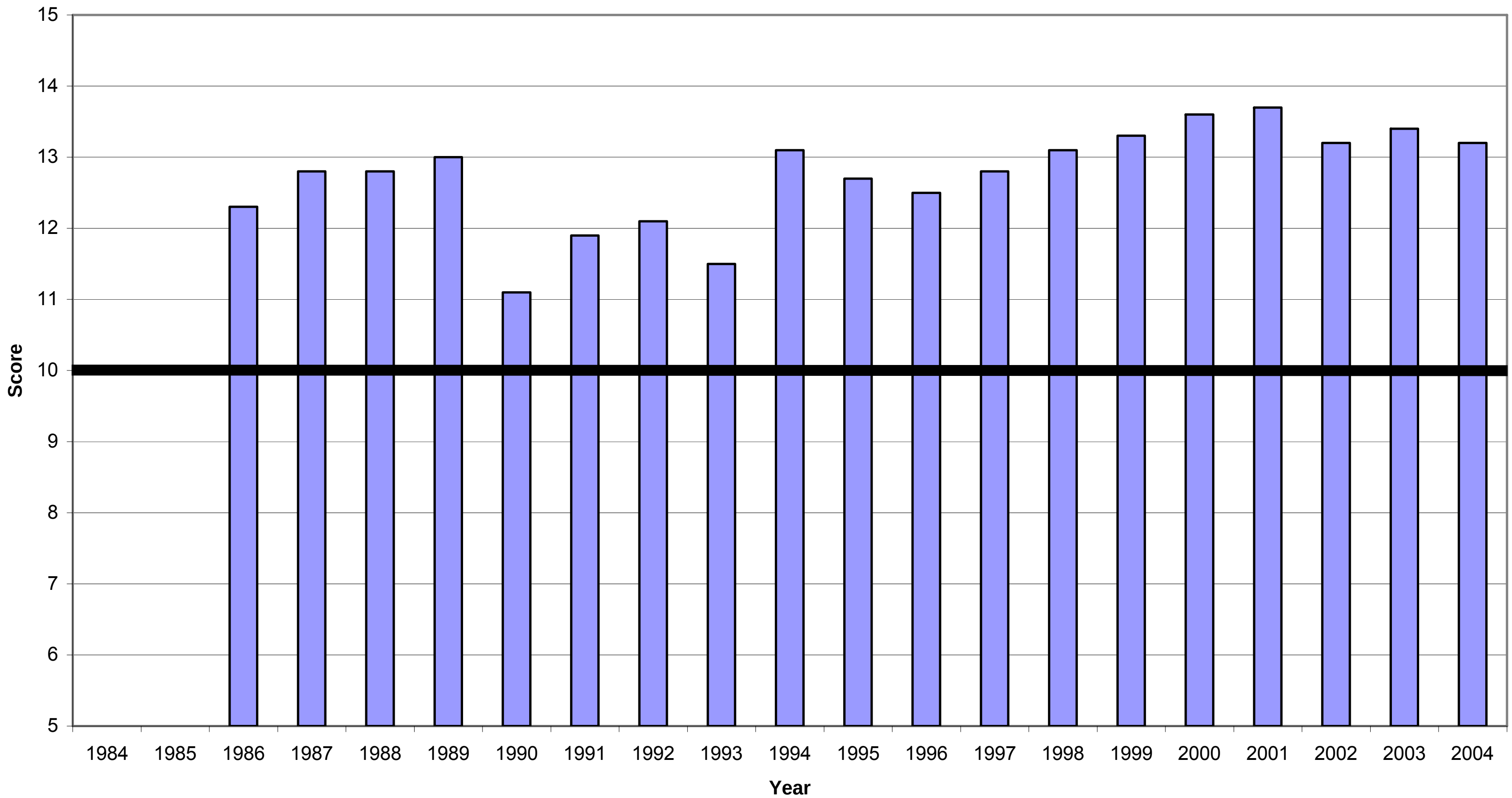


Figure B-9. Substrate scoring results for the Granite Creek index section from 1984 through 2004.

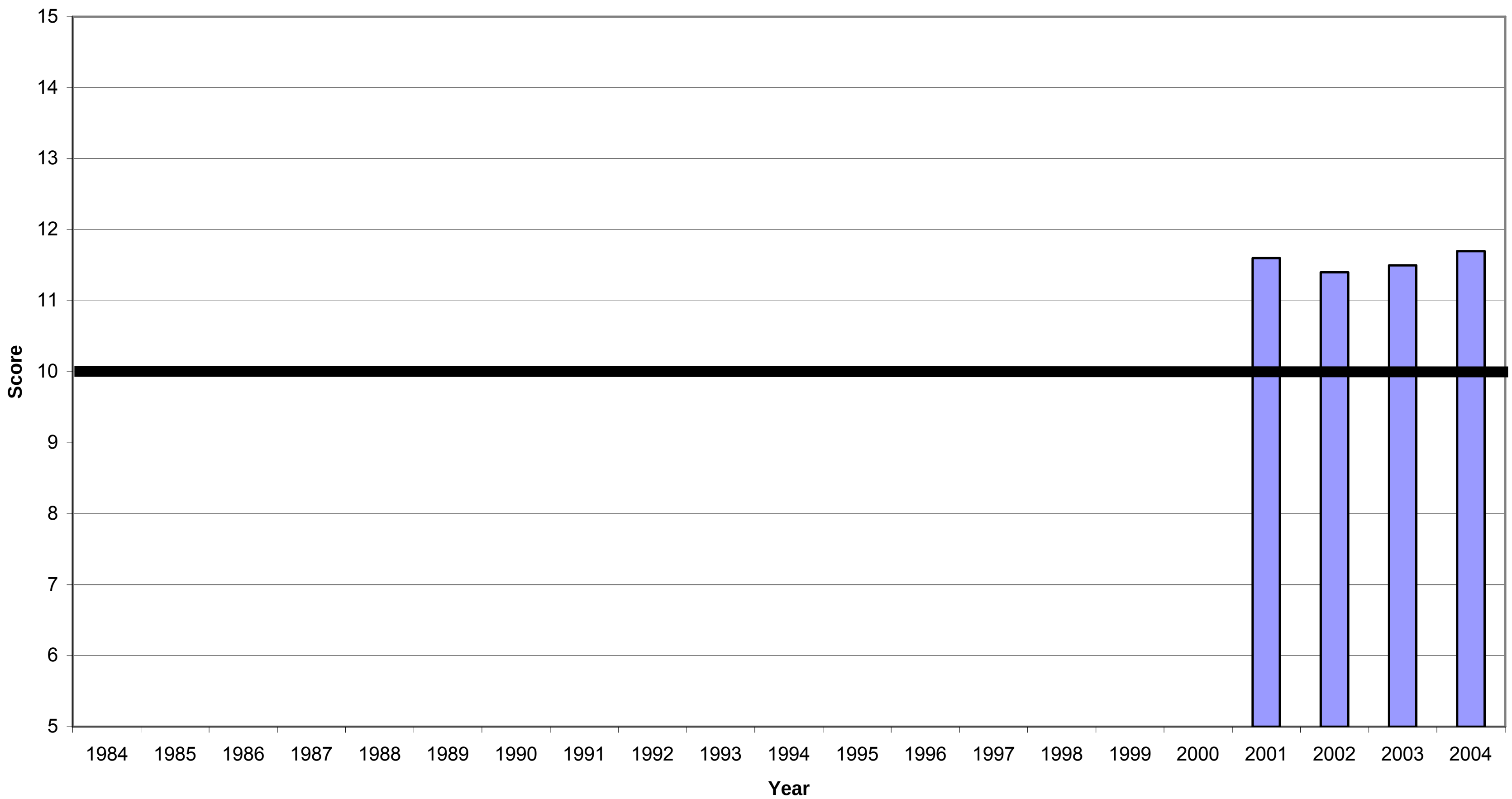


Figure B-10. Substrate scoring results for the Ole Creek index section from 1986 through 2004.

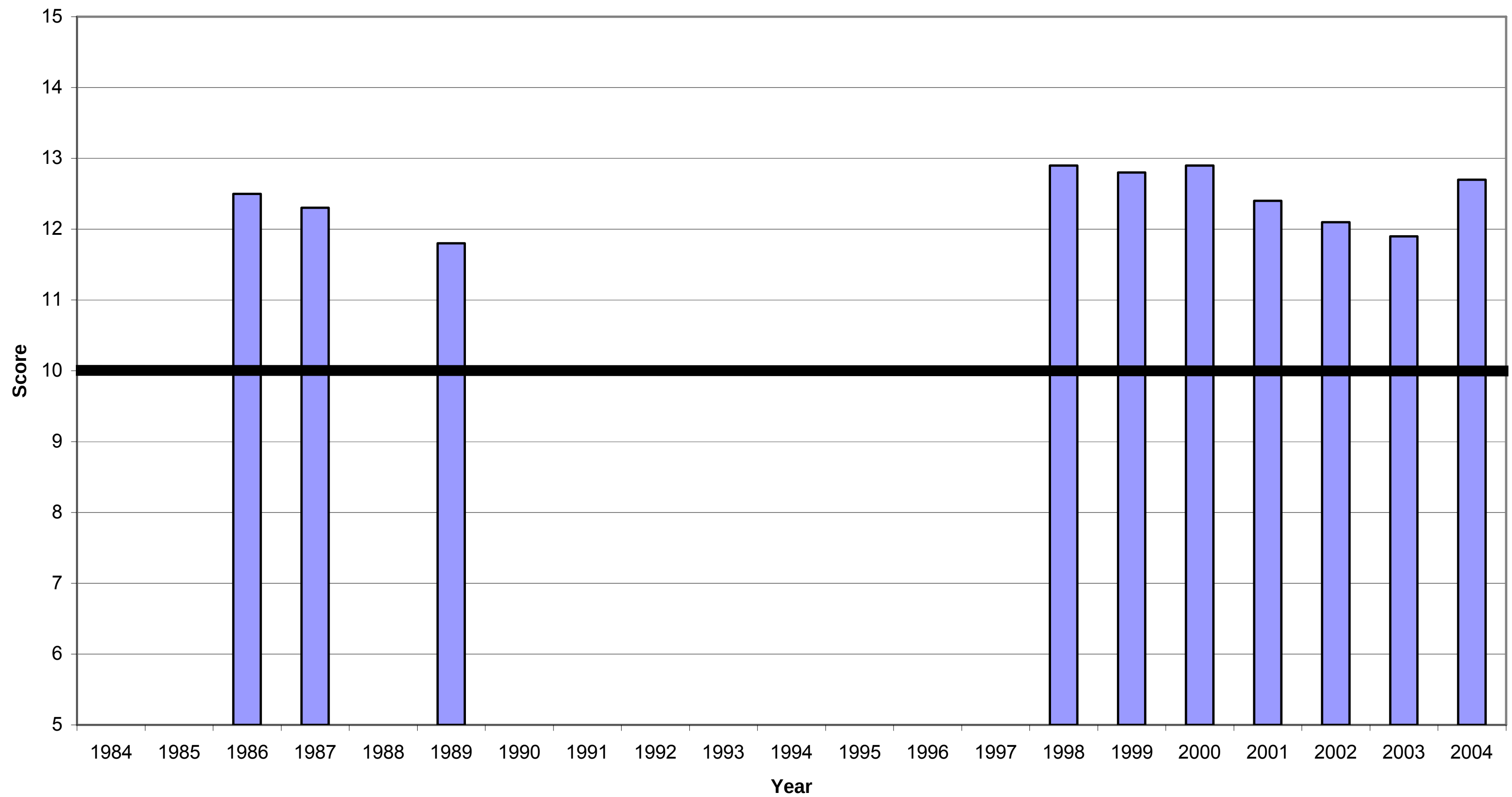


Figure B-11. Substrate scoring results for the Stillwater River index section from 1986 through 2004.

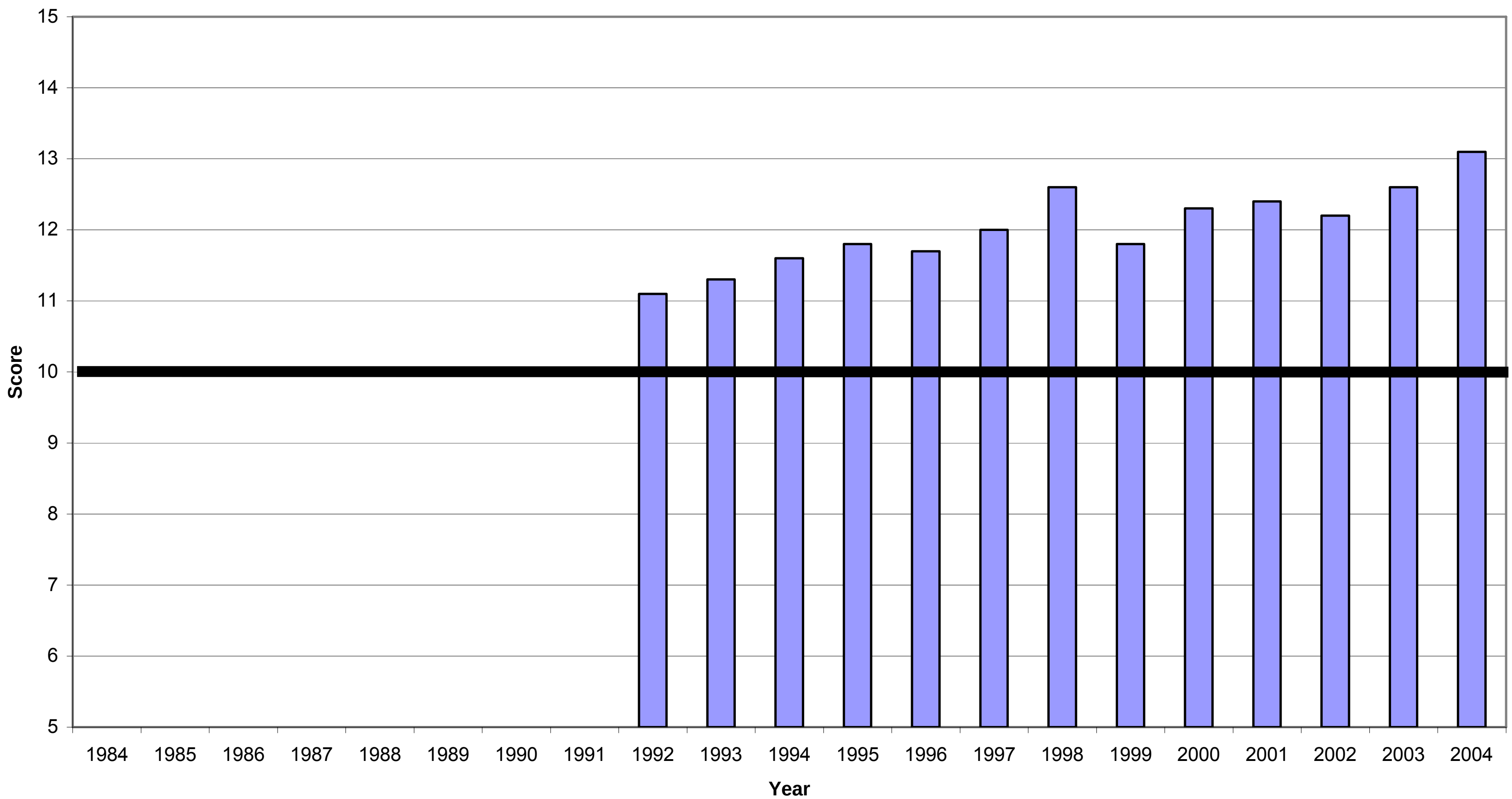


Figure B-12. Substrate scoring results for the Fitzsimmons Creek index section from 1986 through 2004.

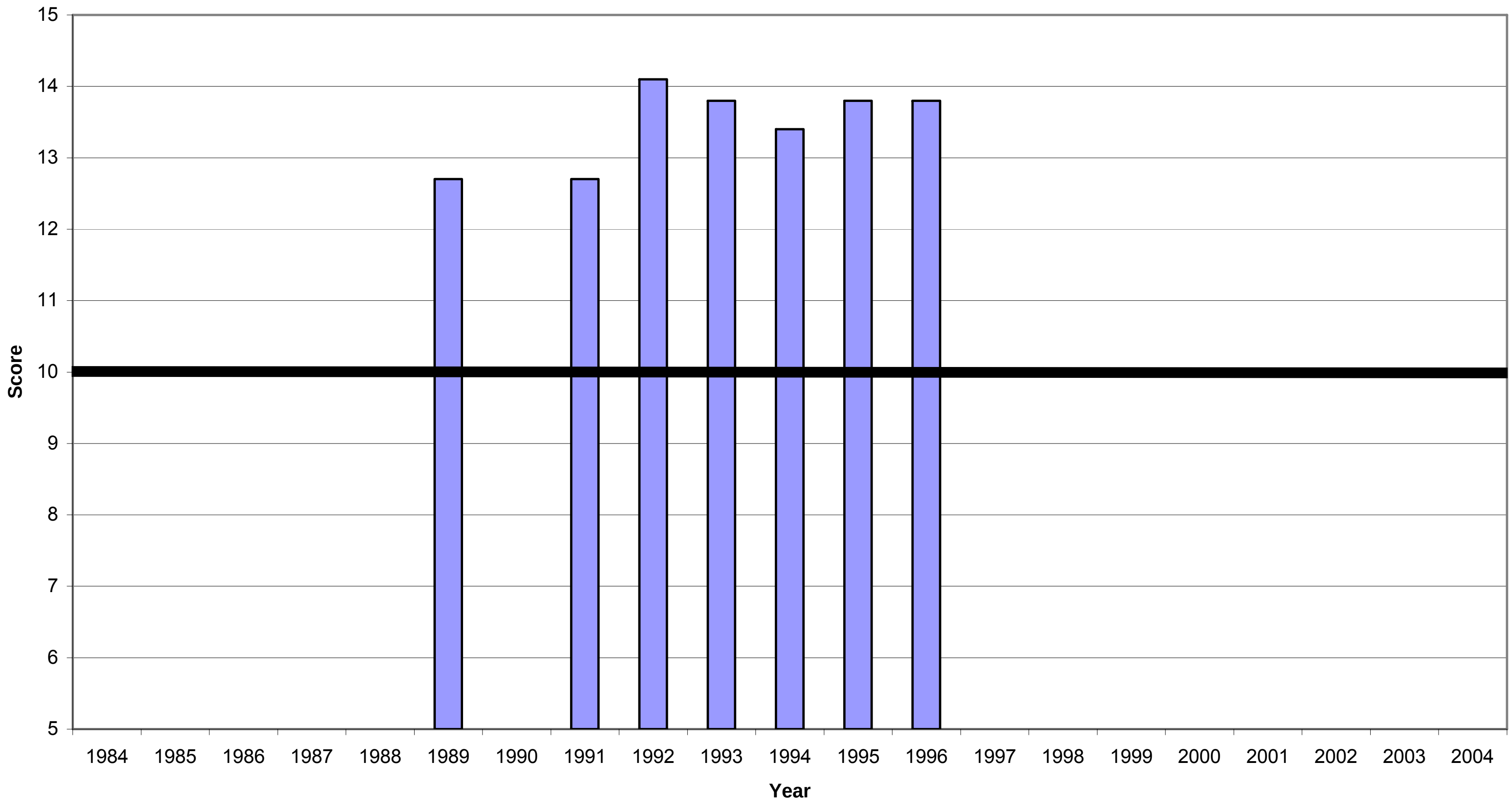


Figure B-13. Substrate scoring results for the East Swift Creek index section from 1986 through 2004.

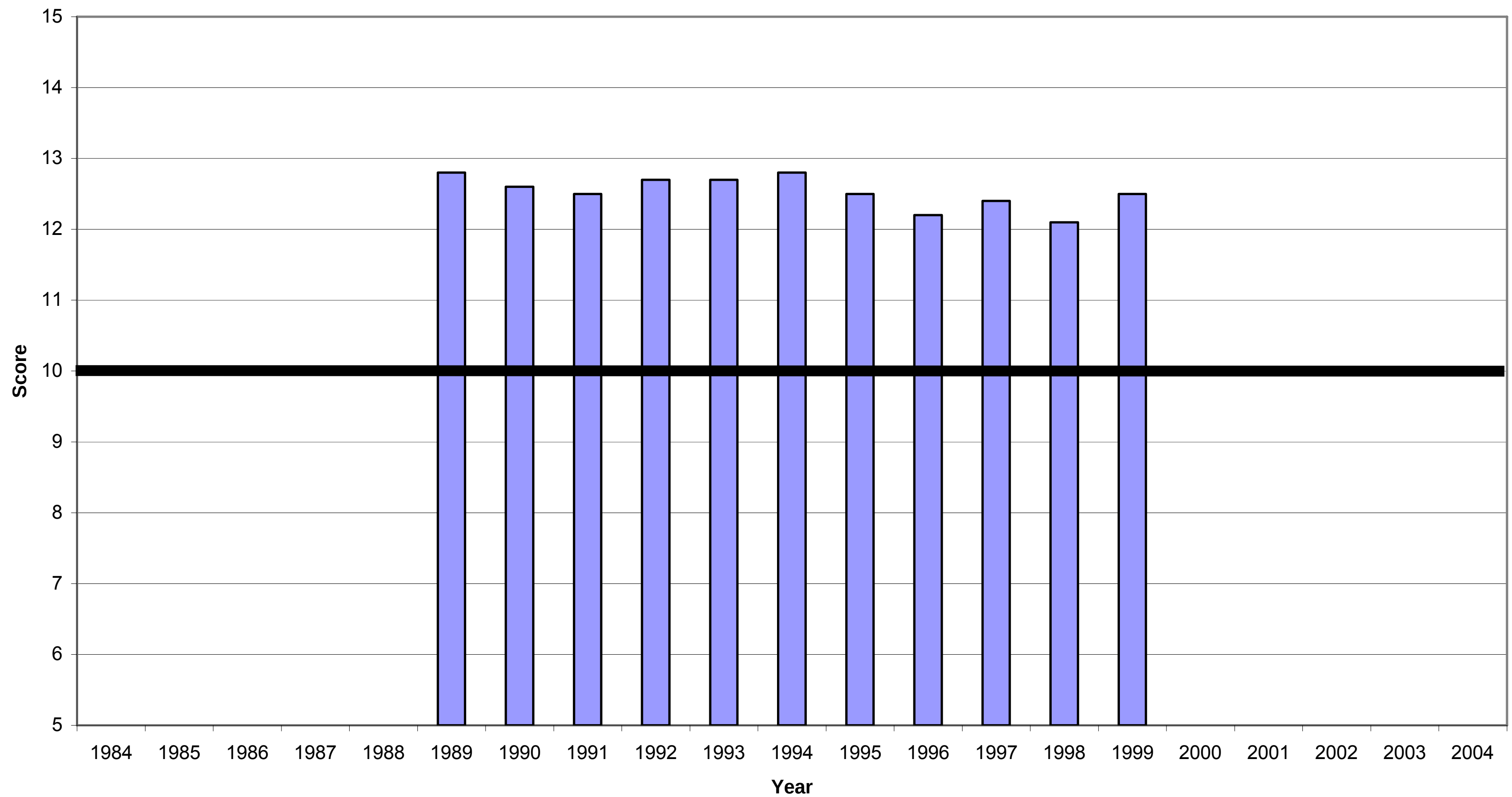


Figure B-14. Substrate scoring results for the West Swift Creek index section from 1986 through 2004.

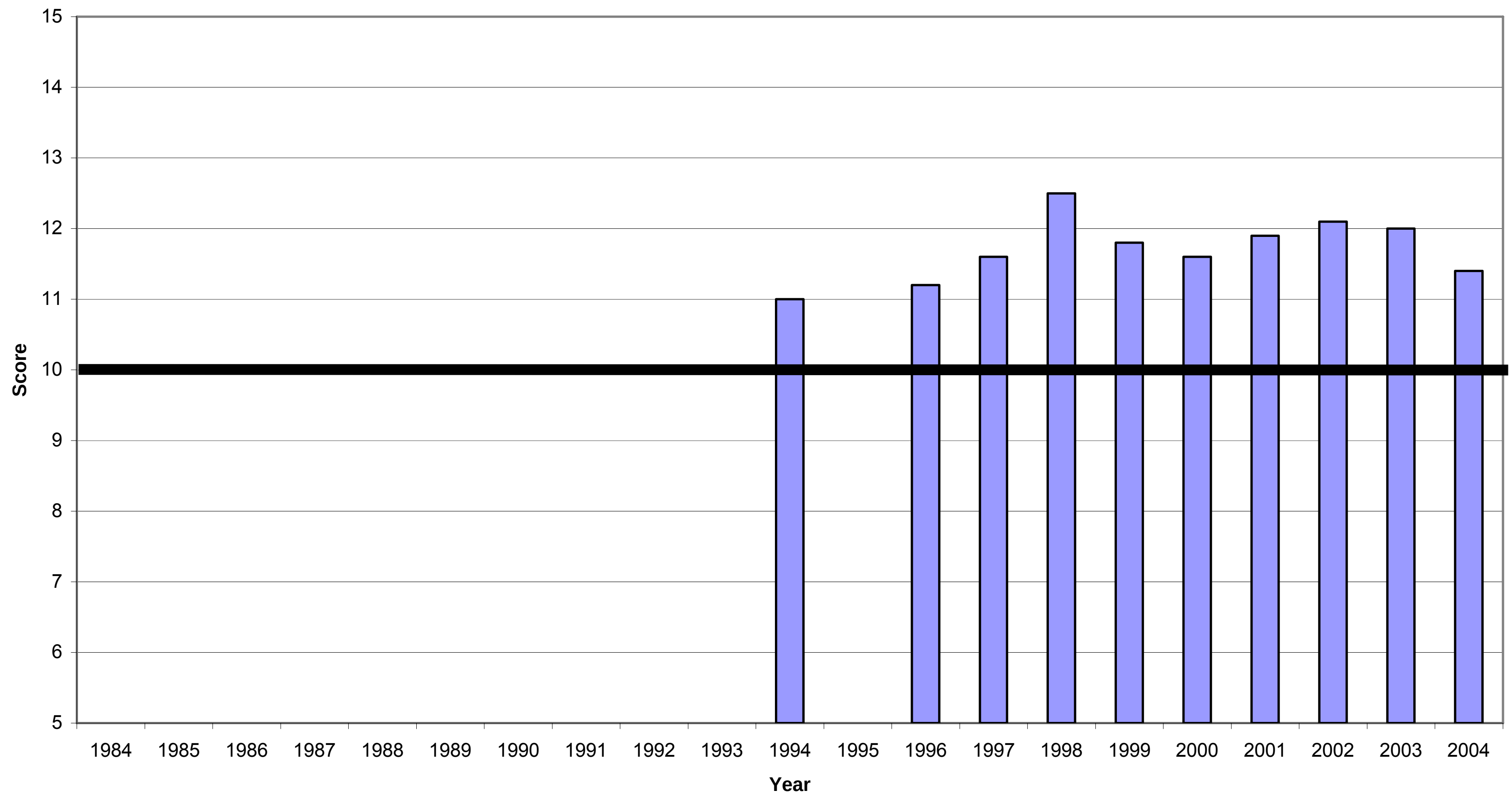


Table B-1. Substrate scores collected from tributaries to the Upper Stillwater from 1984 through 2004. These streams provide juvenile bull trout rearing habitat for the Upper Stillwater Lake bull trout population.

Stream	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Stillwater River	--	--	---	---	---	---	---	---	11.1	11.3
Fitzsimmons	--	--	--	--	---	12.7	---	12.7	14.1	13.8

Stream	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Stillwater River	11.6	11.8	11.7	12.0	12.6	11.8	12.3	12.4	12.2	12.6	13.1
Fitzsimmons	13.4	13.8	13.8	--	--	--	--	--	--	--	--

Table B-2. Substrate scores collected from tributaries to Whitefish Lake from 1984 through 2004. These streams provide juvenile bull trout rearing habitat for the Upper Whitefish Lake and Whitefish Lake bull trout populations.

Stream	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
East Swift	--	--	--	--	--	12.8	12.6	12.5	12.7	12.7
West Swift	--	--	--	--	--	--	--	--	--	--

Stream	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
East Swift	12.8	12.5	12.2	12.4	21.1	12.5	--	--	--	--	--
West Swift	11.0	--	11.2	11.6	12.5	11.8	11.6	11.9	12.1	12.0	11.4

APPENDIX C

Juvenile Abundance Estimates

Population estimation data for Age I and older fish calculated from annual electrofishing in rearing areas for the Flathead Lake population from 1980-2004.

Table C-1. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of Big Creek (Skookoleel Bridge) Creek in the North Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
9/15/86	47	±5	0.78	2.75
8/19/87	48	±6	0.75	3.02
8/18/88	67	±6	0.56	4.23
9/22/89	83	±6	0.54	4.90
9/17/90	65	±17	0.48	4.04
8/27/91	47	±9	0.52	2.85
8/20/92	42	±8	0.69	3.05
8/19/93	28	±13	0.56	1.63
8/22/94	4	No Estimate		0.24
8/31/95	5	No Estimate		0.28
9/19/96	13	No Estimate		0.70
8/27/97	21	±2	0.82	1.15
8/21/98	46	±9	0.51	2.54
9/7/99	38	±6	0.57	2.08
8/15/00	29	±9	0.48	1.73
8/16/01	53	±8	0.71	3.12
9/4/02	126	±11	0.73	7.84
8/15/03	110	±19	0.62	6.70
9/10/04	50	±10	0.67	2.76

Table C-2. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of Coal Creek (Deadhorse Bridge) in the North Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/5/82	85	±39	0.46	4.87
8/23/83	54	±6	0.75	3.17
8/28/84	72	±16	0.61	4.28
8/26/85	65	±6	0.78	4.38
9/5/86	92	±33	0.50	6.57
9/1/87	115	±55	0.43	8.33
9/6/88	64	±28	0.50	4.92
9/15/89	60	±25	0.51	4.07
8/28/90	42	±6	0.59	2.99
9/5/91	72	±16	0.46	4.80
8/24/92	46	±6	0.64	3.26
9/10/93	31	±4	0.80	2.14
8/26/94	32	±8	0.67	2.27
9/12/95	27	±8	0.67	2.00
9/4/96	4	No Estimate		0.26
9/16/97	1	No Estimate		0.07
9/10/98	7	No Estimate		0.36
9/10/99	9	No Estimate		0.62
8/11/00	5	No Estimate		0.32
9/11/01	17	±3	0.77	1.31
8/30/02	7	No Estimate		0.58
8/26/03	19	±3	0.80	1.25
8/18/04	10	No Estimate		0.83

Table C-3. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of North Coal Creek (317 Bridge) in the North Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/4/82	17	±9	0.60	1.34
8/25/83	18	±3	0.78	1.57
8/29/84	48	±12	0.63	4.18
8/27/85	41	±5	0.77	3.67
9/3/86	29	±12	0.59	2.96
8/5/87	47	±17	0.56	4.05
8/16/88	39	±5	0.76	4.08
9/8/89	44	±18	0.54	4.89
8/27/90	33	±3	0.65	2.84
8/21/91	9	±4	0.67	0.69
8/19/92	17	±2	0.87	1.50
9/8/93	6	±2	0.80	0.63
8/17/94	2	No Estimate		0.22
8/29/95	3	No Estimate		0.24
9/12/96	1	No Estimate		0.10
8/22/97	1	No Estimate		0.08
9/14/98	1	No Estimate		0.10
8/31/99	2	No Estimate		0.16
8/23/00	5	No Estimate		0.43
9/13/01	8	±6	0.60	0.75
8/27/02	6	±2	0.80	0.53
8/13/03	3	No Estimate		0.25
8/19/04	12	±8	0.57	1.06

Table C-4. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of South Coal Creek (Section 26) in the North Fork Flathead system.

Date	$\hat{N}$	$\pm$95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/28/85	62	±8	0.74	5.91
1986	--	--	--	--
8/6/87	12	±2	0.48	1.16
8/8/88	24	±2	0.85	2.48
9/29/89	14	±2	0.83	1.73
8/24/90	49	±17	0.57	4.38
8/16/91	58	±7	0.59	4.38
8/14/92	59	±7	0.75	5.38
8/27/93	16	±4	0.75	1.45
8/25/94	9	±2	0.65	0.75
8/30/95	45	±2	0.87	3.77
9/10/96	5	No Estimate		0.41
8/8/97	25	±11	0.60	1.96
8/20/98	2	No Estimate		0.16
8/19/99	15	±4	0.73	1.17
8/21/00	11	±3	0.75	1.04
9/14/01	14	±5	0.67	1.54
8/22/02	28	±2	0.88	2.60
8/12/03	51	±4	0.80	4.99
8/17/04	46	±6	0.59	4.35

Table C-5. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of Red Meadow Creek (1st Bridge) in the North Fork Flathead system.

Date	$\hat{N}$	$\pm$95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/15/83	77	±10	0.70	5.87
1984	--	--	--	--
1985	--	--	--	--
9/16/86	69	±7	0.75	5.72
8/18/87	48	±4	0.82	3.00
10/28/88	19	±5	0.69	1.93
9/9/89	21	±10	0.58	1.91
9/18/90	49	±27	0.48	4.05
1991	--	--	--	--
1992	--	--	--	--
1993	--	--	--	--
9/2/94	5	No Estimate		0.40
9/13/95	2	No Estimate		0.16
9/24/96	5	No Estimate		0.34
1997	--	--	--	--
9/15/98	14	±5	0.67	1.04
8/24/99	11	±2	0.93	0.93
8/17/00	5	No Estimate		0.44
8/22/01	6	No Estimate		0.58
9/10/02	8	±4	0.57	0.63
8/25/03	18	±3	0.79	1.68
8/24/04	5	No Estimate		0.40

Table C-6. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of Whale Creek in the North Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/10/81	76	±31	0.50	4.69
1982	--	--	--	--
8/22/83	38	±8	0.69	2.44
1984	--	--	--	--
1985	--	--	--	--
9/4/86	32	±10	0.74	2.15
8/13/87	63	±17	0.60	3.82
1988	--	--	--	--
9/25/89	33	±12	0.60	2.14
9/26/90	36	±5	0.57	2.30
1991	--	--	--	--
9/2/92	100	±17	0.64	6.19
9/1/93	62	±14	0.58	3.42
9/7/94	79	±18	0.60	5.10
9/6/95	72	±6	0.64	4.39
9/11/96	34	±7	0.71	2.13
9/3/97	9	No Estimate		0.57
9/17/98	134	±7	0.81	8.52
9/14/99	49	±5	0.62	3.18
8/18/00	46	±6	0.58	3.03
8/29/01	63	±6	0.78	4.30
9/5/02	94	±8	0.76	6.32
8/28/03	55	±14	0.62	3.78
9/9/04	64	±22	0.54	3.91

Table C-7. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of Morrison Creek in the Middle Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
9/25/80	91	±15	0.61	13.52
1981	--	--	--	--
9/1/82	93	±5	0.83	15.50
8/18/83	70	±11	0.69	11.44
1984	--	--	--	--
9/25/85	93	±27	0.54	11.27
8/27/86	114	±15	0.67	17.54
8/25/87	138	±9	0.76	17.47
8/30/88	126	±13	0.69	13.23
8/23/89	130	±3	0.55	11.87
9/7/90	28	±13	0.56	2.22
9/11/91	87	±15	0.64	7.57
9/9/92	24	±17	0.50	3.21
9/1/93	91	±9	0.73	6.25
8/28/94	16	±3	0.75	1.46
8/29/95	93	±14	0.66	8.07
9/1/96	24	±3	0.79	2.66
8/23/97	34	±11	0.62	3.46
9/16/98	38	±5	0.76	3.89
9/15/99	41	±15	0.57	4.84
8/16/00	45	±4	0.81	5.74
8/21/01	40	±6	0.72	5.37
9/17/02	46	±6	0.74	5.90
8/5/03	83	±19	0.59	9.97
9/2/04	24	±4	0.78	3.42

Table C-8. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of Ole Creek in the Middle Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
9/13/82	25	±12	0.57	2.10
1983	--	--	--	--
1984	--	--	--	--
1985	--	--	--	--
9/12/86	39	±5	0.76	2.91
8/27/87	42	±14	0.60	3.10
1988	--	--	--	--
10/12/89	46	±2	0.90	3.59
1990	--	--	--	--
1991	--	--	--	--
1992	--	--	--	--
1993	--	--	--	--
1994	--	--	--	--
1995	--	--	--	--
1996	--	--	--	--
1997	--	--	--	--
8/17/98	38	±5	0.60	3.85
8/26/99	11	No Estimate		0.78
9/13/00	40	±3	0.82	2.88
8/30/01	43	±3	0.83	3.25
9/25/02	36	±18	0.53	2.51
8/7/03	27	±4	0.75	1.84
2004	--	--	--	--

Table C-9. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of Granite Creek in the Middle Fork Flathead system.

Date	$\hat{N}$	$\pm$95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/22/01	57	±3	0.86	5.99
9/18/02	39	±4	0.81	4.13
8/6/03	45	±2	0.87	4.69
9/3/04	33	±4	0.81	3.21

Table C-10. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of the Stillwater River.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
9/16/91	24	±17	0.50	1.45
1992	--	--	--	--
1993	--	--	--	--
1994	--	--	--	--
1995	--	--	--	--
9/25/96	20	±3	0.63	1.21
9/4/97	23	±1	0.90	1.39
8/31/98	25	±5	0.72	1.71
9/1/99	10	±1	0.89	0.68
8/24/00	31	±9	0.65	2.10
8/20/01	98	±22	0.57	6.84
9/23/02	100	±30	0.53	6.70
9/2/03	100	±8	0.76	7.18
9/7/04	128	±9	0.77	7.14

Table C-11. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older bull trout calculated from electrofishing in the 150 m index section of the West Fork of Swift Creek.

Date	$\hat{N}$	$\pm$95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/24/95	9	No Estimate		1.04
9/16/96	7	No Estimate		0.81
8/26/97	8	No Estimate		0.92
8/26/98	44	±20	0.52	5.10
8/25/99	14	±1	0.92	1.44
9/7/00	9	±1	0.88	1.52
8/31/01	29	±3	0.83	2.80
9/19/02	12	±2	0.80	1.38
8/29/03	2	No Estimate		0.02
8/20/04	10	No Estimate		1.00

Table C-12. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older westslope cutthroat trout calculated from electrofishing in the 150 m index section of Challenge Creek in the Middle Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
7/14/81	126	±9	0.76	13.26
7/5/82	106	±9	0.75	10.72
7/22/83	66	±7	0.76	9.57
1984	--	--	--	--
1985	--	--	--	--
8/28/86	112	±9	0.76	20.51
8/24/87	209	±9	0.80	31.19
8/31/88	152	±18	0.66	22.69
8/24/89	137	±18	0.66	21.41
9/5/90	82	±10	0.71	12.80
9/10/91	82	±14	0.63	11.71
9/8/92	138	±15	0.68	20.29
8/31/93	96	±4	0.85	10.42
8/27/94	43	±6	0.75	4.74
8/25/95	35	±2	0.87	3.68
8/31/96	94	±5	0.83	14.07
8/29/97	113	±5	0.84	16.14
1998	--	--	--	--
9/15/99	119	±26	0.57	18.62
8/16/00	53	±5	0.79	8.15
8/21/01	56	±7	0.63	8.34
9/17/02	59	±10	0.68	9.70
8/5/03	125	±19	0.63	17.83
9/2/04	162	±11	0.59	27.27

Table C-13. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older trout calculated from electrofishing in the 150 m index section of Langford Creek in the North Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
7/21/83	163	±14	0.72	30.96
1984	--	--	--	--
1985	--	--	--	--
1986	--	--	--	--
1987	--	--	--	--
8/2/88	33	±8	0.68	6.03
1989	--	--	--	--
1990	--	--	--	--
1991	--	--	--	--
1992	--	--	--	--
1993	--	--	--	--
1994	--	--	--	--
1995	--	--	--	--
1996	--	--	--	--
1997	--	--	--	--
7/30/98	77	±8	0.74	14.86
8/12/99	68	±6	0.77	13.05
8/24/00	69	±11	0.68	13.32
9/6/01	No Fish – Moose Fire			0.00
7/30/02	28	±9	0.50	6.62
8/14/03	59	±5	0.78	14.63
8/5/04	34	±7	0.70	8.33

Table C-14. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older trout calculated from electrofishing in the 150 m index section of Cyclone Creek in the North Fork Flathead system.

Date	$\hat{N}$	$\pm$95% C.I.	$\hat{p}$	Density (#/100 m^2)
7/20/83	109	±34	0.55	18.33
1984	--	--	--	--
1985	--	--	--	--
1986	--	--	--	--
1987	--	--	--	--
8/3/88	208	±12	0.77	37.82
8/31/89	104	±9	0.76	18.41
1990	--	--	--	--
1991	--	--	--	--
1992	--	--	--	--
1993	--	--	--	--
1994	--	--	--	--
1995	--	--	--	--
1996	--	--	--	--
9/17/97	45	±9	0.71	6.32
7/28/98	94	±23	0.57	13.25
8/11/99	18	±6	0.67	2.53
2000	--	--	--	--
9/11/01	60	±22	0.53	11.11
8/12/02	53	±17	0.57	9.99
8/14/03	41	$\pm$2	0.86	8.56
8/5/04	26	$\pm$5	0.74	4.87

Table C-15. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older trout calculated from electrofishing in the 150 m index section of North Coal Creek in the North Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/4/82	40	±7	0.72	3.15
8/25/83	27	±3	0.82	2.36
8/29/84	48	±24	0.50	4.18
8/27/85	52	±37	0.32	4.66
9/3/86	39	±10	0.64	3.98
8/5/87	63	±2	0.91	5.43
8/16/88	51	±9	0.69	5.33
9/8/89	51	±9	0.69	5.67
8/27/90	39	±8	0.53	3.36
8/21/91	36	±27	0.33	2.76
8/19/92	71	±8	0.73	6.27
9/8/93	62	±12	0.65	6.53
8/17/94	38	±7	0.70	4.22
8/29/95	42	±6	0.74	3.29
9/12/96	41	±12	0.57	3.44
8/22/97	69	±9	0.71	5.53
9/14/98	53	±11	0.66	8.67
8/31/99	54	No Estimate		8.71
8/23/00	88	±4	0.88	7.65
9/13/01	111	±7	0.80	9.94
8/27/02	99	±4	0.87	8.39
8/13/03	57	±5	0.80	4.82
8/19/04	79	±10	0.72	6.84

Table C-16. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older trout calculated from electrofishing in the 150 m index section of South Coal Creek in the North Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/28/85	63	±71	0.33	6.01
1986	--	--	--	--
8/6/87	39	±7	0.54	3.77
8/8/88	43	±3	0.83	4.45
9/29/89	59	±10	0.67	6.56
8/24/90	48	±5	0.79	4.29
8/16/91	17	±5	0.52	1.28
8/14/92	28	±4	0.76	2.55
8/27/93	30	±2	0.84	2.73
8/25/94	32	±5	0.60	2.67
8/30/95	19	±3	0.80	1.59
9/10/96	4	No Estimate		0.25
8/8/97	21	±1	0.95	1.64
8/20/98	11	No Estimate		0.86
8/19/99	18	±1	0.94	1.40
8/21/00	21	±4	0.75	2.01
9/14/01	34	±10	0.62	3.87
8/22/02	33	±10	0.60	3.05
8/12/03	28	±7	0.68	2.72
8/17/04	17	±3	0.61	1.60

Table C-17. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older trout calculated from electrofishing in the 150 m index section of Red Meadow Creek in the North Fork Flathead system.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
8/15/83	121	±30	0.54	9.22
1984	--	--	--	--
1985	--	--	--	--
9/16/86	43	±11	0.63	3.56
8/18/87	58	±2	0.88	3.62
10/28/88	110	±28	0.55	11.17
9/9/89	64	No Estimate		5.82
9/18/90	85	±14	0.66	7.02
1991	--	--	--	--
1992	--	--	--	--
1993	--	--	--	--
9/1/94	65	±8	0.72	5.20
9/13/95	106	±24	0.57	8.72
9/24/96	55	±7	0.72	4.17
1997	--	--	--	--
9/15/98	76	±6	0.78	5.82
8/24/99	78	±6	0.79	6.53
8/17/00	98	±7	0.78	8.58
8/22/01	129	±20	0.63	12.34
9/10/02	82	±9	0.56	6.77
8/25/03	136	±10	0.74	12.84
8/24/04	80	±13	0.66	6.39

Table C-18. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older westslope cutthroat trout calculated from electrofishing in the 150 m index section of the Stillwater River.

Date	$\hat{N}$	±95% C.I.	$\hat{p}$	Density (#/100 m^2)
9/16/91	5	±3	0.67	0.30
1992	--	--	--	--
1993	--	--	--	--
1994	--	--	--	--
1995	--	--	--	--
9/25/96	49	±12	0.48	2.96
9/4/97	47	±4	0.82	2.85
8/31/98	53	±5	0.78	3.64
9/1/99	49	±10	0.66	3.27
8/24/00	77	±10	0.70	5.24
8/20/01	44	±3	0.84	3.08
9/23/02	113	±13	0.70	7.58
9/2/03	88	±4	0.85	6.34
9/7/04	79	±14	0.65	4.40

Table C-19. Population estimates ($\hat{N}$), 95 percent confidence intervals (C.I.), probability of first pass capture ($\hat{p}$) and densities for Age I and older westslope cutthroat trout calculated from electrofishing in the 150 m index section of East Swift Creek in the Upper Whitefish Lake system.

Date	$\hat{N}$	$\pm$95% C.I.	$\hat{p}$	Density (#/100 m^2)
9/20/89	53	$\pm$19	0.55	6.84
1990	--	--	--	--
1991	--	--	--	--
1992	--	--	--	--
1993	--	--	--	--
1994	--	--	--	--
8/23/95	16	$\pm$4	0.73	1.80
9/12/96	68	$\pm$25	0.53	7.69
1997	--	--	--	--
8/18/98	27	$\pm$8	0.65	3.16
9/3/99*	23	$\pm$4	0.84	2.46
2000	--	--	--	--
8/28/01	24	$\pm$4	0.79	3.14
8/29/02	3	No Estimate		0.40
2003	--	--	--	--
2004	--	--	--	--

APPENDIX D

Bull trout redd numbers in the annual index sections for the Flathead Lake population from 1980 through 2004.

Table D-1. Summary of Flathead Basin bull trout spawning site inventories from 1980-2003 in the stream sections monitored annually.

Drainage: Stream	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Redd Numbers											
North Fork:												
Big	20	18	41	22	9	9	12	22	19	24	25	24
Coal	34	23	60	61	53	40	13	48	52	50	29	34
Whale	45	98	211	141	133	94	90	143	136	119	109	61
Trail	31[a/]	78	94	56	32	25	69	64	62	51	65	27
Total	130	217	406	280	227	168[b/]	184	277	269	244	228	146
Middle Fork:												
Morrison	75	32[a/]	86	67	38	99	52	49	50	63	24	45
Granite	34	14[a/]	34	31	47	24	37	34	32	31	21	20
Lodgepole	14	18	23	23	23	20	42	21	19	43	12	9
Ole	19	19	51	35	26	30	36	45	59	21	20	23
Total	142	83	194	156	134	173[b/]	167	149	160	158	77	97
Flathead Drainage Monitoring Count	272[a/]	300[a/]	600	436	361	341[b/]	351	426	429	402	305	243

Drainage: Stream	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
North Fork:												
Big	16	2	11	14	6	13	30	34	32	22	12	12
Coal	7	10	6	13	3	5	14	7	3	0	0	1
Whale	12	46	32	28	35	17	40	49	68	77	71	34
Trail	26	13	15	28	8	9	17	21	42	27	26	14
Total	61	71	64	83	52	44	101	111	145	126	109	61
Middle Fork:												
Morrison	17	14	21	28	9	39	35	30	44	40	30	21
Granite	16	9	18	25	4	12	22	37	26	18	18	17
Lodgepole	13	9	6	9	8	5	7	11	3	17	12	10
Ole	16	19	6	16	10	14	22	26	33	29	21	21
Total	62	51	51	78	31	70	86	104	106	104	81	69
Flathead Drainage Monitoring Count	123	122	115	161	83	114	187	215	251	230	190	130

[a/] Counts may be low due to incomplete survey

[b/] High flows may have obliterated some redd