Kalispel Resident Fish Project

Annual Report
2001

DOE/BP-37227-5

January 2002

This Document should be cited as follows:

Andersen, Todd, ''Kalispel Resident Fish Project'', Project No. 1995-00100, 82 electronic pages, (BPA Report DOE/BP-37227-5)

Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

KALISPEL RESIDENT FISH PROJECT

ANNUAL REPORT

2001

PREPARED BY:

TODD ANDERSEN
KALISPEL NATURAL RESOURCE DEPARTMENT

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY
BONNEVILLE POWER ADMINISTRATION,
DIVISION OF FISH AND WILDLIFE

P.O. BOX 3621
PORTLAND, OREGON
97208-3621

PROJECT NUMBER 1995-00-100

CONTRACT NUMBER 95-BI-37227

Executive Summary

In 2001 the Kalispel Natural Resource Department (KNRD) continued assessing habitat and population enhancement projects for bull trout (*Salvelinus confluentus*), westslope cutthroat (*Oncorhynchus clarki lewisi*) and largemouth bass (*Micropterus salmoides*). Habitat enhancement measures, as outlined in recommendations from the 1996, 1997, and 1998 annual reports, were monitored during field season 1999, 2000, and 2001. Post assessments were used to evaluate habitat quality, stream morphology and fish populations where enhancement projects were implemented.

Acknowledgments

I would like to thank Glen Nenema (Chairman, Kalispel Tribal Council), the Kalispel Tribal Council and members of the Tribe for providing the support and the opportunity to conduct this project. Special thanks goes to Joe Maroney (KNRD Fisheries Program Manager) for technical and administrative support and assistance. The U.S. Department of Energy, Bonneville Power Administration, provided financial support for this project, contract number 95-B1-37227. Special thanks also to Ron Morinaka (Contracting Officer Technical Representive). The Kalispel Natural Resource Department provided field support and equipment.

Table of Contents

List of Tables

List of Figures

Bull Trout, Cutthroat Trout and Largemouth Bass

Habitat and Population

Assessment and Enhancement

Introduction

Fire history, past timber harvest activities, and dams have influenced the landscape in the Lower Pend Oreille Subbasin. The subbasin was first logged from 1915 to 1930 and much of the old-growth timber was removed. Logging railroad and log flumes were used on the mainstem Pend Oreille River and several of its tributaries. Log flumes were common, simplified the instream habitat, and decreased the recruitment source of large woody debris. In more recent years, road construction and maintenance, timber harvest, and cattle grazing have degraded stream habitat conditions. Numerous forest fires occurred between 1910 and 1929 and impacted many watersheds. From 1917 to 1929, an estimated 60 to 70% of the LeClerc Creek watershed burned. The largest fire in the LeClerc Creek watershed occurred in 1929.

The fish assemblage existing today in the subbasin is drastically different from pre-dam development. Anadromous fish have been extirpated due to the construction of Grand Coulee Dam; over 1,140 linear miles of spawning and rearing habitat in the Upper Columbia River System were eliminated (Scholz et al. 1985). The five dams on the lower Pend Oreille River are also believed to be a significant reason for the decline of native salmonid populations. These dams include Waneta (Canada), Seven Mile (Canada), Boundary (U.S.), Box Canyon (U.S.), and Albeni Falls (U.S.). None of these dams were built with fish passage facilities. Other dams and diversions such as Cedar Creek Dam, Sullivan Lake Dam, Mill Pond Dam, North Fork Sullivan Creek Dam, and Calispell Pumps were constructed in Pend Oreille River tributaries and further fragmented the connectivity of native salmonid populations.

In an attempt to partially mitigate for the resident and anadromous fish losses caused by hydropower development and operation, the Northwest Power Planning Council (Council) called for recommendations to develop a program that would provide measures to protect, mitigate and enhance fish and wildlife affected by the construction and operation of hydroelectric facilities located on the Columbia River and its tributaries. The Tribe, in conjunction with the Upper Columbia United Tribes (UCUT) Fisheries Center, undertook a three-year assessment of the fishery opportunities in the Pend Oreille River (Ashe et al. 1991) to provide the Council with recommendations. Assessment findings indicated that trout species were rare in the reservoir and compose less than 1% of the total abundance. Brown trout (*Salmo trutta)* were the most abundant trout species. Factors limiting trout production in the reservoir were identified as warm water temperatures, lack of habitat diversity and food availability. Trout were more abundant in the tributaries to the reservoir, which mostly supports brook trout *(Salvelinus fontinalis)* and brown trout, however westslope cutthroat *(Oncorhynchus clarki lewisi)*, rainbow *(O. mykiss)*, and bull trout *(Salvelinus confluentus)* were also captured.

Ashe et al. (1991) also found that largemouth bass *(Micropterus salmoides)* comprised approximately 3-4 percent of the total fish population in the reservoir. Results indicate that growth rates of largemouth bass during the first four years in the Box Canyon Reservoir were lower than bass from other locations of the northern United States. The slower growth rates combined with a high rate of juvenile mortality associated with lack of overwintering habitat have reduced the potential for the bass population in the reservoir.

Bennett and Liter (1991) described the fish communities in Box Canyon Reservoir, the sloughs, and tributaries and examined factors that could limit game fish production. Their findings determined that factors such as warm water temperatures and thermal barriers at the mouths of sloughs limited native trout. They estimated that overwinter survival of age 0^+ largemouth bass in Box Canyon Reservoir ranged from 0.4-3.9%. It was suspected that poor overwinter survival is partially due to the lack of cover during the winter months.

Ashe et al. (1991) provided recommendations based upon these findings for enhancing fishery opportunities. Recommendations include: 1) construct an off-site rearing facility to supplement the number of juvenile largemouth bass within the Box Canyon Reservoir; 2) enhance tributary populations of native trout, and; 3) increase the amount of overwinter habitat in the reservoir. Bennett and Liter (1991) suggested similar management possibilities in the Box Canyon Reservoir such as supplementation of largemouth bass to enhance recruitment and introduction of a predator species to take advantage of the extensive forage base.

The recommendations from Ashe et al. (1991) were adopted and incorporated into the 1994 resident fish and wildlife section of the Council's Program and were further revised in the Council's 1995 Program. These recommendations called for:

1) Restoring tributary populations of native cutthroat and bull trout, and

2) Enhancing the largemouth bass population to provide a quality sport and subsistence fishery in the reservoir.

These goals may appear to conflict, but there is a dramatic difference in habitat between the tributaries and Box Canyon Reservoir. The Box Canyon reach of the Pend Oreille River was formed in 1955 by the construction of Box Canyon Dam. The dam forever changed the habitat in this reach to a broad, shallow reservoir. This resulted in higher summer water temperatures that exceed Washington Department of Ecology temperature standards on a regular basis. This change in habitat made favorable conditions for warmwater species. Ashe et al. (1991) and Bennett and Liter (1991) concluded that yellow perch is the most abundant species in Box Canyon Reservoir. The other species in descending order based on relative abundance are pumpkinseed, tench, and largemouth bass. Trout species are rare and of the trout species present, brown trout are the most abundant. Temperature conditions limit the distribution of native trout in the reservoir. In addition to the differences of habitat between tributaries and the reservoir, preliminary adfluvial trapping data suggests that adfluvial populations of cutthroat and bull trout are non-existent. Thus, habitat overlap between native trout and largemouth bass is unlikely and interaction very unlikely (NEPA Doc, 1996).

Cutthroat and bull trout populations residing in the tributaries need to be protected since these appear to be the remaining populations in the Lower Pend Oreille Subbasin. The three greatest impacts to these populations include: 1) habitat degradation from past land use activities; 2) habitat fragmentation and loss of connectivity due to man-made structures; and 3) hybridization and competition from introduced species. Genetic analysis conducted by the Washington Department of Fish and Wildlife (WDFW) showed that Pend Oreille River tributary populations of westslope cutthroat trout were genetically distinct from one another (Shaklee and Young 2000). Of the eight tributaries surveyed in the initial year of the project, none has been stocked with hatchery fish since 1978. Four of the eight have not been stocked since the 1940's. Although relative abundance is low, genetic analysis and stocking records suggest these cutthroat trout populations are sustained without hatchery supplementation.

Isolation due to the fragmentation of native populations is likely to increase the risk of extinction through both environmental stochasticity and lack of genetic variation (Rieman and McIntyre 1993; Lacy 1987). Degraded habitat resulting in poor complexity further increases the risk of extinction for small, isolated populations because refugia from extreme environmental events are lacking (Pearsons et al. 1992, Saunders et al. 1990; Sedell et al. 1990). Hilderbrand and Kershner (2000) estimated that 8 km of stream length are required to sustain an isolated population of cutthroat trout with high abundance (0.3 fish/m).

Interactions with non-native species have also had an impact on resident populations of westslope cutthroat and bull trout. Brook trout X bull trout hybridization appears to be the most prevalent problem in isolated populations (Markle 1992). Competitive interactions with introduced species (mainly brook trout) have likely contributed to depressed cutthroat trout populations in the Lower Pend Oreille Subbasin. Of the 25 streams surveyed by the Kalispel Natural Resource Department (KNRD) in the Lower Pend Oreille Subbasin, the highest cutthroat trout densities have been observed in streams and headwater reaches where brook trout were absent. Several studies indicate that abiotic factors (e.g. water temperature and velocity) may determine which trout species will be dominant in a given length of stream (De Staso and Rahel 1994; Griffith 1988).

The habitat restoration portion of this project has and will continue to address factors that limit tributary populations. Our restoration increases habitat complexity which provides refugia during extreme environmental events and, therefore, lowers the extinction risk for the targeted populations. The Kalispel Tribe (Tribe) recognizes that instream habitat restoration is a temporary solution to habitat degradation and that recovery will only occur when future human impacts are minimized and watershed processes are restored. However, watershed restoration will not yield significant improvements for years or decades. The Tribe also recognizes that some of the native fish populations in the Lower Pend Oreille sub-basin will not persist for years or decades. In some watersheds, individual native fish sightings are rare or populations are isolated in small tributaries. Restoration attempts to increase the habitat attributes that are limiting while the brook trout removal portion of this project will eliminate the threats associated with competition and hybridization with the native populations.

In summary, KNRD's plan for recovering native salmonid populations is:

1. Perform baseline stream habitat and fish population assessments to determine current distribution and abundance and identify core watersheds where recovery efforts will be focused.
2. Work to protect existing native populations and good habitat through participation in regional policy setting groups and consultation with area land, fish, and wildlife management agencies.

3. Pursue funding from various sources and participate jointly with other agencies in watershed restoration projects.
4. Implement instream and riparian restoration in identified recovery areas.
5. In recovery areas with non-native populations, relocate native species, treat streams to remove non-native species, and translocate genetically identical or similar native fish from sister watersheds.
6. Monitor restoration and adapt management plans if needed.

Bull trout and cutthroat trout habitat assessment and population abundance.

The Kalispel Resident Fish Project began in 1995 with the selection of the study tributaries, habitat assessments, and assessment of fish populations in those tributaries. These baseline surveys showed that fish habitat is generally poor due to a lack of large woody debris, lack of pool type habitat, and high volumes of fine sediment. As a result of these conditions, rearing, spawning, and winter habitat were identified as limiting factors to fish populations in most reaches.

Based on the assessments taken during that initial field season, a process was developed to filter out the reaches of those tributaries that contained the most numerous limiting factors to fish habitat quality and quantity (KNRD & WDFW 1995). A set of recommended enhancement measures was subsequently developed for each of these reaches that are intended to address the specific habitat shortcomings. This list of recommendations was implemented during field season 1996 and became the core for additional recommendations for 1997 and 1998. Field season 1998 was the last year of implementation for recommended enhancement measures on the seven designated study tributaries. Post assessments of habitat and fish populations were conducted the year following implementation and on an annual basis thereafter.

2001 marked the third, fourth, and fifth years of conducting monitoring and evaluation on structures that were implemented from 1996 to 1998. Comparative analyses of changes in habitat attributes and changes in fish abundance using graphical displays were conducted following the 2001 field season. Also, the monitoring data has been examined for trends that may indicate which specific types of enhancement measures provide the greatest increase in habitat quality and quantity. However, at this point in the project no detailed analysis and interpretations have been performed and past annual reports have only discussed trends. It is difficult to distinguish the effects of the restoration among many interacting factors and great natural variability within the physical and biological components of the ecosystem. Also, much of the restoration implemented may not yield results for several years or decades. More monitoring needs be performed to minimize the variability in both habitat and fish abundance data.

Largemouth bass habitat enhancement.

The Upper Columbia United Tribes Fisheries Center conducted a three-year baseline study to assess the fishery improvement opportunities on the Pend Oreille River (Ashe 1992). Based on earlier estimates of aquatic macrophyte community composition (Falter et al. 1991) and limited overwinter survival of 0^+ largemouth bass (Bennett et al. 1991), they suggested that the winter reduction in macrophyte communities created higher predation rates on 0^+ bass. This led to their recommendation for the construction and placement of artificial cover structures to increase the amount of winter cover available in the reservoir. Baseline species abundance were determined by electrofishing the selected treatment and control sloughs prior to structure placement. In 1997 100 Berkley artificial structures and 100 Pradco artificial structures were constructed and placed in the study sloughs. Treatment and control sloughs have been sampled twice annually since implementation of the habitat structures. In 2001, data continued to be examined to determine: 1) if artificial structures may provide the missing winter cover component, and 2) if a difference exists between the efficacy of the Pradco and Berkley structures.

Description of Study Area

The Pend Oreille River begins at the outlet of Pend Oreille Lake, Idaho, and flows in a westerly direction to approximately Dalkena, Washington (Figure 1). From Dalkena the river turns and flows north into British Columbia where it joins the Columbia River. The approximate drainage area at the international border is 65,300 km^2 (Barber et al. 1990). The normal high flow month is June with a mean discharge of 61,858 cfs, the normal low flow month is August with a mean discharge of 11,897 cfs (Barber et al. 1990). The Box Canyon Reservoir has 47 tributaries and covers 90 river kilometers of the Pend Oreille River, from Albeni Falls Dam at the southern border to Box Canyon Dam at the northern border.

Cee Cee Ah Creek has a drainage basin area of 63.5 km^2, with 14.6 km of stream (Figure 2). Cee Cee Ah has a diverse morphology with varied gradient. Cee Cee Ah has an intermediate gradient on top, a flat gradient in the middle, a steep gradient in the lower section with a 25 m waterfall, and a low gradient for the last 2 km of stream. This creek has an extensive slough system for the last 1km before it's confluence with the Pend Oreille River. Cee Cee Ah Creek empties into the Pend Oreille River at river kilometer 130.

Browns Creek (Figure 2) is a major tributary of Cee Cee Ah Creek. Originating from springs fed by Browns Lake, the creek flows approximately 3.4 miles from the origin to the confluence with Cee Cee Ah Creek. Browns Creek begins in a series of beaver ponds in the headwaters and runs through relatively undisturbed forests to another series of beaver ponds in the middle reach. The lower portion runs through mature forests with fairly consistent gradient. The drainage basin area for Browns Creek is approximately 21.5 km^2.

LeClerc Creek is the largest drainage of the three priority tributaries. LeClerc Creek’s drainage basin is 161 km^2 (Figure 3). The LeClerc system is split into three separate branches (East, West, and Middle). There is approximately 93 km of stream in the LeClerc system. This is one of the largest tributary systems in the Box Canyon Reservoir. Tributaries to the LeClerc system are, Mineral and Whiteman Creeks (tributaries to the West Branch of LeClerc), and Fourth of July Creek (tributary to East Branch of LeClerc Creek). The East and Middle branch flow together 5 km above the confluence with the Pend Oreille River. The main branch is formed by the merging of the East and West branches 2.5 km above the Pend Oreille River. LeClerc Creek flows into the Pend Oreille River at approximately river kilometer 90.

Indian Creek has the smallest drainage basin of all the tributaries surveyed at 20 km^2 and is one of the shortest tributaries with 3.84 km of stream (Figure 4). This stream has no secondary tributaries and is spring fed. This stream flows through relatively low gradients and is generally wide and shallow. A series of beaver dams are constructed at the mouth of this stream creating potential migration barriers. The stream flows into the Pend Oreille River on the East side at river kilometer 140.

Mill creek has a drainage basin area of 80.2 km^2, with 9.7 km of stream that empties into the Pend Oreille River at river kilometer 95 (Figure 5). The system is fed by water sources from North Baldy and the surrounding lower ridges. The stream in the upper reaches has a gentle gradient with beaver habitat and a slow meandering channel. Due to erosion resistant geology, the lower portion of the stream changes to a high gradient system with cascading riffles and plunge pools until it reaches the confluence with the Pend Oreille River. Mill creek enters the Pend Oreille River at approximately river kilometer 108.

The bass habitat enhancement study was located in zero flow areas of the reservoir (i.e. adjacent to and within sloughs). Four sloughs were used for the study:
1) Campbell slough adjacent to the Pend Oreille Wetlands Wildlife Mitigation Project, located on the east side of the Box Canyon Reservoir, at river km 99, 2) No Name slough located directly across the reservoir from Campbell slough, on the west side of the reservoir, at river kilometer 99, 3) Cee Cee Ah slough, located within the Kalispel Reservation on the east side of the reservoir, at river km 109, and 4) Old Dike slough, contained within the Kalispel Reservation and located on the east side of the reservoir, at river km 107.

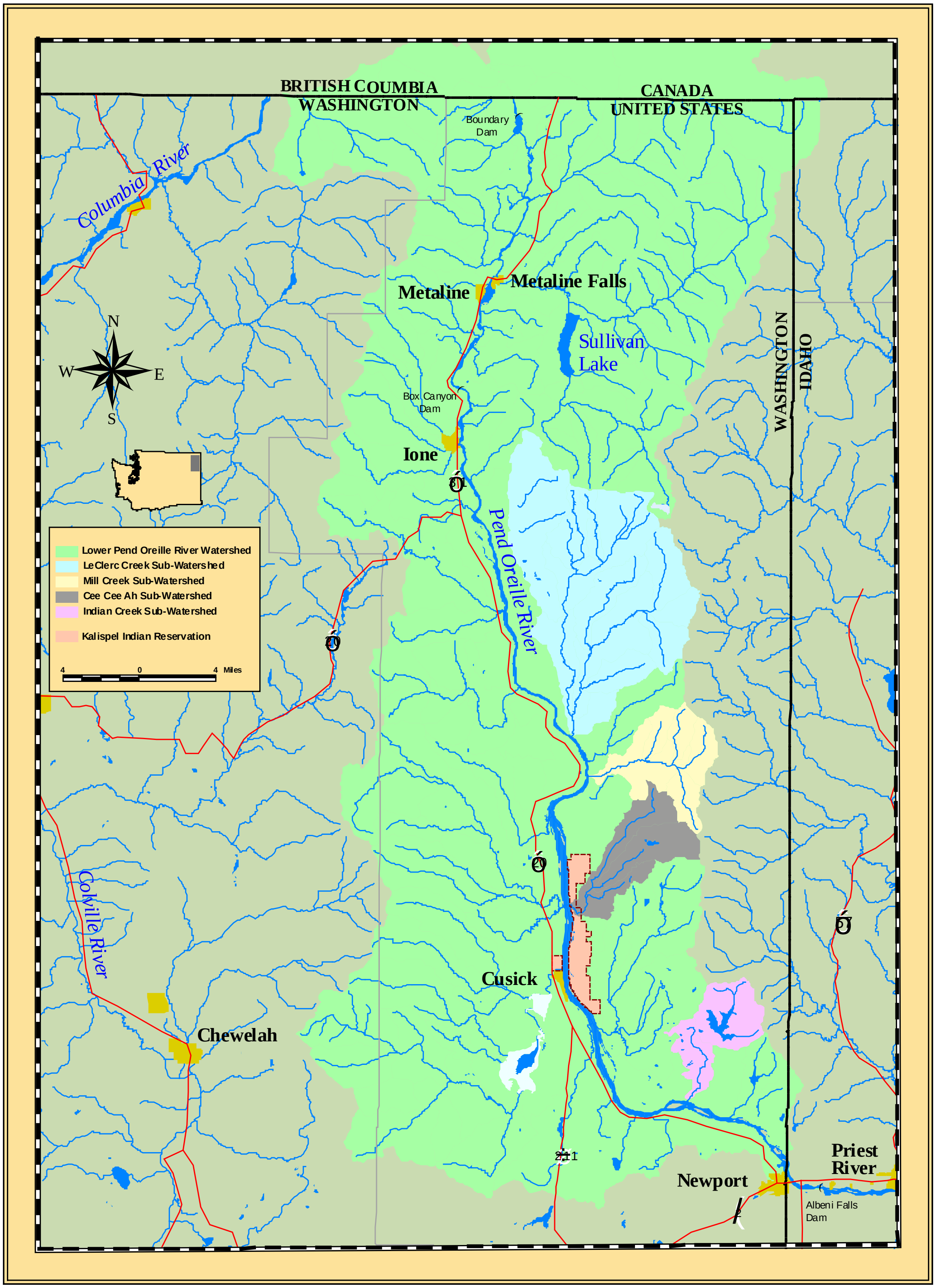

Figure1. Map of study area including Pend Oreille River watershed and sub-watersheds where enhancement activity has been implemented.

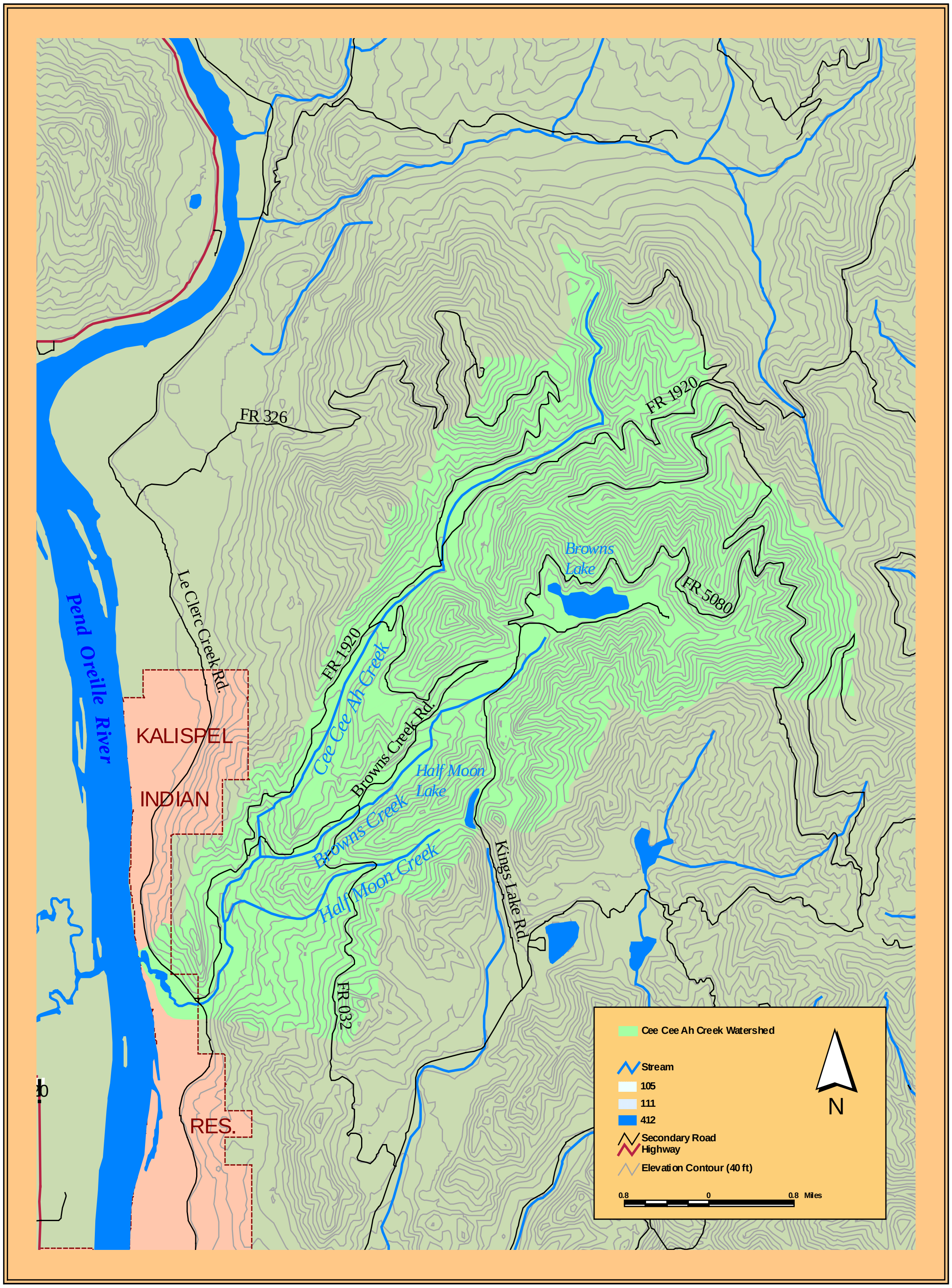

Figure 2. Map of Cee Cee Ah Creek watershed and Browns Creek sub-watershed where habitat enhancement was implemented in 1996, 1997 and 1998.

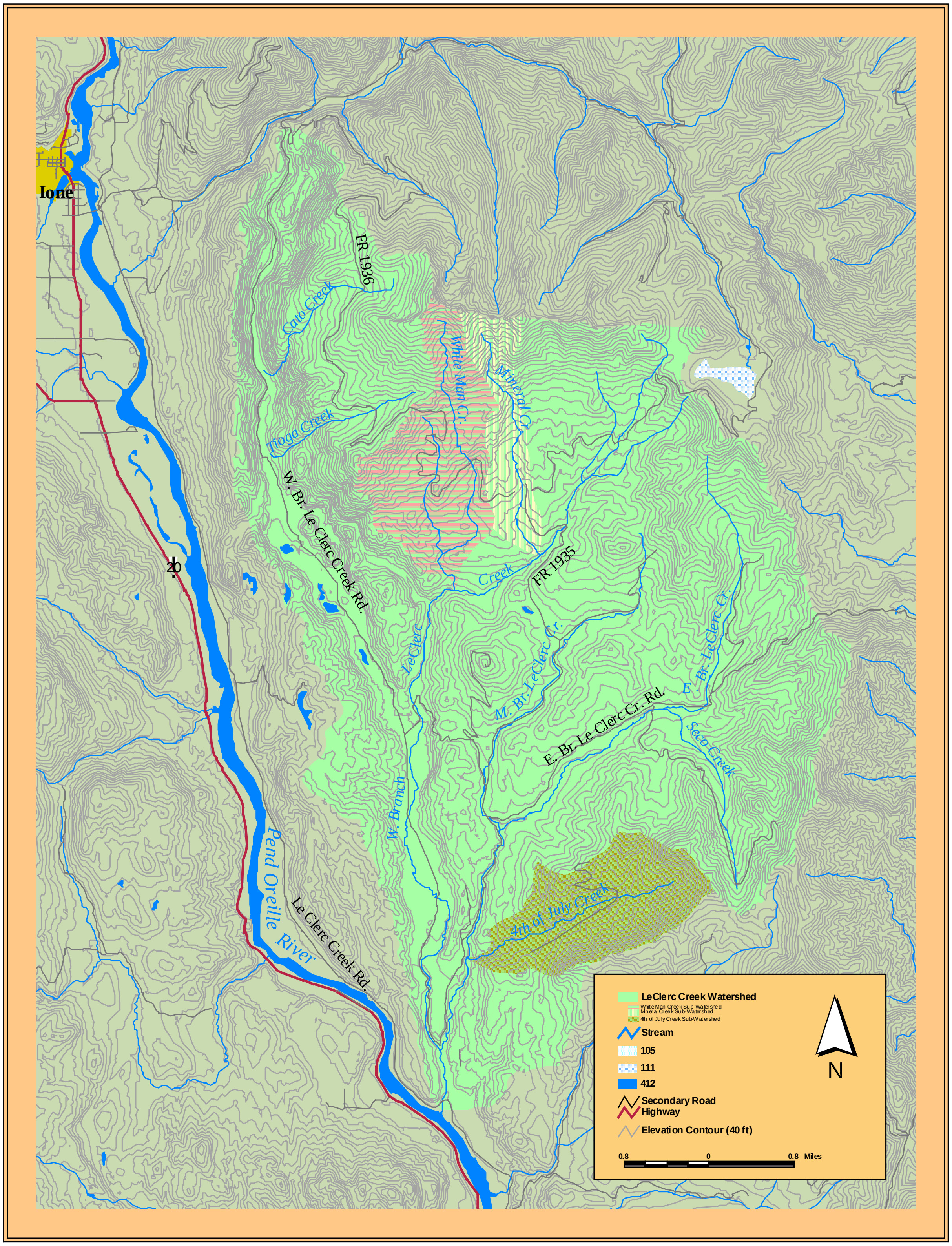

Figure 3. Map of LeClerc Creek watershed and highlighted sub-watersheds where habitat enhancement was implemented in 1996, 1997 and 1998.

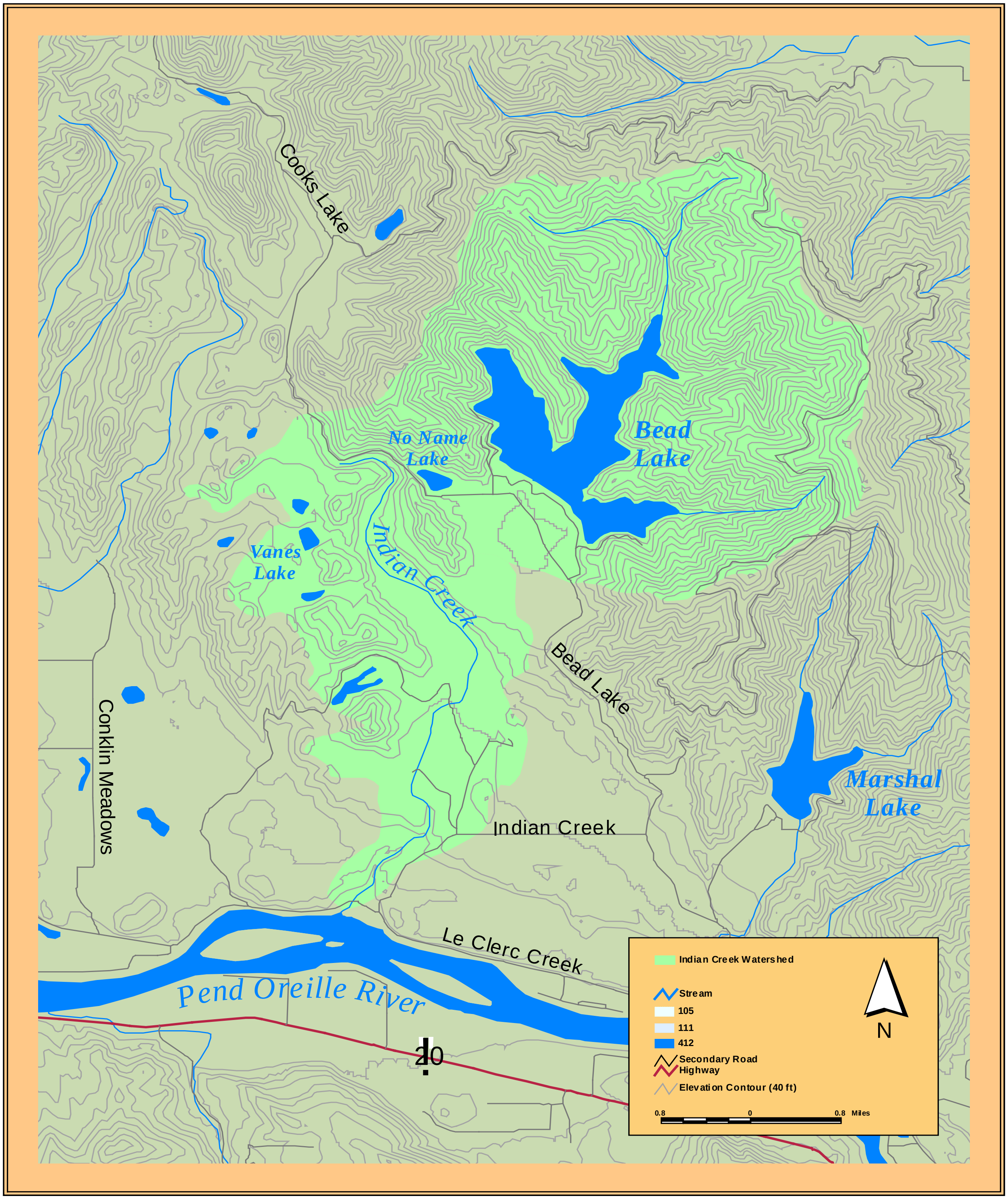

Figure 4. Map of Indian Creek watershed where habitat enhancement was implemented in 1996, 1997 and 1998.

Methods

Bull trout and cutthroat trout habitat assessment and population abundance

Stream and fish population survey methodologies used within the Box Canyon Reach were similar to those developed by Espinosa (1988) and further revised by Huntington and Murphy (1995). The KNRD stream habitat survey methodology contained four facets: transect surveys, reach overviews, interreach comparisons and fish surveys. Habitat surveys were broken into two components: transect surveys and reach overview surveys. Transect surveys were the division of the stream into 30-meter (m) segments. Primary pools, spawning habitat and acting woody debris counts were collected for the entire length of each 30-m segment. The remainder of the habitat quality parameters (Table 1) such as habitat type, substrate, habitat function, bank stability, cover, and embeddedness were collected at the end of each 30-m segment (the actual transect site). This method allowed for a number value to be assigned to each habitat quality parameter. Reaches were defined by stretches of stream with common gradient, substrate and vegetation. Breaks between two homogeneous areas defined a new reach. Reach overview surveys were the visual observation and description of variables occurring within each reach (Table 2). Each reach was permanently marked and flagged using aluminum tags and flagging as a reference point for long-term monitoring.

Fish density estimates for baseline surveys were collected using standard snorkel survey techniques (Espinosa 1988). Sampling was conducted during the period from July 15 through September 15. Population density was addressed by number, size (age class) and species of fish per 100 m^2. The standard size/age classes for salmonid species (Table 3) were determined according to Espinosa (1988). Lengths of baseline snorkel stations were 30 m and selected so that the area snorkeled is representative of the reach. Fish stations were permanently marked and flagged using aluminum tags and flagging.

Following the compilation of transect data, an interreach comparison was conducted using the mean values for each reach. This was the fundamental unit of comparison to determine specific reaches for enhancement projects. Threshold values were established for embeddedness, bank stability, bank cover, instream cover, pool-riffle ratio, spawning gravel and primary pools (Table 4). All threshold values were obtained from Hunter (1991) and/or MacDonald et al. (1991). The mean data for each reach was analyzed by using these threshold criteria. Each habitat value that did not fall within the threshold was counted as habitat that is unsatisfactory for quality or quantity. The reaches with the most numerous unsatisfactory habitat values were identified as potential enhancement sites for that particular stream. Snorkel surveys were used to determine fish population densities and age class distribution for all salmonid populations within each stream. Information from the snorkel surveys and the interreach comparisons was used to draw conclusions on the effects of degraded habitat quality and non-native salmonids on native salmonid species. Conclusions were used to aid in more informed restoration recommendations.

The data from the specific reaches identified in the interreach comparison was evaluated in a flowchart to provide a list of possible options for the types of structures or measures used in enhancement (Figure 5). The flow chart took into account gradient, embeddedness, and pool to riffle ratio. Each structure was designed to perform specific functions and required specific habitat placement (Table 5). Structure selection was made by reviewing the list of options for enhancement and choosing the structure that addresses the limiting factors for each particular reach of enhancement. Reach accessibility was also considered when choosing between structures with similar function but varying levels of effort in their construction. Specific placement was determined by the transects within each reach that were in the habitat type for which each structure was designed.

Prior to implementation, all sites selected as areas for enhancement were pre-assessed using an intense version of the standard transect methodology. The same methodology was used for both pre and post assessments. The only modification to the transect methodology was shortening the length between transects. Riparian project areas were assessed with 10-m transects for each kilometer where fencing and planting occurred. Instream structures were assessed using 5-m transects from 30 m above (upstream) the structure site to 30 m below (downstream).

Fish monitoring stations for riparian restoration were calculated to be one 30-m snorkel station per 250 m of stream. A minimum sample size of three snorkel stations for each restoration area was conducted, unless the area was less than or equal to 90 m long, in which case the entire area was snorkeled. Assuming the lowest known bull trout population density (0.075 bull trout/30 m) in the state of Washington (Hillman and Platts 1993), we were 95% confident that if bull trout were in the stretch of the stream we would observe them at this rate of sampling. Bull trout were used to determine the sample size because they are the least abundant native salmonid species in the area. Each monitoring station was benchmarked at the upper and lower boundary with labeled aluminum tags attached to rebar stakes. Data from snorkel stations will be used to determine densities of all fish species present.

Fish monitoring for instream structures was conducted annually to determine the fish numbers and species within the enhancement area. The stream length snorkeled, from 30 m below to 30 m above the stream section where structures were placed, was identical to where habitat monitoring occurs.

All in-stream structure enhancement areas were monitored annually. Riparian planting and cattle exclusion fence sites are intended to provide longer term rehabilitation over an extended time schedule. The rate of post-assessment sampling for these sites will be every third year.

Post assessment data in 14 reaches were compared to pre-assessment data for structures implemented from 1996 to 1998. Comparisons were limited to the following stream survey attributes: 1) substrate embeddedness, 2) percent pool habitat, 3) average depth, 4) average width, 5) number of primary pools, and 6) spawning gravel. These survey attributes were chosen for comparison because they have the best potential to reflect short term changes in habitat that may result from the restoration structures. Also, these were the attributes identified in the baseline surveys as limiting fish populations. Since no control reaches were sampled, changes to habitat attributes were assumed to be the result of the restoration structures.

Changes to the spawning gravel assessment were made prior to the 2001 sampling season. Previous assessments of spring spawning gravel included areas that were underwater during the spring but dry at base flows (generally starting in July or August), while fall spawning gravel was evaluated at base flow conditions. In 2000, local resident cutthroat trout were observed spawning in mid July at base flows. It appears that previous fall spawning habitat assessments more accurately reflected available spring spawning habitat, as well as fall spawning habitat. Therefore in 2001, evaluation of spawning habitat only considered gravels within the base flow wetted channel. Since there appears to be little local difference between the spawning habitat of spring and fall spawners, no distinction between fall and spring spawning habitat was made in the 2001 habitat post assessments. Comparisons of 2001 spawning habitat were made with previous years' fall spawning habitat since it appears to more accurately represent actual spawning habitat.

Largemouth bass habitat enhancement

Selection of the sloughs used in the bass habitat study was based on the two types of sloughs available within the reservoir. The sloughs are either backwater stream mouths or dead end river backwater. Four sloughs were selected: one stream fed treatment slough, one stream fed control slough, one backwater treatment slough and one backwater control slough.

Two types of artificial structures were used in the treatment sloughs. The Berkley structures are 4-ft. cubes of plastic slats that provide cover in the interstitial spaces. The Pradco structures resemble palm trees and provide cover under the palms. The placement of each type was alternated between the two treatment sloughs (Berkley in the mouth transect in one slough and in the inland transect of the second slough).

Each slough was sampled prior to artificial habitat installation. Two 75-m sampling transects were established for each slough. Between the transects, a 75-m buffer was established to avoid data collection overlap. Each transect was then electrofished for a period of 300 seconds and all fish were collected. Bass total lengths and abundance were recorded; all other fish were recorded as total numbers by species.

In the spring and fall, each transect is electrofished annually. Relative abundance (CPUE) and species composition are calculated for each transect. Analysis will include whether the structures increase the abundance of juvenile largemouth bass and whether utilization is higher for either the Berkely or Pradco structures.

Table 1. Transect variables and method of collection.

Variable	Method of collection
Habitat Type	Visually determine habitat types (i.e., pool, riffle, glide, pocketwater, run, alcove).
Dominant Substrate Size	Visually determine largest percentage of substrate for that habitat type (i.e., silt, sand, gravel, cobble, boulder, bedrock).
Habitat Function	Visually determine habitat functions (i.e., winter, summer, spawning or unusable).
Spawning Gravel Amount and Quality	Measure potential square meters of spawning gravels within each transect and quality (i.e. gravel size, location and current velocity Kalispel internal doc.1-95) Good = All criteria met. Fair = 2 criteria met. Poor = 1 criteria met.
Stream Depths	Measure depth at 1/4, 1/2, 3/4 across channel to the nearest cm.
Habitat Widths	Measure each specific habitat type in a transect to the nearest 0.1m.
Primary Pools	Number of pools with length or width greater than the avg. width of stream channel within each transect.
Pool Quality	Rating based upon collection of length, width, depth, and cover.
Pool Creator	Identify item creating the pool (e.g., large woody debris, boulders, beaver, enhancement, other).
Cobble Embeddedness	Visual estimate of the percentage fine or coarse sediment surrounding substrate / Actual measurement was recorded with an embed meter approximately every 20 transects. Regression of the estimated numbers with the actual measurements calculated a correction factor for all estimated values.

Table 1. *continued*

Variable	Method of collection
Bank Stability	Visual estimate of the percentage of unstable bank per transect for possible sediment source.
Instream Cover Rating	Percent of the stream surface covered by large woody debris, aquatic vegetation, bank vegetation in or near the surface of the water / Amount of cover provided by undercuts, root wads, boulders or turbulence.
Dominant/Subdominant Riparian Vegetation	Visual estimate of dominant vegetation and of subdominant vegetation species.
Stream Channel Gradient	Using a clinometer measure percent slope.
Acting Woody Debris	Number of woody debris with a diameter >10cm and a length >1m in the stream.
Potential Debris Recruitment	Number of trees within the transect that could potentially fall into the stream > 10 cm and a length > 1m.
Residual Pool Depth	The average pool depth by averaging the deepest portion of the pool and the pool tailout. Measure to the nearest cm.

Table 2. Reach variables and method of collection.

Variables	Method of Collection
Air and Water Temperature	Thermometer reading in centigrade.
Channel Type	A general classification of channel type based on channel morphology (see Rosgen 1994).
Average Embeddedness	Estimate of the average embeddedness for the entire reach Actual measurement was recorded with an embed meter approximately every 20 transects, Regression of the estimated numbers with the actual measurements calculated a correction factor for all estimated values.
Dominant Habitat Type	Dominant habitat type for the reach (i.e., pool, riffle, glide, pocketwater, run, alcove).
Disturbance	Estimation of the effects of land use practices (i.e. logging, roads, cattle, mining).
Aquatic Vegetation	Estimation of the occurrence of aquatic vegetation for the reach (i.e., abundant, fairly common, scarce, none).
Shading	Visual estimation of the amount of stream shaded by canopy along the stream reach
Habitat Quality	Estimation of the habitat quality for the entire reach (i.e., good, fair, poor).
Other	Any notable attribute not required for recording that can be recorded for reference to impact, or in interest to habitat quality.

Table 3. Fish species age/length class distributions (Espinosa 1988).

Species	Age	Length
Cutthroat Trout	0+	< 65 mm FL
Rainbow Trout	1+	65-110 mm FL
	2+	111-150 mm FL
	3+	151-200 mm FL
	4+	201-305 mm FL
	BIG	> 305 mm FL
Bull Trout	0+	< 65 mm FL
Brook Trout	1+	65-115 mm FL
Brown Trout	2+	116-165 mm FL
	3+	166-210 mm FL
	4+	211-305 mm FL
	BIG	>305 mm FL
Mountain Whitefish	N/A	< 100 mm
	N/A	100 - 305 mm
	N/A	> 305 mm
Sculpin	Total Number	Record Species If Possible
Sucker	Total Number	Record Species If Possible

Table 4. Interreach comparison threshold values (after Hunter 1991; MacDonald 1991).

Limiting Factors	Threshold Value
Embeddedness	Any value ≥ .30 or ≤ .70
Bank Stability	Any value ≤ 75%
Bank Cover	Any value ≤ 2.5
Instream Cover	Any value ≤ 2.0
Pool - Riffle Ratio	Any value ≤ .5:1 or ≥ 1.5:1
Spawning Gravel	Three lowest cumulative values
Primary Pools	Three lowest values

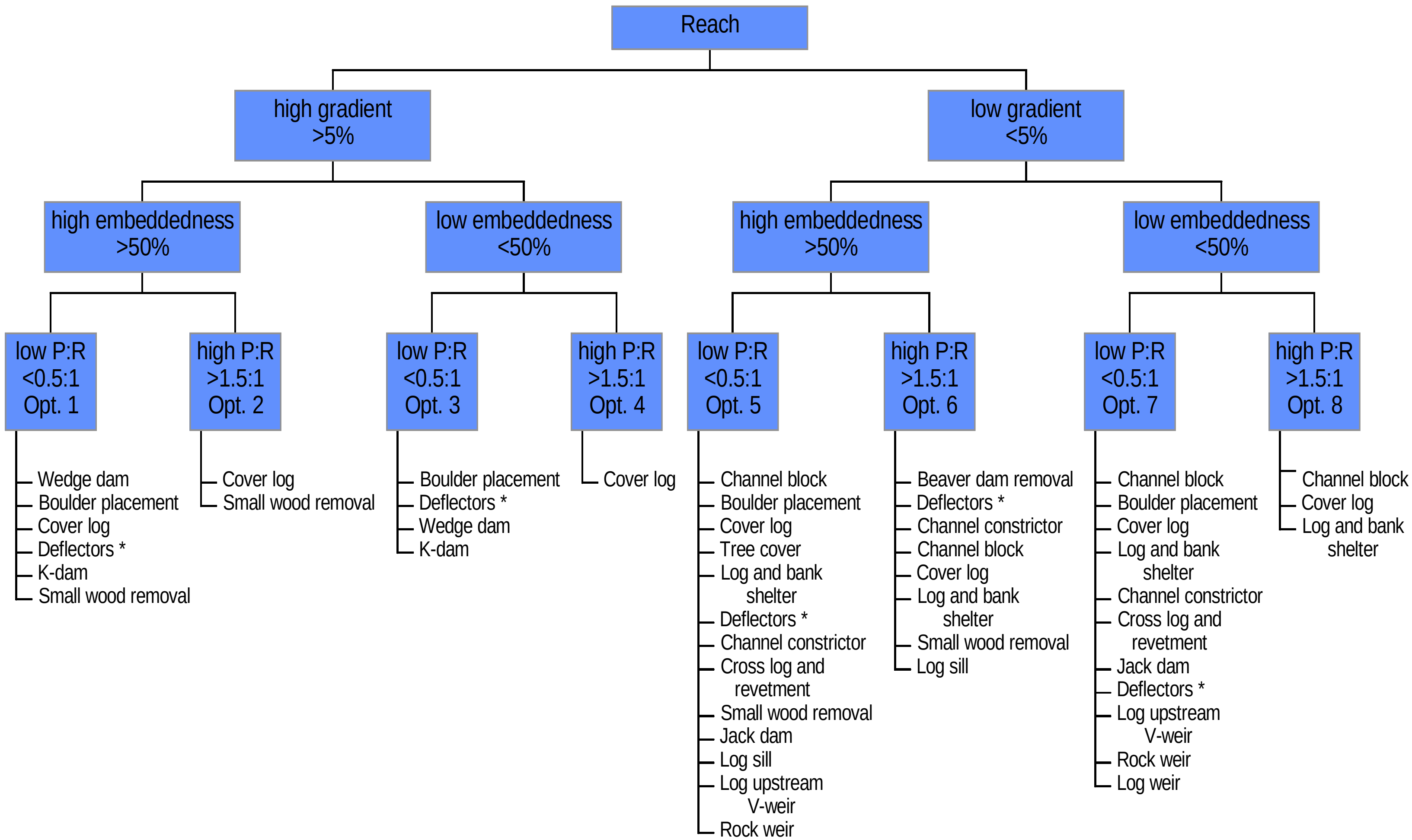

Figure 5. Flowchart for identified reaches of enhancement and the possible structures available for enhancement. Values derived after Harrelson et al. 1994, Macdonald 1991 and Hunter 1991.Table 4. Instream structures and the descriptions for placement requirements, function and impacts.

Table 5. Instream structures and the descriptions for placement requirements, functions and impacts.

Structure	Habitat	Stream Requirements	Purpose	Impacts
Wedge dam	Riffles Runs	Well defined stream banks. Stream < 30 ft. wide. Gradient >5%. Substrate consisting of: Rubble, cobble and gravel Ideal locations are at a break In gradient with a steeper section Immediately upstream.	Creates a fair to excellent scour pool. Creates spawning gravel at tail-out of pool	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Boulder placement	Riffles Runs Glides Open Pools	Greatest benefits in currents Exceeding 2 feet per Second. Suitable for any size stream.	Provides overhead cover and resting areas. Creates natural appearance.	+ Creates pocketwater behind boulder. + Added depth is also created by the scouring resulting from reduced channel capacity and increased current velocity.
Cover log	Open Pools Runs	Works best in meanders or in conjunction with deflectors. Requires adequate water depth (at least 8" deep.) Suitable for any size stream.	Provides optimum cover.	+ Creates overhead cover. + Directs current away from meander. - May cause unwanted bank cutting.
Single-Wing Deflector	Riffles Glides Runs	When possible, divert water into a Relatively stable section of stream Bank	Constricts and diverts water flow so that Pools are formed by	+ Constricts and diverts water flow. +/- May cause deposition of sediment just below Structure towards bank

Table 5. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
Double-Wing Deflector	Riffles Runs Glides	Especially suitable for shallow sections of stream where the gradient is too steep for effective deflector and cover log.	Creates mid-channel pools through scouring. Creates spawning gravel at tail-out of pool.	+ Narrows channel. + Scours a pool below structure. +/- May cause deposition of sediment just below structure towards bank. - May cause unwanted bank cutting.
Channel Constrictor	Riffles Runs Glides	Provides best results when placed in long, straight, low-gradient stretches of stream.	Provides overhead cover. Narrows channel. Scour and deepen streambed.	+ Scours the streambed. + Increases velocity. + Helps transport sediment. - May concentrate sediment below structure. +/- Incises the channel.
Log Deflector	Riffles Glides Runs	When possible, divert water into a relatively stable section of stream bank. Suitable for a variety of sites. Most suitable in wide shallow riffles.	Constricts and diverts water flow so that pools are formed by scouring. Creates spawning gravel	+ Constricts and diverts water flow. +/- May cause deposition of sediment just below structure towards bank. + Directs meander.

Table 5. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
Log Paired Deflector	Riffles Runs Glides	Especially suitable for shallow sections of stream where the gradient is too steep for effective deflector and cover log.	Creates mid-channel pools through scouring. Creates spawning gravel at tail-out of pool.	+ Narrows channel + Scours a pool below structure. +/- May cause deposition of sediment just below structure towards bank.
Rock Deflector	Riffles Runs Glides	When possible, divert water into a relatively stable section of stream bank. Suitable for a variety of sites. Most suitable in wide shallow riffles.	Directs flow from cut bank. Directs meander. Scours pool.	+ Constricts and diverts water flow. +/- May cause deposition of sediment just below structure towards bank. + Directs meander.
Boulder Paired Deflector	Riffle Runs Glides	Especially suitable for shallow sections of stream where the gradient is too steep for effective deflector and cover log.	Creates mid-channel pools through scouring. Creates spawning gravel at tail-out of pool.	+ Narrows channel. + Scours a pool below structure. +/- May cause deposition of sediment just below structure towards bank.

Table 5. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
K – Dam	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient >5%. Substrate consisting of: rubble, cobble and gravel. Ideal locations are at a break in gradient with a steeper section immediately upstream.	Creates a fair to excellent scour pool. Creates spawning gravel at tail-out of pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment. - Prone to undercutting of structure.
Small Wood Removal	Riffles Glides Runs	Small wood must be acting as a silt trap or inhibiting fish migration in order to be removed. Typically used to increase velocity and transport sediment.	Typically used to increase velocity and transport sediment. Helps expose substrate.	+ Increases velocity. + Transports sediment. + Exposes substrate. + Narrows channel.

Structure	Habitat	Stream Requirements	Purpose	Impacts
Channel Block	Braided Channel	Braided channel that is virtually unusable.	Consolidates flow . into a single, deeper channel.	+ Concentrates flow into a single deeper channel. + May increase velocity. - May concentrate sediment deposition downstream.

Table 5. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
Tree Cover	Riffles Runs Glides	Suitable for a variety of sites. Greatest benefits probably occur in wide shallow streams with sand or gravel substrate.	Provides excellent overhead cover. Increases stream velocity. Transports sediment.	+ Constricts wide shallow channels. + Increases stream velocity. + Transports sediment.
Log & Bank Shelter	Open Pools	Suitable for use in low gradient. Stream bends or meanders. Can be used with a deflector.	Provides overhead cover. Provides some streambank protection.	+ Creates overhead cover. + Directs current away from meander.
Cross Log & Revetment	Riffles Runs	Structure works best in low gradient sections of the stream. Works even better at the beginning of wide, shallow bends with marginal pools or cover.	Creates scour pool. Creates overhead cover. Protects the bank.	+ Creates a scour pool. + Protects bank.
Jack Dam	Riffles Runs	High banks. Moderate to steep gradient.	Produces deep scour pools.	+/- Creates calmer water above the structure. + Creates scour pool.

Table 5. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
Log Sill	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%.	Creates scour pool. May create spawning gravel.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Structure	Habitat	Stream Requirements	Purpose	Impacts
Log Upstream V-Weir	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%. Works well in sand and gravel substrate.	Creates deep plunge pool. Creates spawning gravel at tail-out of pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Rock Weir	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%.	Creates scour pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Log Weir	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%.	Creates scour pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Beaver dam removal	Long Pools	A beaver dam in the in the lower 2/3 of the stream . A beaver dam that may inhibit fish passage.	Narrows channel. Exposes substrate.	- Releases a large volume of sediment downstream. +/- Incises the channel . + Decreases sediment upstream. + May expose substrate such as cobble, gravel and boulders.

Results

Bull trout and cutthroat trout densities and habitat attributes in restoration sites.

Cee Cee Ah Creek

<u>Reach 4</u>

In 1996, three K-dams were constructed in reach 4 following the pre-assessment. Inter-annual trends have been variable; however, substrate embeddedness decreased from 48% in the pre-assessment to 40% in 2001 (Table 6). Embeddedness ranged from 32% in 2000 to 60% in 1999. Spawning gravel was high in the pre-assessment (8.1 m^2), but no substrate was classified as spawning gravel in 4 of the 5 years of post assessment. The percent of pool habitat increased from 7% in the 1996 pre-assessment to 38% in 2001. Average depths have increased from 12.1 cm in the pre-assessment to 20.2 cm in 2001. Increased average width was observed through 2000; however, average width decreased to 3.0 in 2001. Primary pools increased from 2 in the 1996 pre-assessment to 5 in 1999; however, only 2 pools were classified as primary in both 2000 and 2001.

In the 1997 implementation site, four K-dams were constructed following the pre-assessment. Substrate embeddedness has remained relatively constant, with a high of 48% in the 1997 pre-assessment to a low of 32% in 1998 (Table 7). Spawning gravels have been absent in all of the assessments. Percent pool habitat increased; pools comprised 17% of the habitat in 1997 and 31% in 2001. Average depth decreased from 31.9 cm in 1997 to 16.1 cm in 2001. Average width has varied annually; and the smallest average width occurred in 2001 (3.2 m). Primary pool numbers increased; no primary pools were observed in the pre-assessment and 5 primary pools were identified in 2001.

Five structures were implemented in 1998. Substrate embeddedness has been variable; pre-assessed embeddedness was 45% and 2001 embeddedness was 41% (Table 8). No spawning gravel was observed in the pre-assessment, and spawning gravel was classified in only one post assessment (0.5 m^2 in 2000). Percent pool habitat has increased substantially. No habitat was classified as pool in the 1998 pre-assessment and 27% of the habitat was classified as pool in 2001. Average depth decreased from 31.6 cm in 1998 to 15.5 cm in 2001. Average width also decreased; width was 4.5 m in the 1998 pre-assessment and 3.5 m in 2001. The number of primary pools has increased from 1 in the pre-assessment to 5 in 2001.

Brook trout were the only fish species observed in the structures implemented in reach 4. From pre-assessment to 2001, fish densities increased in the 1997 and 1998 implementation sites and decreased in the 1996 site (Figure 6). In the section of reach 4 where structures were implemented in 1996, pre-assessment brook trout densities were 8.6 fish/100 m^2, declined to 3.1 fish/100 m^2 in 2000, and increased to 7.2 fish/100 m^2 in 2001. For the reach 4 site implemented in 1997, brook trout densities increased from 4.7 fish/100 m^2 to 10.2 fish/100 m^2 in 2001. In the 1998 implementation site, brook trout density has increased from the 3.9 brook trout/100 m^2 in the pre-assessment to 10.3 brook trout/100 m^2 in 2001. No snorkel data were collected in reach 4 during the 1999 field season because of a U.S. Forest Service area closure due to safety concerns with a helicopter logging operation and heavy log truck traffic.

Table 6. Annual Cee Cee Ah Creek reach 4 habitat attributes from the 1996 implementation site.

	96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	48	52	38	60	32	40
Pool/Riffle	0.4	0.4	0.7	0.3	0.3	0.5
Spawning Gravel (m^2)	8.1	0.0	4.5	0.0	0.0	0.0
% Pool	7	5	5	19	24	38
% Riffle	65	61	50	48	69	51
% Run	11	20	26	33	5	11
% Pocketwater	15	14	19	0	0	0
% Glide	1	0	0	0	2	0
Avg Depth (cm)	12.1	24.6	30.2	21.6	19.5	20.2
Avg Width (m)	3.1	3.3	3.8	3.6	3.8	3.0
# Primary Pools	2	1	2	5	2	2

Table 7. Annual Cee Cee Ah Creek reach 4 habitat attributes from the 1997 implementation site.

	97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	48	32	45	34	44
Pool/Riffle	0.7	0.6	0.4	1.0	0.4
Spawning Gravel (m^2)	0.0	0.0	0.0	0.0	0.0
% Pool	17	10	22	42	31
% Riffle	56	30	60	49	69
% Run	8	44	18	8	0
% Pocketwater	18	16	0	0	0
% Glide	0	0	0	0	0
Avg Depth (cm)	31.9	29.8	16.8	21.2	16.1
Avg Width (m)	3.7	4.2	3.3	3.7	3.2
# Primary Pools	0	3	1	2	5

Table 8. Annual Cee Cee Ah Creek reach 4 habitat attributes from the 1998 implementation site.

	98 Structures			
Attribute	Pre '98	Post '99	Post '00	Post '01
Embeddedness (%)	45	59	43	41
Pool/Riffle	0.4	0.8	1.5	0.3
Spawning Gravel (m^2)	0.0	0.0	0.5	0.0
% Pool	0	33	51	27
% Riffle	67	35	45	59
% Run	16	32	3	14
% Pocketwater	13	0	0	0
% Glide	0	0	0	0
Avg Depth (cm)	31.6	23.8	21.2	15.5
Avg Width (m)	4.5	3.6	4.4	3.5
# Primary Pools	1	4	3	5

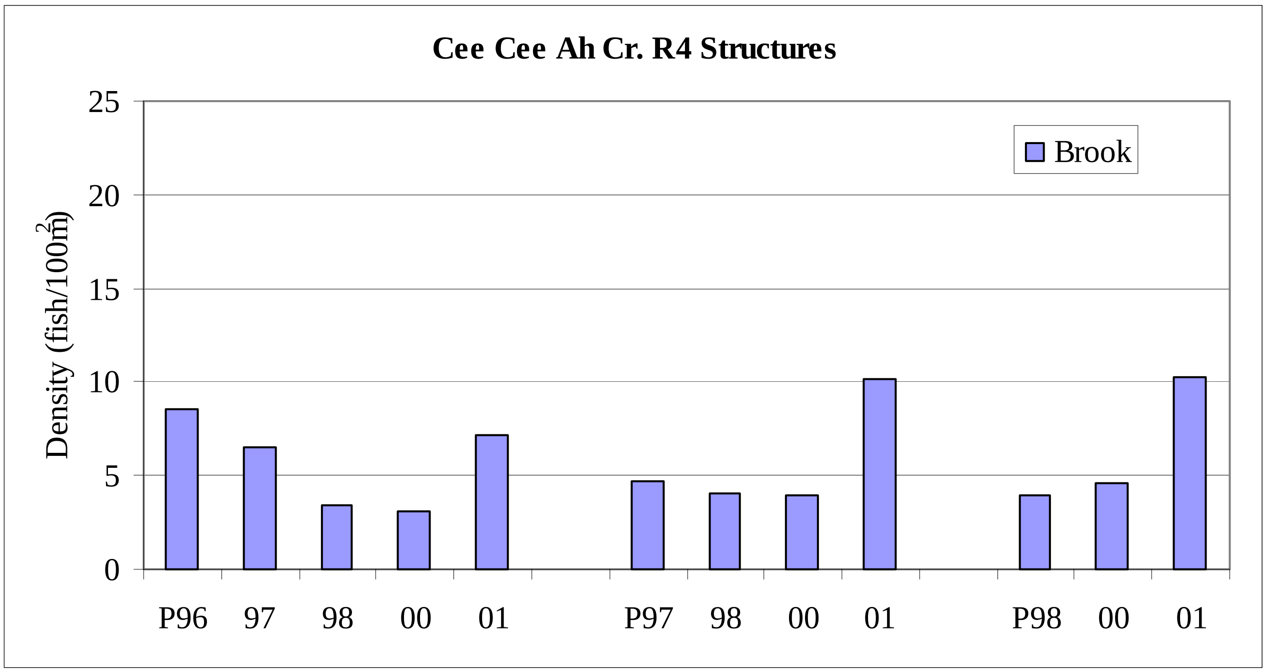

Figure 6. Annual Cee Cee Ah Creek reach 4 fish densities from the 1996, 1997, and 1998 implementation sites.

Reach 5

In reach 5, three cross log revetments were constructed in 1996 to create scour pools. Substrate embeddedness in the 1996 implementation site decreased from 77% to 38% in 2001 (Table 9). No spawning gravel was identified in the pre-assessment or in 2001, but 0.5 m^2 and 1.0 m^2 were observed in 1999 and 2000, respectively. Pool habitat was not observed in the 1996 pre-assessment; however, 38% of the habitat was classified as pool in 2001. Average depth was greater in all post assessment years except 2001 where it was unchanged at 16.2 cm. Average width increased from 3.1 m in 1996 to 3.3 m in 2001.

In the 1997 implementation site of reach 5, four cross log revetments were constructed to create scour pools. Annually, substrate embeddedness was variable but decreased from 1997 to 2001 from 61% to 27%, respectively (Table 10). The only spawning gravel identified in the assessments was in 2000 (1.0 m^2). Pool habitat increased from 8% in 1997 to 52% in 2001. Average depth increased from the 1997 pre-assessment (26.7 cm) to 1998 (32.4 cm). However, the 2001 average depth was less than the pre-assessed depth. Average width increased initially from 3.6 m in the pre-assessment. However, average width was essentially unchanged in 2001 at 3.7 m. The pre-assessment primary pool number was 1; post assessment primary pool number varied annually from a high of 4 in 1999 to 2 in 1998 and 2001.

Four structures were implemented in reach 5 in 1998. Embeddedness decreased from 62% in the pre-assessment to 48% in 2001 (Table 11). No spawning gravels were observed in 1998, 1999, or 2001; however, 1.0 m^2 were observed in 2000. Percent pool habitat increased from 20% in 1998 to 44% in 2001. Average depth decreased annually while average widths have been variable. One primary pool was classified in the 1998 pre-assessment, 2 were identified in 1999 and 2001, and 5 were observed in 2000.

In reach 5, post implementation brook trout densities increased in the 1996 site (Figure 7). Brook trout density increased from 6.2 fish/100 m^2 to 20.9 fish/100 m^2 in 2001. Cutthroat trout (n=1) were only observed at this site in 1996. For the reach 5 site implemented in 1997, brook trout density increased from 8.5 fish/100 m^2 to 10.3 fish/100 m^2 in 2001. Density has been variable in this site with a high of 14.5 fish/100 m^2 in 1999 and a low of 3.8 fish/100 m^2 in 2000. Annual decreases in brook trout were observed in the 1998 implementation site up to 2001. Density declined from 14.6 fish/100 m^2 in 1998 to a low of 7.4 fish/100 m^2 in 2000; however, brook trout density increased to 18.0 fish/100 m^2 in 2001.

Table 9. Cee Cee Ah Creek reach 5 habitat attribute values from the 1996 implementation site.

	96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post ‘00	Post ‘01
Embeddedness (%)	77	56	47	58	43	38
Pool/Riffle	0.2	0.2	0.2	0.2	0.8	0.6
Spawning Gravel (m^2)	0.0	0.0	0.0	0.5	1.0	0.0
% Pool	0	7	0	19	43	38
% Riffle	66	53	57	67	41	56
% Run	21	34	32	13	11	2
% Pocketwater	13	6	11	0	0	0
% Glide	0	0	0	0	4	4
Avg Depth (cm)	16.2	21.5	25.7	18.1	18.1	16.2
Avg Width (m)	3.1	3.2	4.0	3.2	2.6	3.3
# Primary Pools	2	3	5	2	7	5

Table 10. Cee Cee Ah Creek reach 5 habitat attribute values from the 1997 implementation site.

	97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00	Post ‘01
Embeddedness (%)	61	44	62	46	27
Pool/Riffle	0.6	0.7	0.5	5.0	1.3
Spawning Gravel (m^2)	0.0	0.0	0.0	1.0	0.0
% Pool	8	7	26	80	52
% Riffle	49	18	54	11	38
% Run	30	64	19	9	0
% Pocketwater	13	8	0	0	0
% Glide	0	2	0	0	10
Avg Depth (cm)	26.7	32.4	19.2	23.0	18.2
Avg Width (m)	3.6	4.7	4.1	2.6	3.7
# Primary Pools	1	2	4	3	2

Table 11. Cee Cee Ah Creek reach 5 habitat attribute values from the 1998 implementation site.

	98 Structures			
Attribute	Pre '98	Post '99	Post '00	Post '01
Embeddedness (%)	62	68	52	48
Pool/Riffle	0.3	0.7	1.5	1.0
Spawning Gravel (m^2)	0.0	0.0	1.0	0.0
% Pool	20	25	56	44
% Riffle	52	50	44	56
% Run	21	26	0	0
% Pocketwater	7	0	0	0
% Glide	0	0	0	0
Avg Depth (cm)	31.9	22.7	21.0	16.5
Avg Width (m)	4.0	4.7	3.0	4.4
# Primary Pools	1	2	5	2

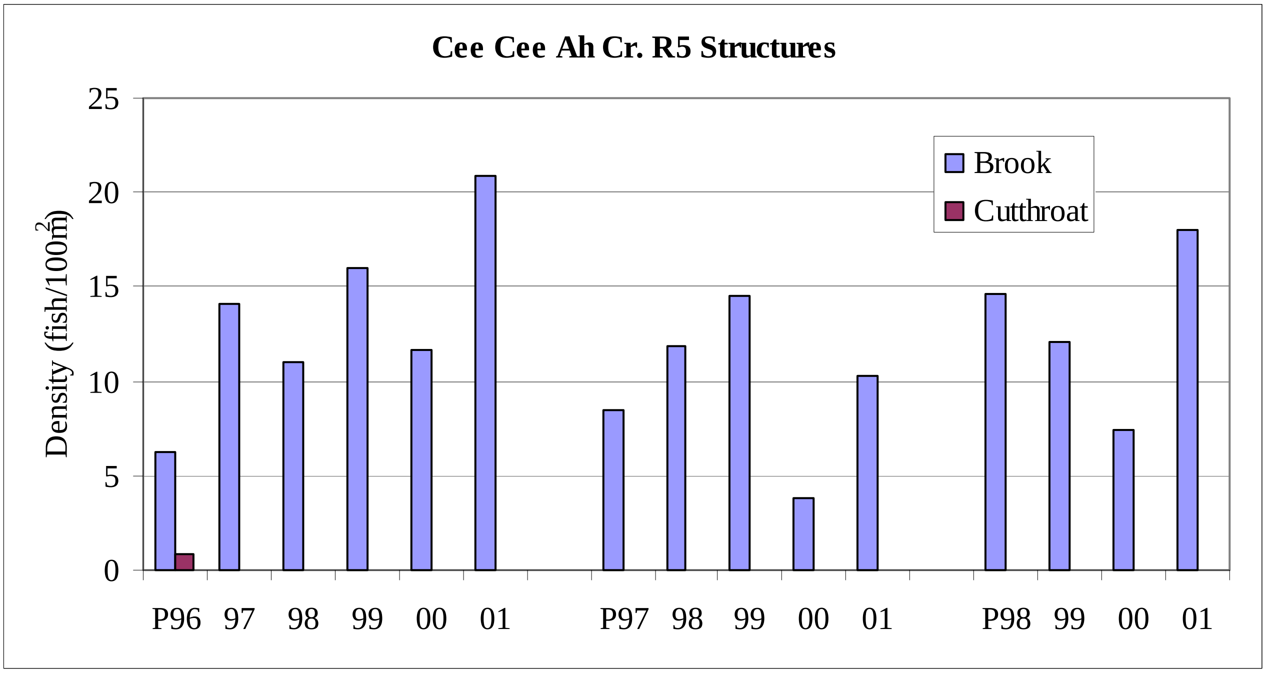

Figure 7. Annual Cee Cee Ah Creek reach 5 fish densities from the 1996, 1997, and 1998 implementation sites.

Reach 6

In 1996, three upstream v-weirs were constructed to create pool habitat and recruit spawning gravel. Substrate embeddedness in this implementation site generally decreased. Pre-assessed embeddedness was 59% and 2001 embeddedness was 41% (Table 12). A decrease in spawning gravel was observed. 6.4 m^2 was identified in the 1996 pre-assessment while post assessment spawning gravel ranged from 1.0 m^2 in 1999 and 2000 to 0.0 m^2 in 1997 and 1998. Pool habitat increased annually in the 1996 implementation site to 2000. Pre-assessed pool habitat composition was 9% and increased to 51% in 2000; a slight decrease was observed in 2001 to 49%. All post assessment average depths were greater than the pre-assessed average depth (18.7 cm) except for 2001 (17.4 cm). Average widths increased from 2.5 m in 1996 to 3.0 m in 2001 with a high of 3.2 m in 1998 and1999. The number of primary pools appeared to remain relatively unchanged. 5 primary pools were identified in 1996, 4 pools were classified as primary in 1997, 1999, and 2001, no primary pools were identified in 1998, and 5 were classified in 2000.

Four upstream v-weirs were constructed in reach 6 in 1997. Substrate embeddedness was 67% in 1997 (pre-assessment) and decreased to 36% in 2001 (Table 13). Spawning gravel appeared to increase initially; no gravel was observed in the pre-assessment, 1.0 m^2 in 98, and 1.5 m^2 in 1999; however, no spawning gravel was present in 2000 or 2001. Pool habitat increased from 5% in 1997 to 36% in 2001. The pre-assessed depth was 34.3 cm in 1997 and decreased to 17.5 cm in 2001. Excluding 2000, average widths were relatively unchanged (3.3 m to 3.5 m, while 2000 was 2.5 m). Primary pool number increased from 2 in 1997 to 4 in 2001.

In 1998, three structures were implemented to increase pool habitat and recruit spawning gravel. Substrate embeddedness decreased annually from 63% in 1998 to 37% in 2001 (Table 14). Spawning gravel was only observed in the pre-assessment (0.5 m^2) and in 2000 (0.5 m^2). No pool habitat was classified in the pre-assessment and 53% of the habitat was classified as pool in 2001. Average depth decreased from 31.1 cm in 1998 to 17.2 cm in 2001. Average width also decreased. The pre-assessed average width was 3.6 m and decreased to 3.1 m in 2001. Primary pools increased substantially from 1 to 5.

In reach 6, brook trout densities were relatively stable in the site where structures were implemented in 1996 up to 2000 (Figure 8). Pre-implementation density was 16.6 fish/100 m^2; density remained relatively unchanged up to 2000 when 5.6 fish/100 m^2 were observed. However, brook trout density increased to 21.7 fish/100 m^2 in 2001. Brook trout density in the 1997 implementation site has doubled from 11.5 fish/100 m^2 to 23.6 fish/100 m^2 in 2001. In the 1998 restoration site, brook trout density increased 400% from 4.3 fish/100 m^2 to 17.8 fish/100 m^2 in 2001. In reach 6, cutthroat trout (n=1) were only observed in the 1997 pre-implementation site.

Table 12. Cee Cee Ah Creek reach 6 habitat attribute values from the 1996 implementation site.

	96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	59	61	41	57	49	41
Pool/Riffle	0.2	0.5	0.7	0.7	1.0	0.9
Spawning Gravel (m^2)	6.4	0.0	0.0	1.0	1.0	0.5
% Pool	9	12	17	38	51	49
% Riffle	45	35	51	49	35	51
% Run	39	49	24	3	7	0
% Pocketwater	2	4	8	1	0	0
% Glide	4	0	0	8	4	0
Avg Depth (cm)	18.7	23.9	31.7	19.9	21.6	17.4
Avg Width (m)	2.5	2.9	3.2	3.2	2.6	3.0
# Primary Pools	5	4	0	4	5	4

Table 13. Cee Cee Ah Creek reach 6 habitat attribute values from the 1997 implementation site.

	97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	67	47	67	45	36
Pool/Riffle	0.6	0.7	0.7	1.6	0.7
Spawning Gravel (m^2)	0.0	1.0	1.5	0.0	0.0
% Pool	5	7	39	61	36
% Riffle	53	60	43	32	64
% Run	21	19	9	7	0
% Pocketwater	21	14	0	0	0
% Glide	0	0	8	0	0
Avg Depth (cm)	34.3	29.9	19.6	21.9	17.5
Avg Width (m)	3.3	3.5	3.3	2.5	3.4
# Primary Pools	2	2	3	4	4

Table 14. Cee Cee Ah Creek reach 6 habitat attribute values from the 1998 implementation site.

	98 Structures			
Attribute	Pre '98	Post '99	Post '00	Post '01
Embeddedness (%)	63	46	45	37
Pool/Riffle	0.3	0.4	0.8	0.8
Spawning Gravel (m^2)	0.5	0.0	0.5	0.0
% Pool	0	25	48	53
% Riffle	65	58	44	47
% Run	20	5	8	0
% Pocketwater	13	0	0	0
% Glide	0	12	0	0
Avg Depth (cm)	31.1	18.4	20.6	17.2
Avg Width (m)	3.6	3.2	2.5	3.1
# Primary Pools	1	2	5	5

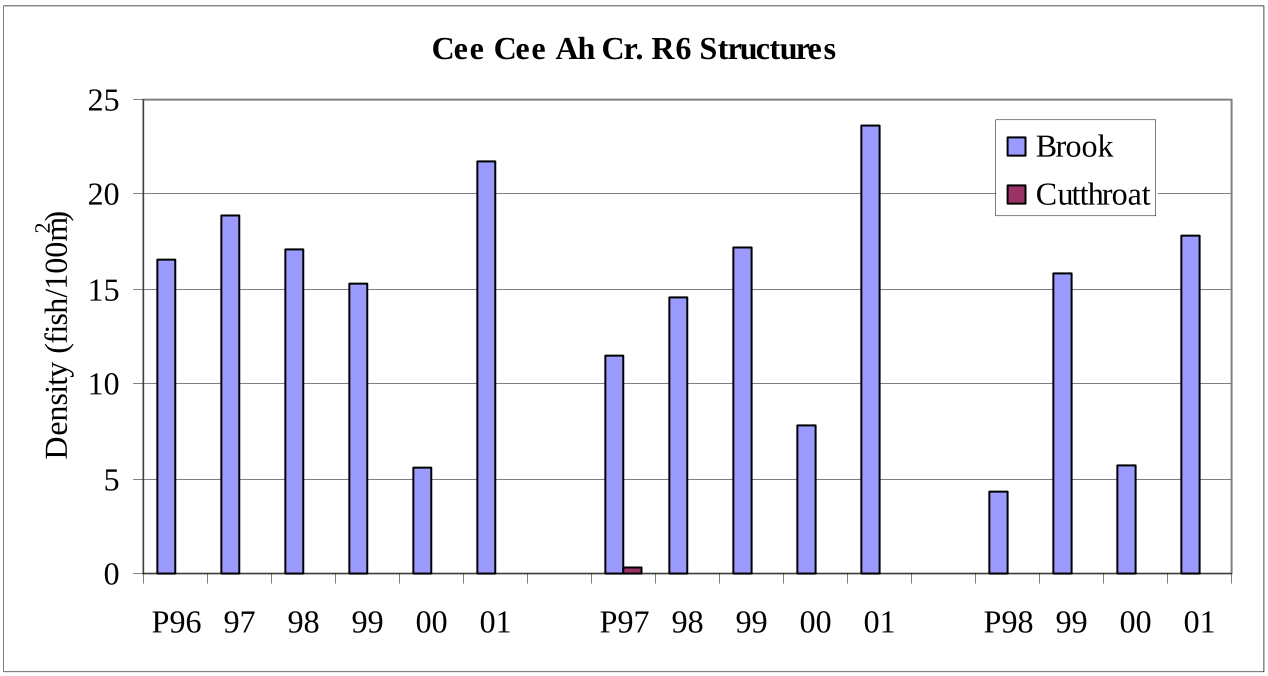

Figure 8. Annual Cee Cee Ah Creek reach 6 fish densities from the 1996, 1997, and 1998 implementation sites.

Indian Creek

Reach 3

In 1996, three double-wing deflectors were constructed in reach three following the pre-assessment. Post implementation substrate embeddedness in reach 3 was lower in all years of monitoring (Table 15). Pre-implementation embeddedness was 80 percent and monitoring values ranged from 75% in 1998 to 53% in 2001. Spawning gravel progressively declined from the pre-assessed estimate of 23 m^2; no spawning gravel was observed in 2001. Pool type habitat in reach 3 increased from 0% in 1996 to 50% in 2001. Average depths in monitoring years were all greater than the 1996 pre-assessment value. In 1996, the average depth was 17.9 cm and post assessments depths ranged from 22.0 cm in 2001 to 41.7 cm in 1997. Annual average widths increased over the pre-assessed value with the lowest post assessment average width recorded in 2001. Primary pool numbers increased from 0 in the 1996 pre-assessment to 3 in 2001.

Fish densities in reach 3 appeared to decline from pre-assessment in 1996 to 2001 (Figure 9). Cutthroat trout were not observed in the pre-assessment nor in 2000 or 2001; they were initially observed in 1997 and densities decreased annually in 1998 and 1999. The brook trout density varied annually; pre-assessment density was 6.0 fish/100 m^2, the high was 7.0 fish/100 m^2 in 1998, and the low of 2.0 fish/100 m^2 was observed in 2000. Brown trout density was highest during the pre-assessment (5.0 fish/100 m^2) and 1997 was the low (0.8 fish/100 m^2).

Table 15. Indian Creek reach 3 habitat attribute values from the 1996 implementation site.

	96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	80	56	75	67	68	53
Pool/Riffle	0.2	0.8	0.6	0.5	2.0	1.0
Spawning Gravel (m^2)	23.0	14.0	9.0	1.5	0.5	0.0
% Pool	0	0	0	5	51	50
% Riffle	64	33	35	25	27	48
% Run	26	47	56	66	19	2
% Pocketwater	7	19	9	3	0	0
% Glide	2	0	0	0	2	0
Avg Depth (cm)	17.9	41.7	29.1	38.3	26.7	22.0
Avg Width (m)	2.9	4.8	5.0	4.7	4.3	4.2
# Primary Pools	0	2	0	1	5	3

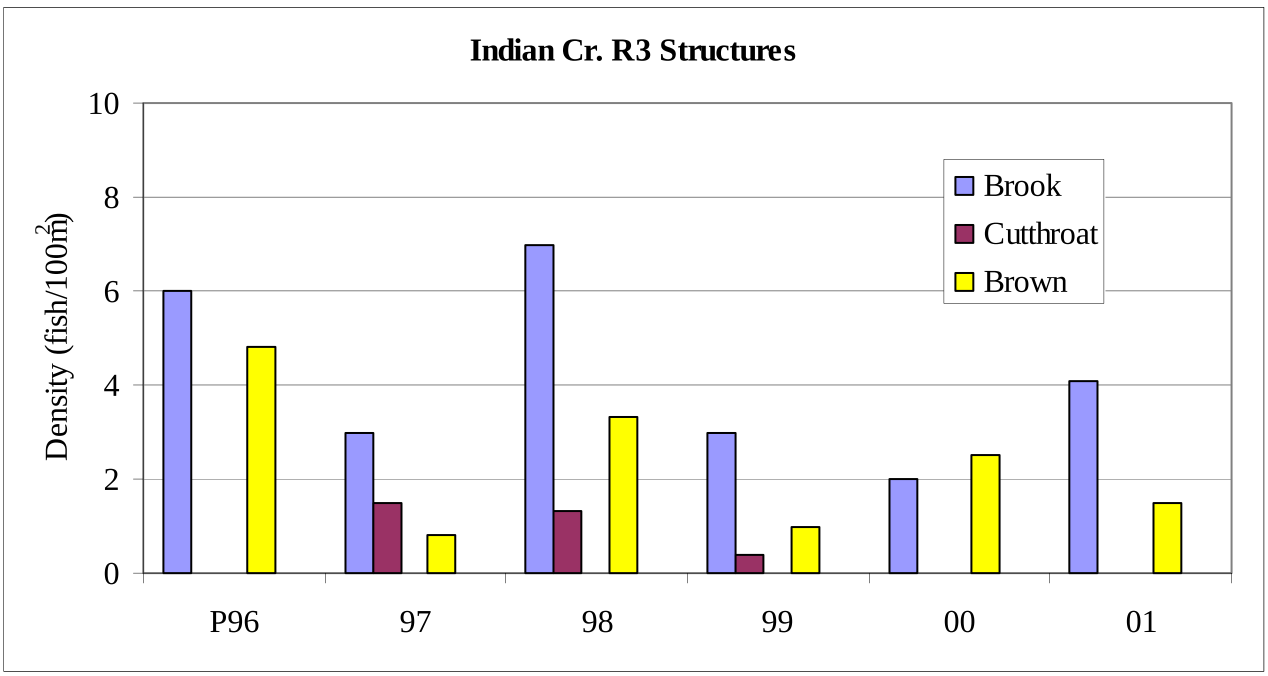

Figure 9. Annual Indian Creek reach 3 fish densities from the 1996 implementation site.

Reach 4

In reach 4, three log weirs were constructed to provide to scour pools and recruit spawning gravel. Substrate embeddedness decreased from a 1996 pre-assessed value of 82% to 33% in 2001 (Table 16). Relative to pre-assessment quantities, fewer areas of spawning gravel were observed in all post assessment years except in 1998. In 1996, pre-assessed spawning gravel was estimated at 9.0 m^2, monitoring estimates ranged from 1.5 m^2 in 2000 to 10.0 m^2 in 1998. 4.0 m^2 of gravel were classified as spawning habitat in 2001. No pool type habitat was classified in the pre-assessment survey in 1996. Pool habitat has increased annually to 23% in 2001. Average widths and depths increased in years following the pre-assessment. The pre-assessed average depth was 10.9 cm; in subsequent monitoring years, average depths ranged from 17.7 cm in 2001 to 28.7 cm in 1997. The pre-assessed average width was 2.1 m; post assessment average widths decreased annually to 3.7 m by 2001. In 1997 and 2000, 3 pools were classified as primary and 4 primary pools were identified in 2001.

Changes to fish densities in reach 4 were variable (Figure 10). Cutthroat density increased over 300% from 1996 to 2000. However, no cutthroat trout were observed in 2001. The highest densities of brook and brown trout occurred in 2001 at 6.1 fish/100 m^2 and 5.5 fish/100 m^2, respectively. The only bull trout observed (in 1997) was believed to be an adfluvial fish from Lake Pend Oreille since it was fin clipped. This fish was previously captured and passed in a downstream trap.

Table 16. Indian Creek reach 4 habitat attribute values from the 1996 implementation site.

	96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	82	16	33	50	38	33
Pool/Riffle	0.1	0.2	0.1	0.0	0.3	0.3
Spawning Gravel (m^2)	9.0	5.5	10.0	2.5	1.5	4.0
% Pool	0	4	2	1	15	23
% Riffle	85	82	90	94	80	77
% Run	8	4	1	5	0	0
% Pocketwater	6	10	7	0	4	0
% Glide	0	0	0	0	1	0
Avg Depth (cm)	10.9	28.7	22.1	26.5	19.8	17.7
Avg Width (m)	2.1	4.3	4.2	4.2	3.8	3.7
# Primary Pools	0	3	0	0	3	4

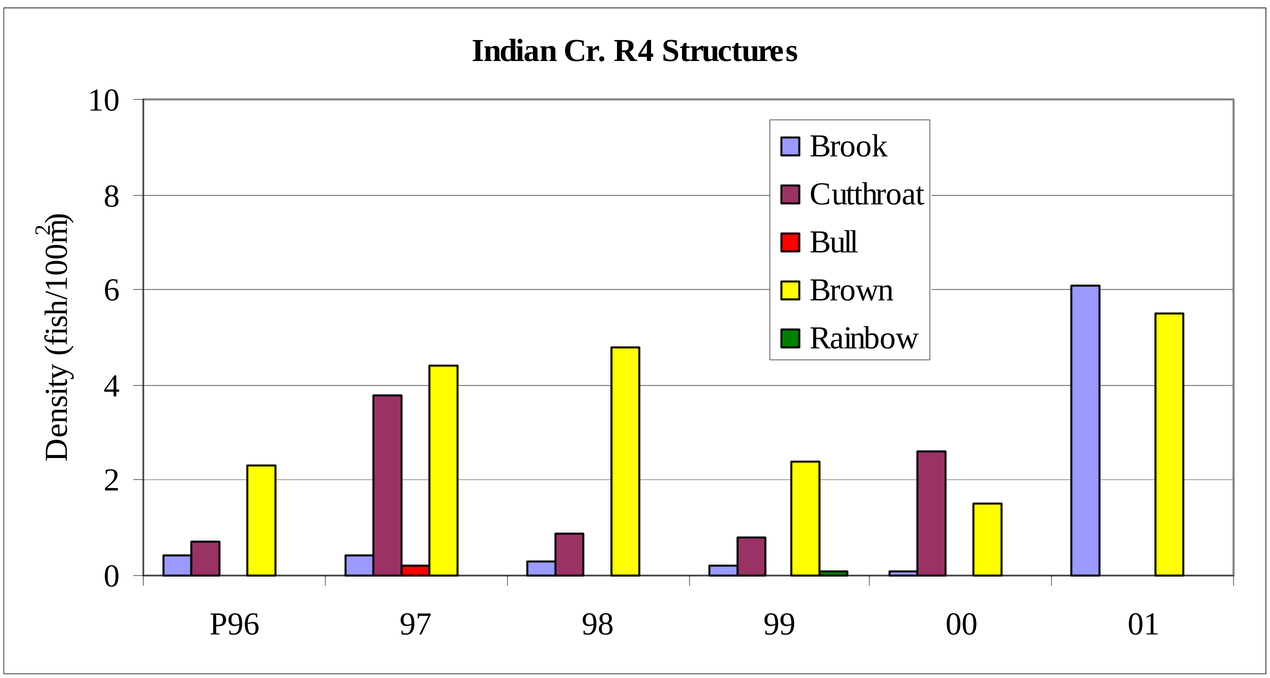

Figure 10. Annual Indian Creek reach 4 fish densities from the 1996 implementation site.

Browns Creek

Reach 4

Three K-dams were constructed in reach 4 in 1997. Pre-assessed substrate embeddedness was 31% and initially increased to 47% in 1999; embeddedness decreased in subsequent years to 29% in 2001 (Table 17). Spawning gravels in monitoring years appeared to decrease markedly over pre-assessed estimates. 1997 pre-assessed spawning gravel was estimated at 12.5 m^2; no gravel was classified as spawning habitat in the 2001 post assessment. The percent of pre-assessed habitat classified as pool was 3% and increased to 17% in 2001. Average depth decreased from 25.7 cm in 1997 to 13.1 cm in 2001. Wetted width was relatively unchanged from a pre-assessed average of 4.9 m to 4.8 m in 2001. In the 1998 post assessment, surveyors classified three pools as primary pools. No primary pools were observed in 1997, 1999, or 2000, while 1 pool was classified as primary in 2001.

Three additional structures were built in reach 4 in 1998. Embeddedness in this site increased from 28% in the pre-assessment to 52% in 1999 (Table 18). However, substrate embeddedness in 2001 decreased to 29%. Pre-assessed spawning gravel was 4.5 m^2; no spawning gravel was observed in 1999 or in 2001. Pool type habitat increased in this restoration reach. No habitat was classified as pool in the 1998 pre-assessment and the 1999 post assessment. However, 33% and 9% of the habitat was classified as pool in the 2000 and 2001 post assessments, respectively. Average depths decreased annually to a low of 15.4 cm in 2001. Average width has been highly variable. The pre-assessed width was 4.0 m, increased to 7.2 m in 1999, decreased to 3.9 m in 2000 and 2001. No pools were classified as primary during the pre-assessment in 1998 or in 1999. However, 2 primary pools were observed in the 2000 post assessment, and 4 in 2001.

Post implementation brown trout densities increased over pre-implementation densities in reach 4 (Figure 11). In the 1997 implementation site, brown trout densities increased from 4.2 fish/100 m^2 in 1997 to 9.2 fish/100 m^2 in 2001. Pre-assessment brook trout density was 0.2 fish/100 m^2 and increased to 0.7 fish/100 m^2 in 1999. However, no brook trout were observed in the 1997 implementation site in 2001. Brown and brook trout densities also increased in the 1998 implementation site. Brook trout density increased from 0.2 fish/100 m^2 in 1998 (pre-assessment) to 0.7 fish/100 m^2 in 1999 and 0.4 fish/100 m^2 in 2001. Brown trout increased from 4.1 fish/100 m^2 in 1998 to 6.2 fish/100 m^2 in 2001. Only one cutthroat trout was observed in reach 4 and that fish was seen during the 1998 pre-assessment.

Table 17. Browns Creek reach 4 habitat attribute values from the 1997 implementation site.

	97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00	Post ‘01
Embeddedness (%)	31	41	47	39	29
Pool/Riffle	0.1	0.3	0.1	0.3	0.2
Spawning Gravel (m^2)	12.5	4.5	0.0	1.5	0.0
% Pool	3	6	3	19	17
% Riffle	88	76	84	79	75
% Run	2	9	13	3	3
% Pocketwater	6	9	0	0	0
% Glide	0	0	0	0	5
Avg Depth (cm)	25.7	22.4	24.2	19.7	13.1
Avg Width (m)	4.9	5.2	4.7	4.1	4.8
# Primary Pools	0	3	0	0	1

Table 18. Browns Creek reach 4 habitat attribute values from the 1998 implementation site.

	98 Structures			
Attribute	Pre '98	Post '99	Post '00	Post ‘01
Embeddedness (%)	28		41	29
Pool/Riffle	0.0	0.0	0.5	0.1
Spawning Gravel (m^2)	4.5	0.0	3.0	0.0
% Pool	0	0	33	9
% Riffle	92	87	67	80
% Run	2	12	0	11
% Pocketwater	5	1	0	0
% Glide	0	0	0	0
Avg Depth (cm)	26.5	26.2	19.8	15.4
Avg Width (m)	4.0	7.2	3.9	3.9
# Primary Pools	0	0	2	4

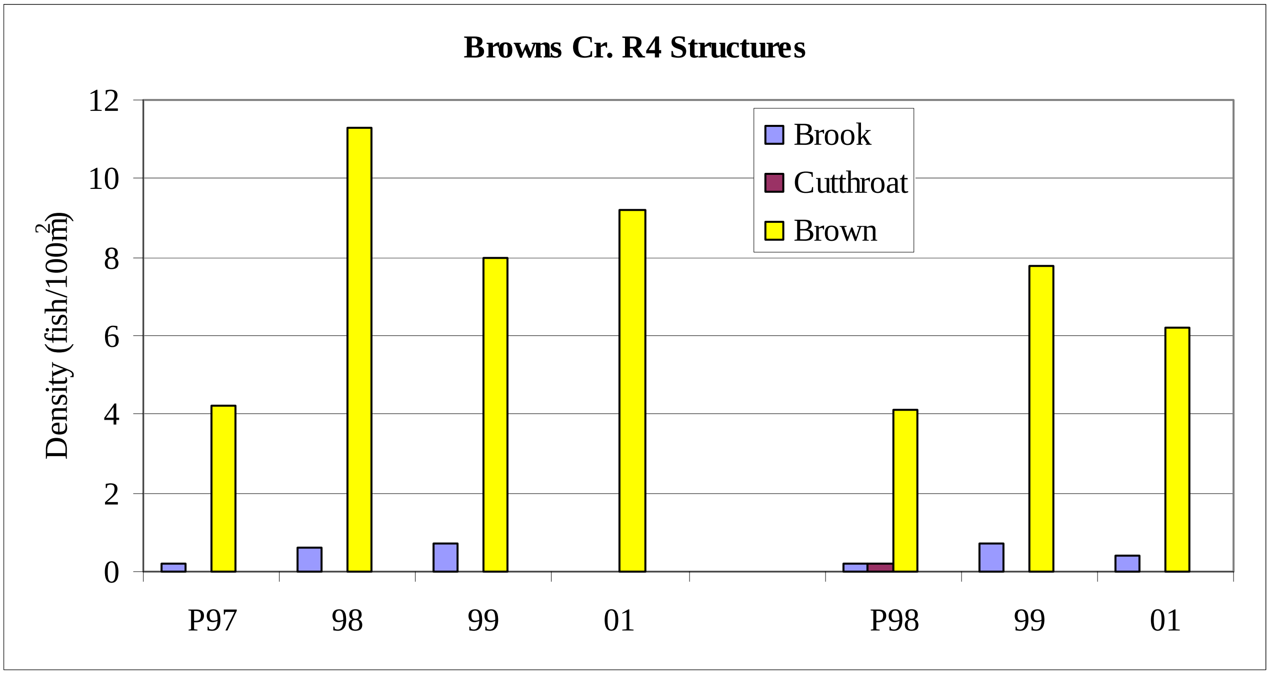

Figure 11. Annual Browns Creek reach 4 fish densities from the 1997 and 1998 implementation site.

Reach 9

In reach 9, three single wing deflectors were implemented in 1997. Substrate embeddedness was 42% in 1997, decreased to 23% in 2000, and then increased to 47% in 2001 (Table 19). Spawning substrate and pool type habitat were not present in pre or post assessments until 2001. In 2001, 33% of the habitat was classified as pool and 0.5 m^2 of spawning gravel was observed. Average depths were relatively unchanged from 1997 to 1999; but, depth decreased to 23.3 cm in 2001. Average width also decreased. The pre-assessed average width was 4.1 m and decreased to 2.7 m in 2001. Observers classified two primary pools during the pre-assessment and again in 2001. In 1998, 1999, and 2000 post assessments, no pools were given the primary classification.

Three additional structures were implemented in reach 9 in 1998. Embeddedness in this site increased from 21% in 1998 to 46% in 2001 (Table 20). No spawning gravels have been detected in any of the assessments. No pool type habitat was observed in 1998 and 1999; but 22% and 51% of the habitat was classified as pool in 2000 and 2001 respectively. Average depth decreased from 38.6 cm in 1998 to 24.3 cm in 2001. The pre-assessed average width was 3.5 and ranged from 3.5 to 4.1 from 1999 to 2001. No primary pools were observed in the pre-assessment; however 2 primary pools were observed in 2000 and 1 in 2001.

Fish densities in reach 9 have been variable. In the 1997 implementation site, brown trout decreased dramatically from a pre-assessed density of 20.6 fish/100 m^2 to 2.0 fish/100 m^2 in 1998 (Figure 12). However, increases were observed in subsequent years to 9.9 fish/100 m^2 in 2001. Cutthroat trout were only present during the 1997 pre-assessment. Brook trout were not observed in the 1997 pre-assessment but have increased to 3.0 fish per 100 m^2 in 2001. Densities in the 1998 implementation site have increased. Brown trout was the only species observed during the pre-assessment and had a density of 2.2 fish/100 m^2. Brook and cutthroat trout were observed in the 2000 post assessment and brown trout density increased to 6.6 fish/100 m^2. Densities for all fish species increased in 2001. In 1999, lower Browns Creek was under a U.S. Forest Service area closure that prevented access to the reach 9 implementation site.

Table 19. Browns Creek reach 9 habitat attribute values from the 1997 implementation site.

	97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	42	32	35	23	47
Pool/Riffle	0.1	0.2	0	0	0.4
Spawning Gravel (m^2)	0.0	0.0	0.0	0.0	0.5
% Pool	0	0	0	0	33
% Riffle	79	84	100	100	58
% Run	6	0	0	0	9
% Pocketwater	15	16	0	0	0
% Glide	0	0	0	0	0
Avg Depth (cm)	34.8	36.0	32.8	22.9	23.3
Avg Width (m)	4.1	3.6	3.6	3.2	2.7
# Primary Pools	2	0	0	0	2

Table 20. Browns Creek reach 9 habitat attribute values from the 1998 implementation site.

	98 Structures			
Attribute	Pre '98	Post '99	Post '00	Post '01
Embeddedness (%)	21	45	31	46
Pool/Riffle	0.2	0.0	0.4	1.3
Spawning Gravel (m^2)	0.0	0.0	0.0	0.0
% Pool	0	0	22	51
% Riffle	84	95	73	41
% Run	0	0	0	8
% Pocketwater	16	5	5	0
% Glide	0	0	0	0
Avg Depth (cm)	38.6	33.8	23.2	24.3
Avg Width (m)	3.5	4.1	3.5	3.8
# Primary Pools	0	0	2	1

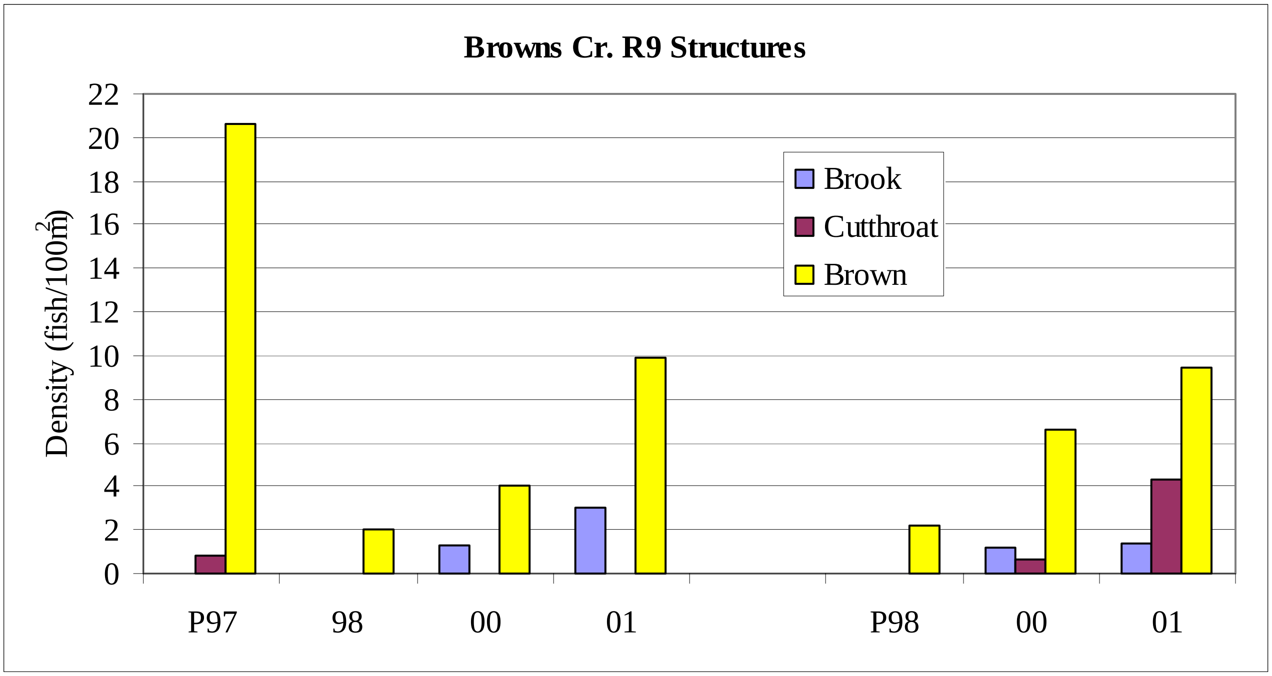

Figure 12. Annual Browns Creek reach 9 fish densities from the 1997 and 1998 implementation site.

Fourth of July Creek

Reach 4

In 1996, approximately 800 m in reach 4 of Fourth of July Creek was fenced to exclude cattle from the riparian area. Streambank stability increased from 70% in the 1996 pre-assessment to 98% in 2001 (Table 21). Spawning habitat appeared to decrease; in 1996, 39.0 m^2 of gravel was classified as spawning habitat while 6.5 m^2 of spawning gravel was identified in 2001. Pool habitat increased from 3% in 1996 to 50% in 2001. Average depth and width have increased from the pre-assessment. Average depth was 17.0 cm, increased to 30.7 in 1998, and was 18.4 cm in 2001. The pre-assessed average width was 1.8 m; post assessed average widths were greater measuring 2.3 m in 1998 and 2.0 m in 2001. The number of pools classified as primary increased over 500% from 1996 (n=3) to 1998 (n=17). However, the number of primary pools observed in 2001 was 4.

Cutthroat trout were the only fish species observed in reach 4 of Fourth of July Creek. In the 1996 pre-assessment, cutthroat density was 25.9 fish/100 m^2 (Figure 13) Density decreased to 18.7 fish/100 m^2 in 1998 but the highest density was observed in 2001 at 29.7 fish/100 m^2.

Table 21. Fourth of July Creek reach 4 habitat attribute values from the 1996 pre-assessment and the 1998 and 2001 post assessments.

	1996 Riparian Exclosure		
Attribute	Pre '96	Post '98	Post '01
Embeddedness (%)	89	92	99
Bank Stability (%)	70	88	98
Pool/Riffle	0.1	0.1	3.3
Spawning Gravel (m^2)	39.0	20.0	6.5
% Pool	3	3	50
% Riffle	53	62	17
% Run	39	29	28
% Pocketwater	5	6	2
% Glide	0	0	2
Avg Depth (cm)	17.0	30.7	18.4
Avg Width (m)	1.8	2.3	2.0
# Primary Pools	3	17	4

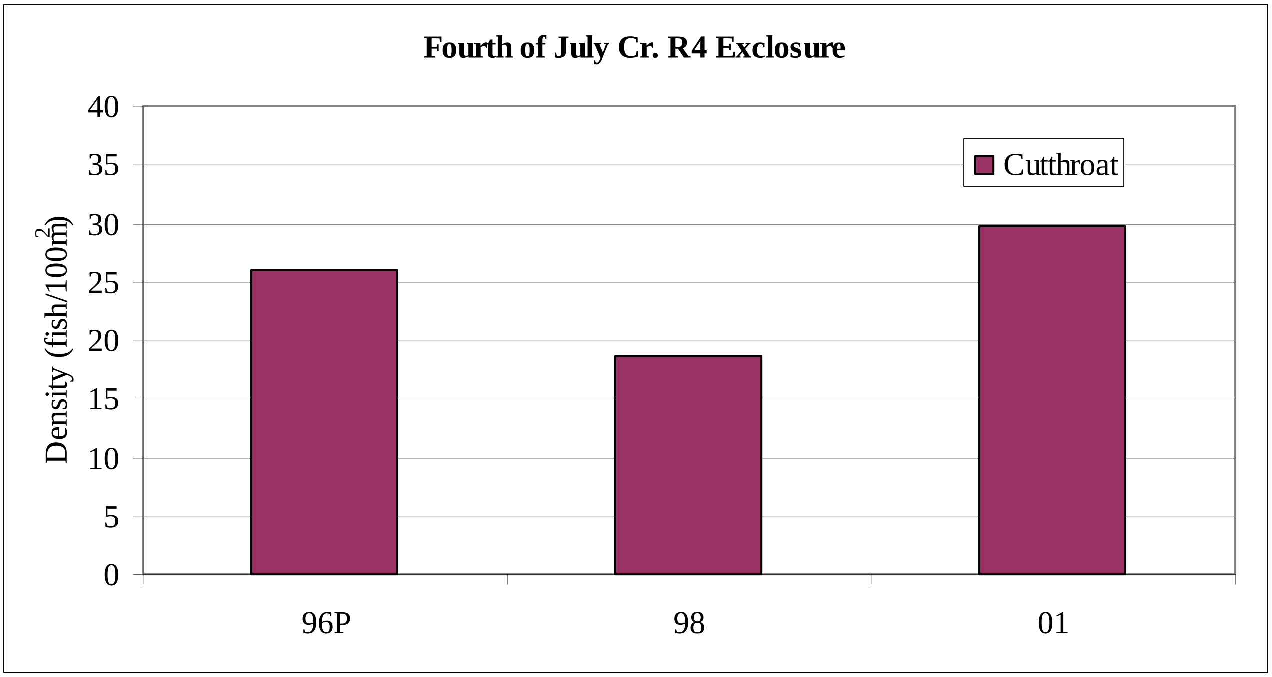

Figure 13. Annual Fourth of July Creek reach 4 fish densities from the 1996 riparian exclosure.

Reach 8

In 1997, three wedge dams and three log weirs were constructed in reach 8 of Fourth of July Creek. 1997 pre-assessment substrate embeddedness in reach 8 was 82% (Table 22). Decreased embeddedness was observed in subsequent years of monitoring (60% in 1998, 71% in 1999, 20% in 2000, and 53% in 2001). Spawning gravels increased from 9.0 m^2 in 1997 to 10.0 m^2 in 1998. However, no spawning gravel was identified during the 1999 monitoring survey and only 0.5 m^2 was observed in 2000 and 2001. No habitat was classified as pool in 1997 and 1998. However, pool composition has increased to a high of 36 % in 2001. Average depth increased from 12.5 cm in 1997 to 16.0 cm in 1998, but has decreased in succeeding years to 11.3 cm in 2001. Average width also decreased; the 1997 pre-assessed width was 2.4 m and the 2001 average width was 1.8 m. No primary pools were identified in the 1997 pre-assessment or the 1998 post assessment. Surveyors counted one primary pool in 1999 and 6 in the 2000 and 2001 post assessments.

Cutthroat trout (density of 8.0 fish/100 m^2) and brook trout (density of 3.0 fish/100 m^2) were observed in the 1997 pre-implementation snorkel survey (Figure 14). In 1998, cutthroat trout density declined to 5.0 fish/100 m^2, brook trout density increased to 5.0 fish/100 m^2, and bull trout and brown trout were also observed (densities of 1 fish/100 m^2). Cutthroat trout densities increased 700% in 1999 to 35.0 fish/100 m^2. Bull trout and brown trout were also observed in 1999 (densities of 1 fish/100 m^2); however, no brook trout were present. In 2000, the cutthroat density declined to 9.3 fish/100 m^2 while the brook trout density increased to 22.2 fish /100 m^2. Cutthroat and brook trout densities both declined from 2000 to 2001. Cutthroat density was near the 1997 pre-implementation density (7.9 fish /100 m^2) while brook trout density was less than half the 1997 density at 1.4 fish /100 m^2.

Table 22. Fourth of July Creek reach 8 habitat attribute values from the 1997 implementation site.

	97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	82	60	71	20	53
Pool/Riffle	0.1	0.4	0.3	0.5	0.6
Spawning Gravel (m^2)	9.0	10.0	0.0	0.5	0.5
% Pool	0	0	12	32	36
% Riffle	85	59	51	61	61
% Run	8	19	37	3	0
% Pocketwater	6	21	0	1	3
% Glide	0	0	0	0	0
Avg Depth (cm)	12.5	16.0	14.2	11.8	11.3
Avg Width (m)	2.4	3.0	2.3	1.9	1.8
# Primary Pools	0	0	1	6	6

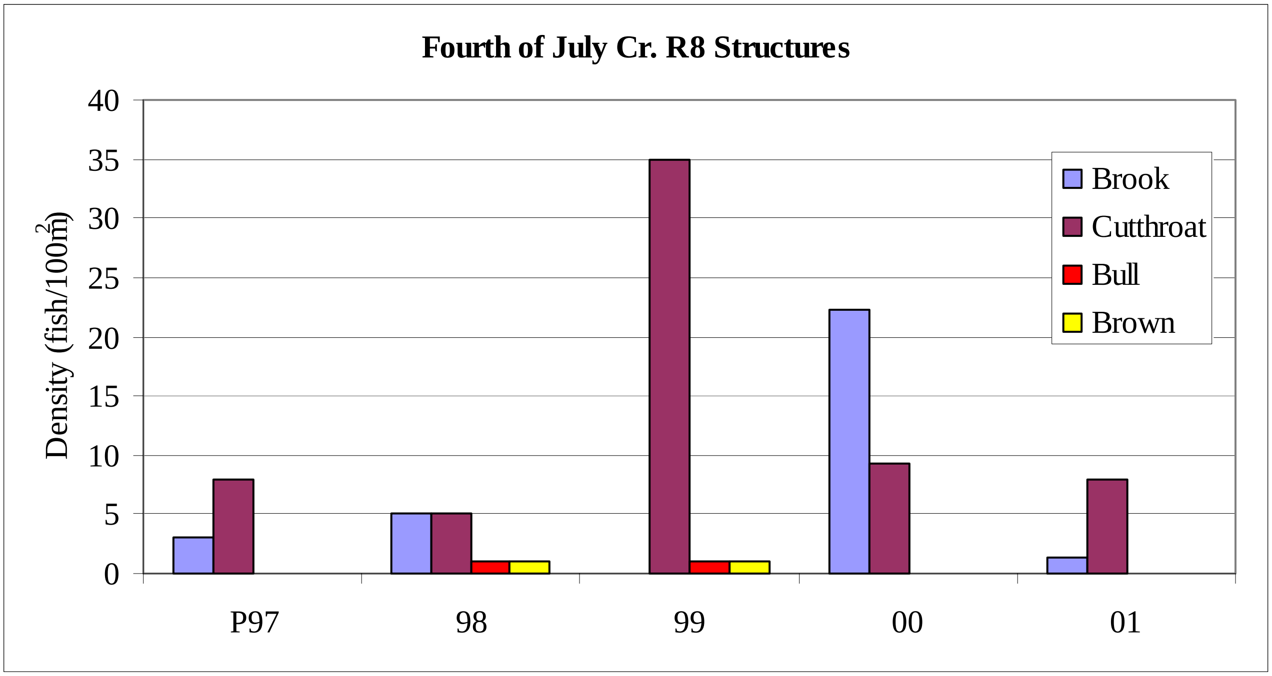

Figure 14. Annual Fourth of July Creek reach 8 fish densities from the 1997 implementation site.

Mineral Creek

A total of ten double wing deflectors were implemented in reach 1 of Mineral Creek from 1996 to 1998. Pre-assessment substrate embeddedness was 53% in the 1996 site, and has been annually variable with a high of 61% in 2000 and a low of 32% in 2001 (Table 23). 1996 pre-assessed spawning gravel was 15.3 m^2. Gravel was classified as spawning habitat in only one post assessment survey (2000 with 0.5 m^2). Percent pool type habitat increased from 4% in 1996 to 14% in 2001. Average depths in the 1996 implementation area increased annually through 1999 and then decreased in 2000 and 2001. The 1996 pre-assessed average depth was 16.4 cm, the greatest depth was 25.3 cm in 1999 and the lowest average depth was 13.4 cm in 2001. Average widths also increased annually up to 2000. The average pre-assessment width was 2.6 m and the 2001 width was 2.8 m. Four pools were classified as primary during the 1996 pre-assessment and again in he 2001 post assessment.

In reach 1 where structures were implemented in 1997, pre-assessed substrate embeddedness was 71% and declined to 46% in 2001 (Table 24). Spawning gravel appeared to increase from 1.0 m^2 in the 1997 pre-assessment to 2.5 m^2 in 2001. Percent pool habitat increased from 19% in the 1997 to 26% in 2001. Depths decreased from the pre-assessed average of 43.6 cm in 1997 to 13.2 in 2001. Average width also decreased; the pre-assessed width averaged 3.5 m and width was 2.9 m in the 2001 post assessment. The number of pools classified as primary has been annually variable. Two primary pools were present in the pre-assessment and in the 2001 post assessment.

Embeddedness in the 1998 restoration site decreased from 54% in 1998 to 36% in 2001 (Table 25). Spawning gravel remained fairly constant with 1.0 m^2 identified in the pre-assessment, and in the 2000 and 2001 post assessments. Percent pool type habitat increased from 15% in 1998 to 48% in 2001. Average depth and width decreased in 2000 relative to 1998 pre-assessment values. Average depth decreased from 34.0 cm to 21.4 cm, while average width decreased from 3.6 m to 2.8 m. No primary pools were identified in the pre-assessment and 4 were observed in the 2001 post assessment.

For the 1996 implemented structures, post assessment fish densities have declined from pre-assessment densities (Figure 15). Brook and cutthroat densities initially increased in 1997 but were lower in subsequent years. The 1996 brook trout density was 6.0 fish/100 m^2 and declined to 2.3 fish/100 m^2 in 2001. Pre-assessed cutthroat density was 14.0 fish/100 m^2 and declined to 5.2 H fish/100 m^2 in 2001. Fish densities in the 1997 implementation site showed a declining trend up to 2000. The 1997 pre-assessed cutthroat trout density was 20.0 fish/100 m^2 and declined to 7.7 fish/100 m^2 in 2000. In 2001, however, cutthroat density increased to 11.5 fish/100 m^2. Cutthroat density in the 1998 restoration site has increased. The pre-assessed density was 5.0 fish/100 m^2 and the 2001 density was 10.7 fish/100 m^2. Brook trout density has also been increasing in the 1998 implementation site. No brook trout were observed in the 1998 pre-assessment and density has increased annually to 3.0 fish/100 m^2 in 2001.

Table 23. Mineral Creek reach 1 habitat attribute values from the 1996 implementation site.

	96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	53	35	45	52	61	32
Pool/Riffle	0.5	0.3	0.6	0.1	0.8	0.5
Spawning Gravel (m^2)	15.3	0.0	0.0	0.0	0.5	0.0
% Pool	4	0	21	4	32	14
% Riffle	61	67	57	92	52	65
% Run	16	21	3	3	0	3
% Pocketwater	19	12	19	1	12	15
% Glide	1	0	0	0	4	3
Avg Depth (cm)	16.4	19.0	23.7	24.7	14.4	13.4
Avg Width (m)	2.6	2.9	3.4	3.7	2.5	2.8
# Primary Pools	4	0	2	0	3	4

Table 24. Mineral Creek reach 1 habitat attribute values from the 1997 implementation site.

	97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	71	62	57	69	46
Pool/Riffle	0.3	0.8	0.1	0.6	0.2
Spawning Gravel (m^2)	1.0	0.0	0.0	4.5	2.5
% Pool	19	24	10	43	26
% Riffle	62	50	48	40	71
% Run	13	16	42	0	0
% Pocketwater	5	9	0	0	0
% Glide	0	0	0	17	3
Avg Depth (cm)	43.6	25.6	31.1	15.0	13.2
Avg Width (m)	3.5	2.9	3.4	2.6	2.9
# Primary Pools	2	1	2	3	2

Table 25. Mineral Creek reach 1 habitat attribute values from the 1998 implementation site.

	98 Structures			
Attribute	Pre '98	Post '99	Post '00	Post '01
Embeddedness (%)	54	63	64	36
Pool/Riffle	0.3	0.6	0.8	1.1
Spawning Gravel (m^2)	1.0	0.0	1.0	1.0
% Pool	15	17	33	48
% Riffle	71	57	52	46
% Run	5	23	0	6
% Pocketwater	6	3	14	0
% Glide	0	0	0	0
Avg Depth (cm)	34.0	34.4	15.2	21.4
Avg Width (m)	3.6	3.6	2.1	2.8
# Primary Pools	0	0	1	4

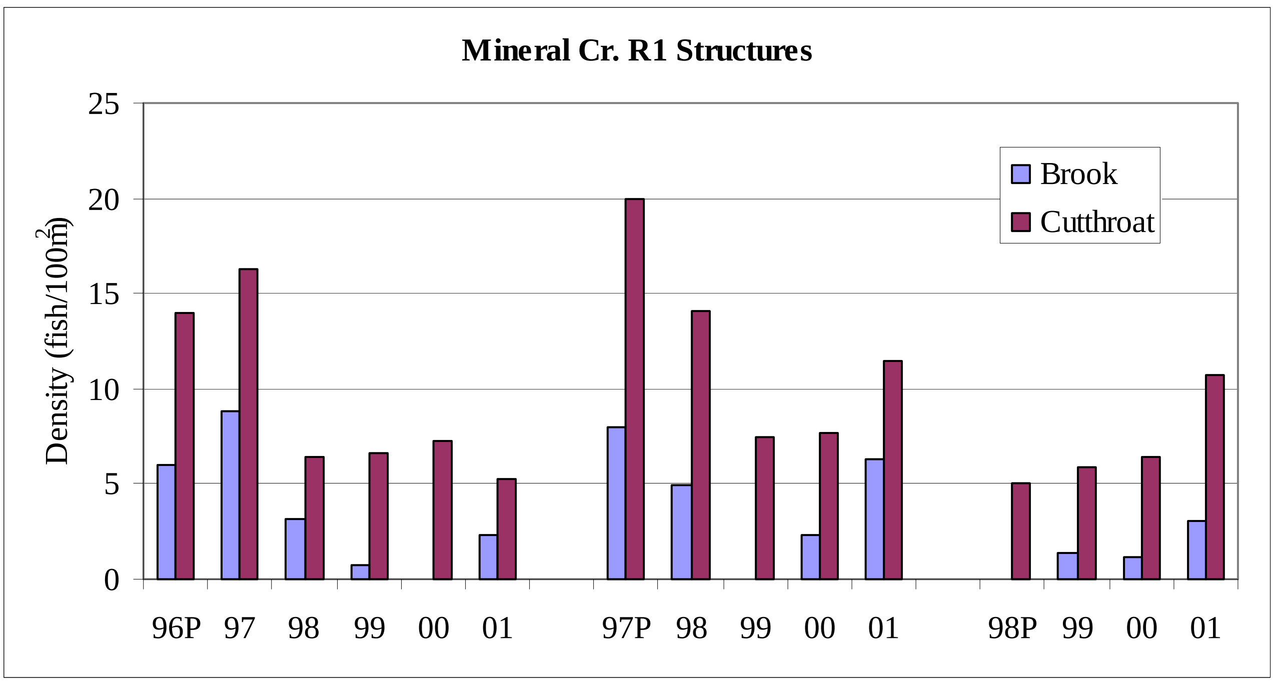

Figure 15. Annual Mineral Creek reach 1 fish densities from the 1996, 1997 and 1998 implementation sites.

Whiteman Creek

Reach 4

In 1997, channel blocks were constructed in three sections where the channel was braided. Also, six log structures were created to provide cover and direct flow from unstable banks. This entire restoration site is enclosed by a fencing project completed in 1996. Following implementation, substrate embeddedness was relatively high and unchanged in reach 4. 1997 pre-assessed substrate embeddedness was 95% and in 2001 embeddedness was 94% (Table 26). Bank stability appeared to increase dramatically; the pre-assessed bank stability was 51% and increased to 93% in 2001. 4.0 m^2 of spawning gravel were observed in 1997 and increased to 17.5 m^2 in 2000. However, in 2001 spawning gravel declined to 5.0 m^2. Pool composition increased from 7.5% in the 1997 pre-assessment to 62% in 2001. Average depth has been higher in every post assessment year except in 2000. The pre-assessed average depth was 34.0 cm and was 43.7 cm in 2001. Average depth ranged from 25.5 cm in 2000 to 48.2 cm in 1999. Average width increased from 3.1 m in 1997 to a high of 4 m in 1998. The average width in 2001 was 3.2 m. One pool was classified as primary in 1997 and again in 1998. 10 primary pools were observed in 2001; a high of 21 primary pools were identified in 2000.

Brook trout was the only species observed in reach 4 up to 2001. Post implementation brook trout densities were higher than the pre-implementation density (Figure 16). Brook trout densities in 1998 (45.0 fish/100 m^2) and 2000 (44.5 fish/100 m^2) were over double the 1997 pre-assessed density (20.0 fish/ 100 m^2). 2001 fish densities were 26.7 fish/ 100 m^2 for brook trout and 0.1 fish/ 100 m^2 for cutthroat trout.

Table 26. Whiteman Creek reach 4 habitat attribute values from the 1997 implementation site.

	97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	95	84	93	88	94
Bank Stability (%)	51	89	99	99	93
Pool/Riffle	0.0	0.0	1.2	2.8	4.3
Spawning Gravel (m^2)	4.0	10.5	0.0	17.5	5.0
% Pool	7	0	12	66	62
% Riffle	0	13	8	20	11
% Run	92	84	80	9	24
% Pocketwater	0	0	0	1	1
% Glide	0	0	0	4	1
Avg Depth (cm)	34.0	41.9	48.2	25.5	43.7
Avg Width (m)	3.1	4.0	3.4	2.4	3.2
# Primary Pools	1	1	5	21	10

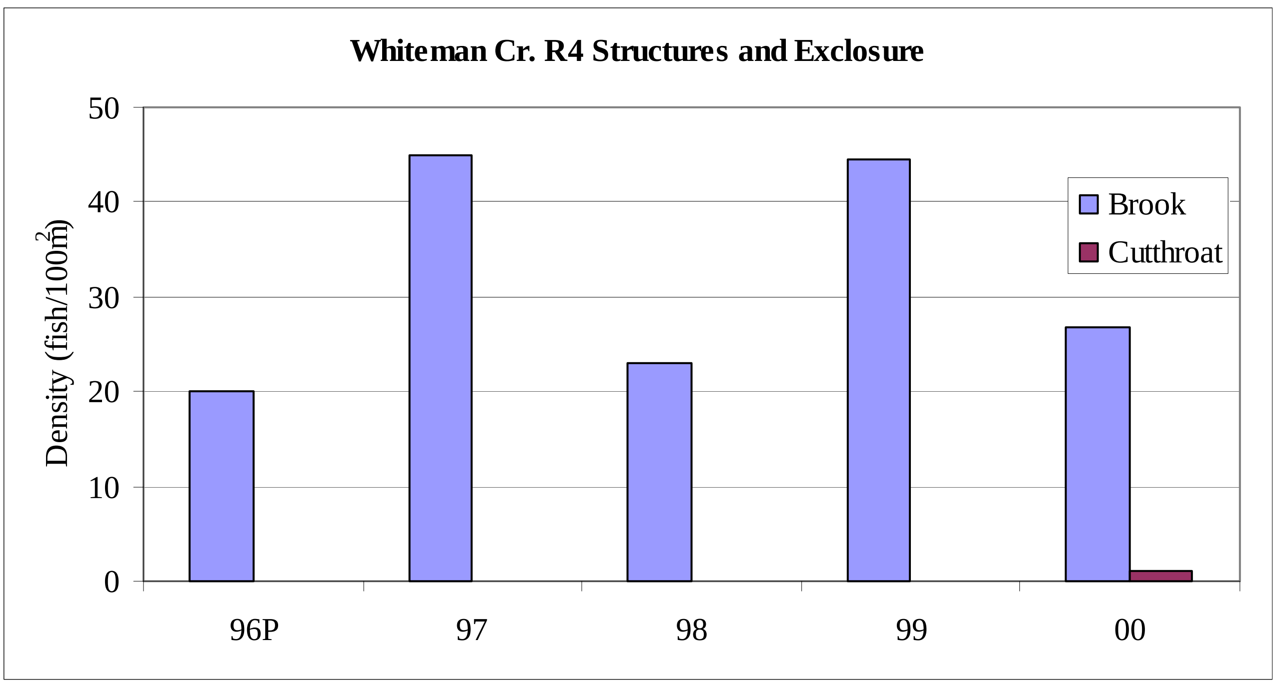

Figure 16. Brook and cutthroat trout densities in reach 4 of Whiteman Creek where instream structures and a riparian exclosure were constructed in 1996.

Reach 5

In 1996, boulder structures were placed in reach 5 to create pool habitat. Percent embeddedness has decreased from 54% in 1996 to 34% in the 2001 post assessment (Table 27). Spawning gravel was absent from the assessment area for all years except in 2001 where 0.5 m^2 of gravel was classified as spawning habitat. Pool habitat increased from 7% in 1996 to 50% in 2001. Post assessed average depths increased from the pre-assessed average depth of 13.3 cm. Post assessed average depths ranged from 15.5 cm in 2000 to 21.5 cm in 1997. Average widths also increased from the pre-assessed width of 2.6 m. Average width ranged from 4.7 m in 1998 to 3.3 m in 2000. Average depth and width in 2001 were 15.6 cm and 3.6 m, respectively. The number of primary pools increased from 0 in 1996 to a high of 8 in 1999. However, primary pool number was 4 in 2001.

In reach 5, cutthroat densities were relatively low and unchanged through 1999 (Figure 17). Cutthroat density in the pre-assessment was 0.5 fish/100 m^2. However, the cutthroat density increased to 1.2 fish/100 m^2 in 2000 and 2.0 fish/100 m^2 in 2001. Brook trout densities in reach 5 increased annually from a pre-implementation density of 6 fish/100 m^2 in 1996 to 15 fish/100 m^2 in 1999. Brook trout density then declined to 7.6 and 6.7 fish/100 m^2 in 2000 and 2001, respectively.

Table 27. Whiteman Creek reach 5 habitat attribute values from the 1996 implementation site.

		96 Structures				
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	54	67	47	49	48	34
Pool/Riffle	0.2	0.4	0.5	0.6	1.1	1.8
Spawning Gravel (m^2)	0.0	0.0	0.0	0.0	0.0	0.5
% Pool	7	0	24	21	39	50
% Riffle	82	61	57	57	43	33
% Run	6	10	15	11	2	0
% Pocketwater	6	29	4	11	15	14
% Glide	0	0	0	0	0	3
Avg Depth (cm)	13.3	21.5	19.9	17.5	15.5	15.6
Avg Width (m)	2.6	4.1	4.7	3.5	3.3	3.6
# Primary Pools	0	1	1	8	2	4

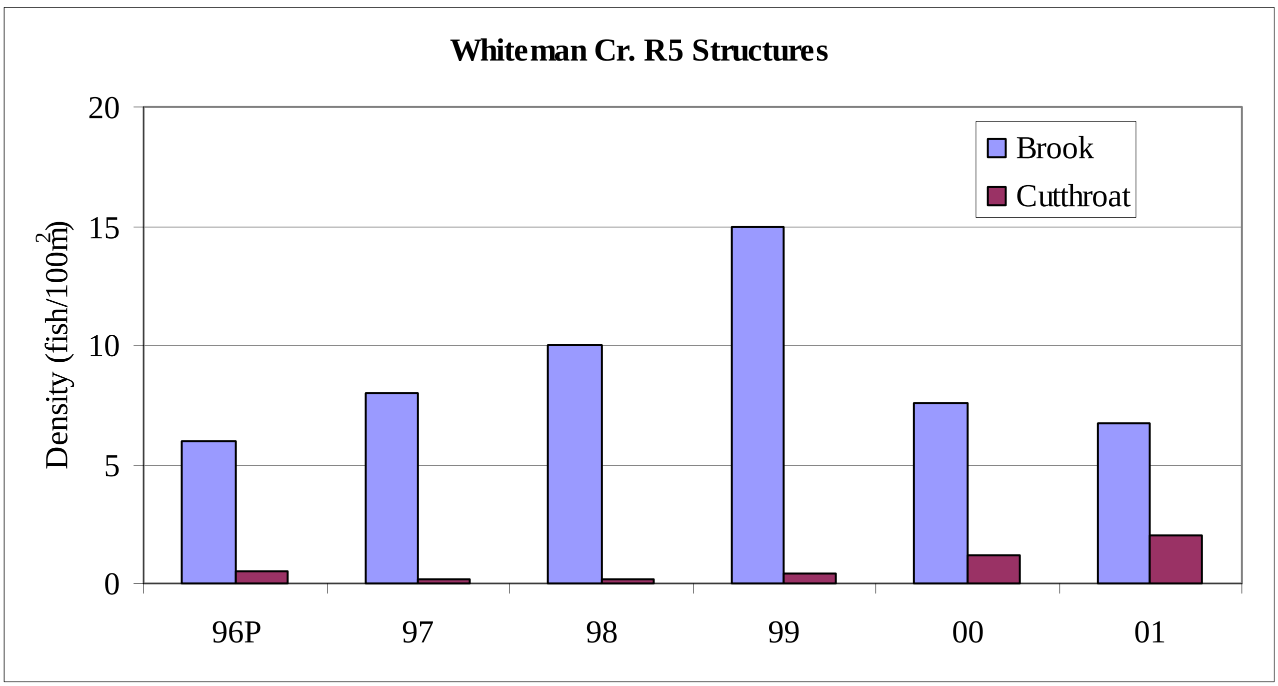

Figure 17. Annual Whiteman Creek reach 5 fish densities from the 1996 implementation site

.

Reach 6

Boulder structures were also placed in reach 6 to create pool habitat. Post assessment substrate embeddedness decreased from the pre-assessed embeddedness of 73% (Table 28). Post assessed embeddedness ranged from a low of 29% in 2001 to a high of 60% in 1999. An increase in spawning substrate was observed until 1999. 2.0 m^2 of spawning habitat was observed in the pre-assessment. Spawning substrate increased to 4.5 m^2 in 1997 and 2.5 m^2 in 1998. However, no spawning gravel was identified in 1999 or 2000 and 1.5 m^2 was observed in 2001. Pool habitat increased annually from 0% in the 1996 pre-assessment to 46% in the 2001 post assessment. Pre-assessed (1996) average depth was 23.4 cm and increased to 27.5 cm in 1997. Average depths decreased in subsequent years and ranged from 14.3 cm in 1999 to 18.8 cm in 2001. Average widths increased in the first two years of post assessment. The pre-assessed width was 3.8 m; width increased to 4.6 m in 1997 and 6.4 m in 1998. In 1999, 2000, and 2001, average widths decreased to 3.2 m, 2.7 m, and 3.3 m, respectively. No primary pools were observed in the 1996 pre-assessment and the 1997 and 1998 post assessments. Primary pool number increased to 2 in 1999 and 3 in 2000 and 2001.

Cutthroat densities in reach 6 have increased from the 1996 pre-assessed density of 0.5 fish/100 m^2 to 2.1 fish/100 m^2 in 2001(Figure 18). Post assessed brook trout densities were variable. The 1996 pre-assessed brook trout density was 14.0 fish/100 m^2; density decreased to 10.0 fish/100 m^2 in 1997 and then increased to 16 fish/100 m^2 and 17 fish/100 m^2 in 1998 and 1999, respectively. Brook trout density was 7.7 fish/100 m^2 in 2000 and 9.5 fish/100 m^2 in 2001.

Table 28. Whiteman Creek reach 6 habitat attribute values from the 1996 implementation site.

	96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01
Embeddedness (%)	73	55	38	60	55	29
Pool/Riffle	0.3	0.4	0.1	0.8	0.9	1.1
Spawning Gravel (m^2)	2.0	4.5	2.5	0.0	0.0	1.5
% Pool	0	4	4	32	38	46
% Riffle	73	51	83	51	54	46
% Run	12	30	10	3	0	0
% Pocketwater	14	15	3	14	7	6
% Glide	0	0	0	0	0	2
Avg Depth (cm)	23.4	27.5	18.5	14.3	15.6	18.8
Avg Width (m)	3.8	4.6	6.4	3.2	2.7	3.3
# Primary Pools	0	0	0	2	3	3

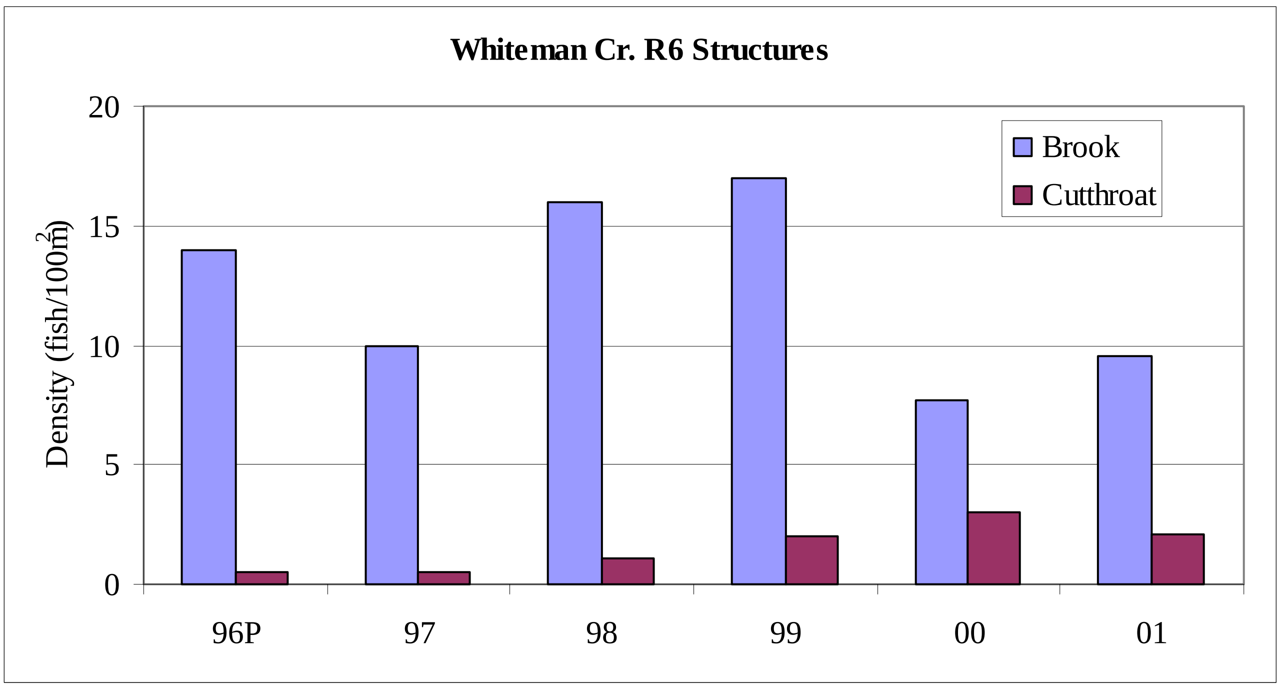

Figure 18. Annual Whiteman Creek reach 6 fish densities from the 1996 implementation site.

Largemouth bass habitat enhancement

From 1997 (pre-assessment) to fall 2001, largemouth bass relative abundance varied at each sampling site. Sampling of the largemouth bass enhancement sites did not occur in the fall of 1998 or 2000. Early sub-freezing temperatures iced the sloughs over in early November and the ice remained throughout the month. However, 2001 fall largemouth bass abundance had increased over 1997 fall abundance (pre-treatment) in seven of the eight sites and abundance was unchanged in the remaining site. In Cee Cee Ah Slough #1, largemouth bass relative abundance was 2 in the fall of 1997 and 7 in the fall of 2001 (Figure 19). In Cee Cee Ah Slough #2, largemouth bass were only present in the catch in the fall of 1999 (n=2, Figure 20).

In No Name Slough #1, largemouth bass relative abundance appeared to increase significantly in the fall of 1999 when 14 were collected (Figure 21). No largemouth bass were collected in the 1997 pre-assessment or the 1999, 2000, or 2001 spring post assessments. Five largemouth bass were collected at this site in the fall of 2001. No bass were present in the 1997 pre-assessment sample in No Name Slough #2 (Figure 22). Two bass were collected in the spring of 1998 and four bass were collected in the fall 1999 sample. No fish were collected in the 1999, 2000, or 2001 spring sampling periods and 6 largemouth bass were present in the 2001 fall sample.

In Old Dyke #1, two bass were captured in the 1997 pre-assessment. Largemouth bass were collected in only two other sampling periods: one in the fall of 1999 and 3 in the fall of 2001 (Figure 23). No largemouth bass were present in the catch in any of the spring sampling periods. In Old Dyke #2, largemouth bass were present in the catch in all sample periods except in the spring of 2001 (Figure 24). One bass was captured in the 1997 pre-assessment and three were captured in the fall of 2001. The most bass captured at this site was 6 in the 1999 fall sampling period. Relative abundance of all other species declined in Old Dyke #2. 1997 pre-assessment and spring 1998 abundance were at or near 40; abundance declined to 9 in fall 2001.

In Campbell Slough #1, largemouth bass have been present in the catches of all sampling periods. Relative abundance increased dramatically from pre-assessment (n=1) to fall 2001 (n=24)(Figure 25). Largemouth bass abundance in the spring of 1998 and 2001 was also relatively high with 19 and 17 bass captured, respectively. Largemouth bass relative abundance initially increased in Campbell Slough #2 (Figure 26). The 1997 pre-assessed abundance was 1. Large increases were observed in spring 1998 (n=19) and spring 1999 (n=18). Five largemouth bass were captured in fall 1999. Bass numbers declined in the fall of 1999 (n=5) and spring of 2000 (n=1). However in 2001, largemouth bass relative abundance increased in the spring to 8 and in the fall to 30.

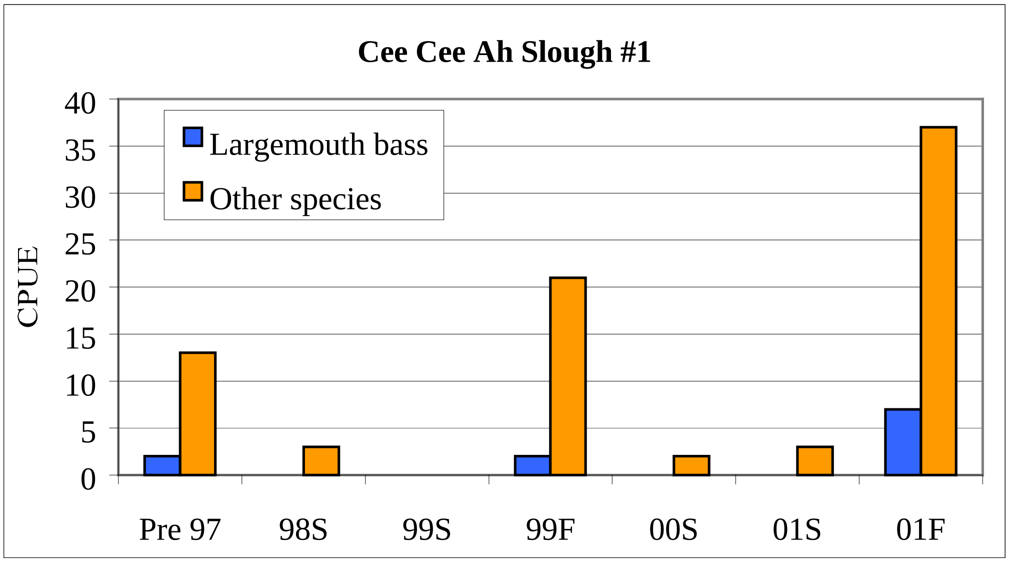

Figure 19. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #1.

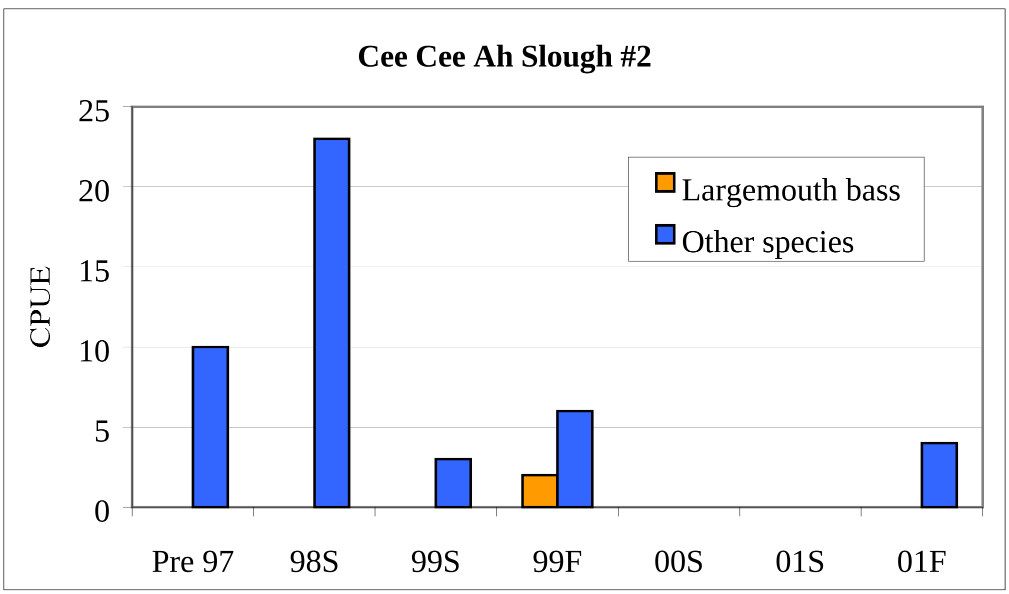

Figure 20. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #2.

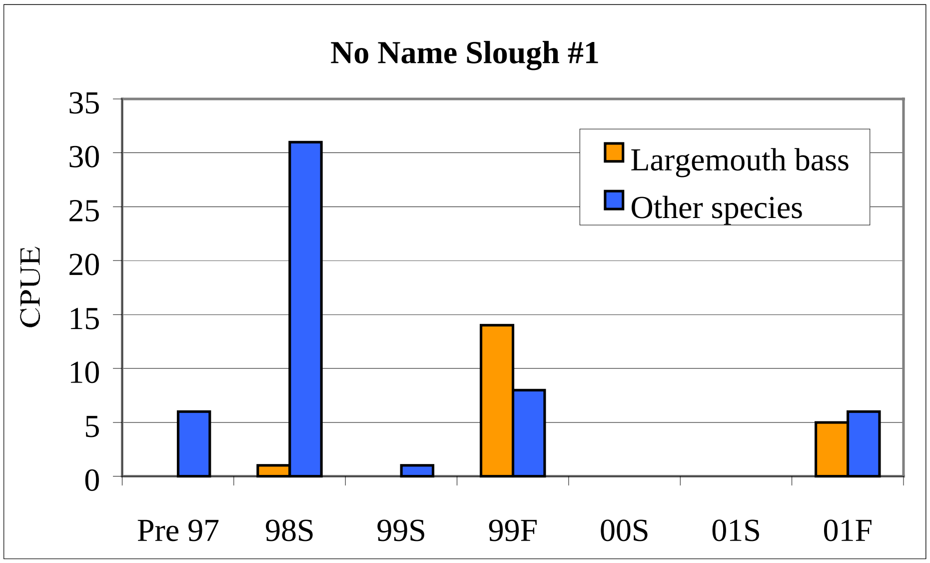

Figure 21. Largemouth bass and combined fish relative abundance for transects in No Name Slough #1.

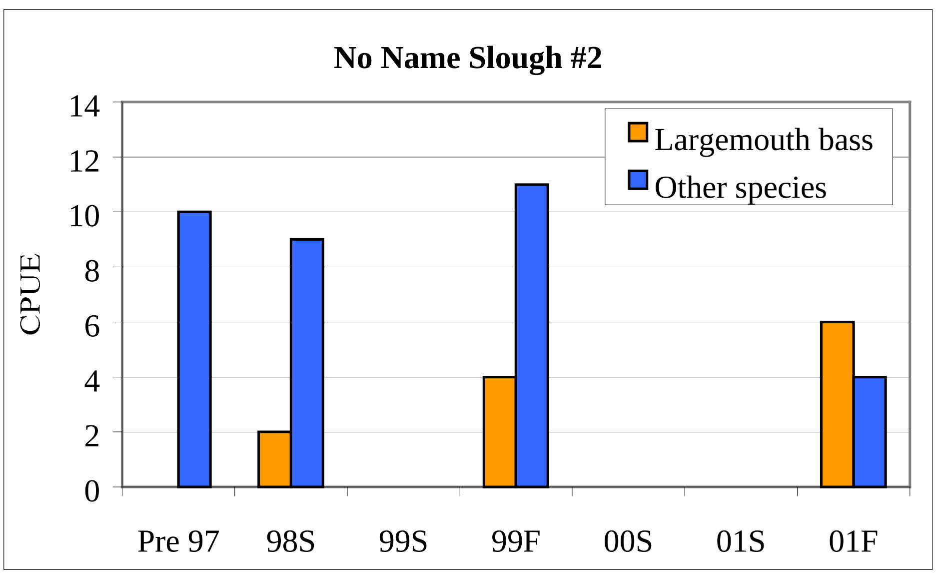

Figure 22. Largemouth bass and combined fish relative abundance for transects in No Name Slough #2.

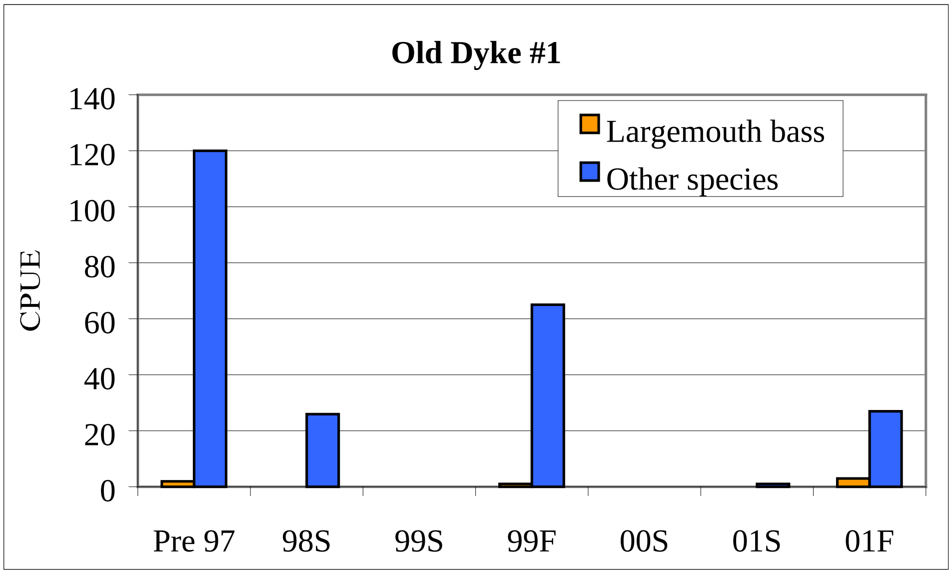

Figure 23. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #1.

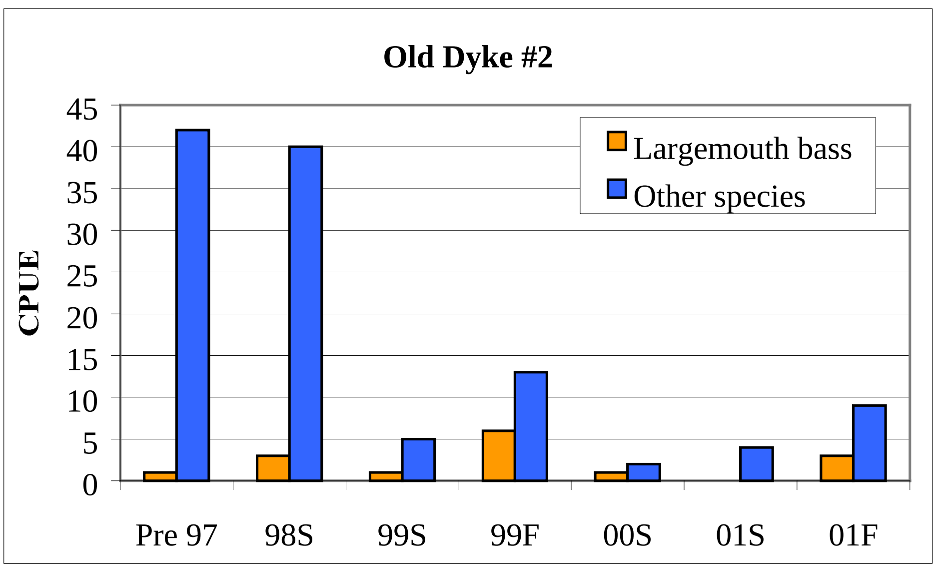

Figure 24. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #2.

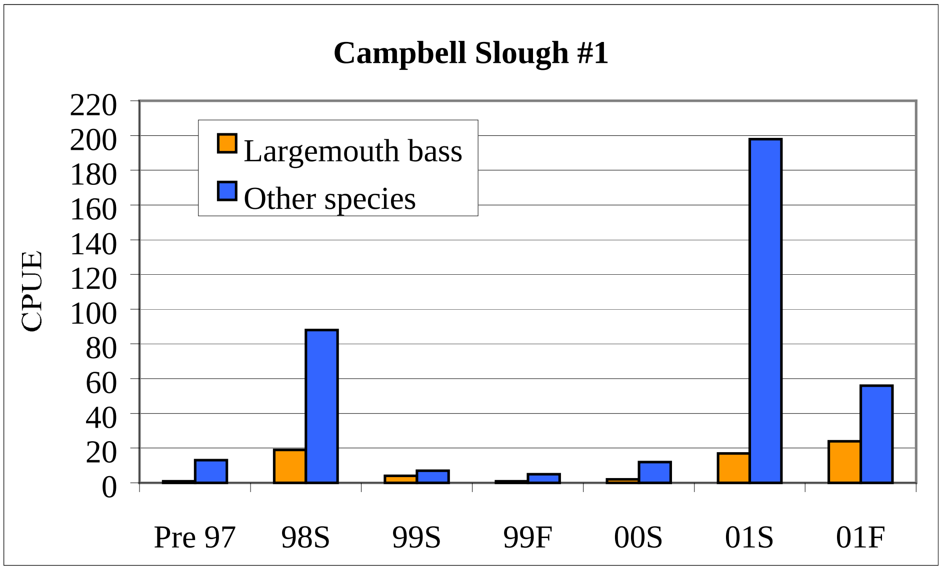

Figure 25. Largemouth bass and combined fish relative abundance for transects in Campbell slough #1.

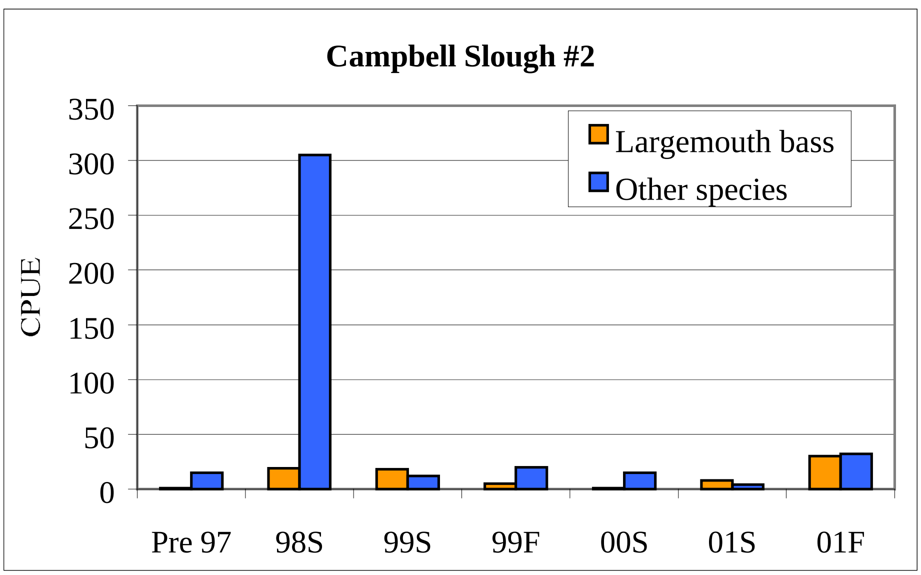

Figure 26. Largemouth bass and combined fish relative abundance for transects in Campbell Slough #2.

The mean size of largemouth bass was significantly different for fish captured in the fall and spring (P<0.0001). Juvenile largemouth bass are more likely to be present in the catch in the fall while larger adults are captured more frequently in the spring (Figure 27). In the fall of 1997, before any bass structures had been placed (pre-assessment), no adult largemouth bass were captured in any of the sample sloughs. The greatest combined number of adults caught was in the spring of 1998. Since 1998, spring adult numbers have declined.

The length frequency graph appears to have distinct modes for age 0+ and age 1+ largemouth bass (Figure 28). The means were 66 mm and 146 mm for age 0+ and age 1+ fish, respectively. Dampening of the length frequency modes occurred for fish older than 1+.

The percent of the catch has increased for all bass combined (Figure 29). Largemouth bass comprised 3.5% of the catch in the 1997 pre-assessment. Percent of catch was higher in all post assessment samples and ranged from 7.7% in the spring of 1998 to 44% in the spring of 1999. However, in the spring sampling periods juvenile largemouth bass catch has been higher than the pre-assessment (3.5%) in only one year – 2000 (5.9% of the catch, Figure 30). The proportion of juvenile largemouth bass catch in the fall has been considerably higher; percent of catch was 16.8% in 1999 and 36.3% in 2001.

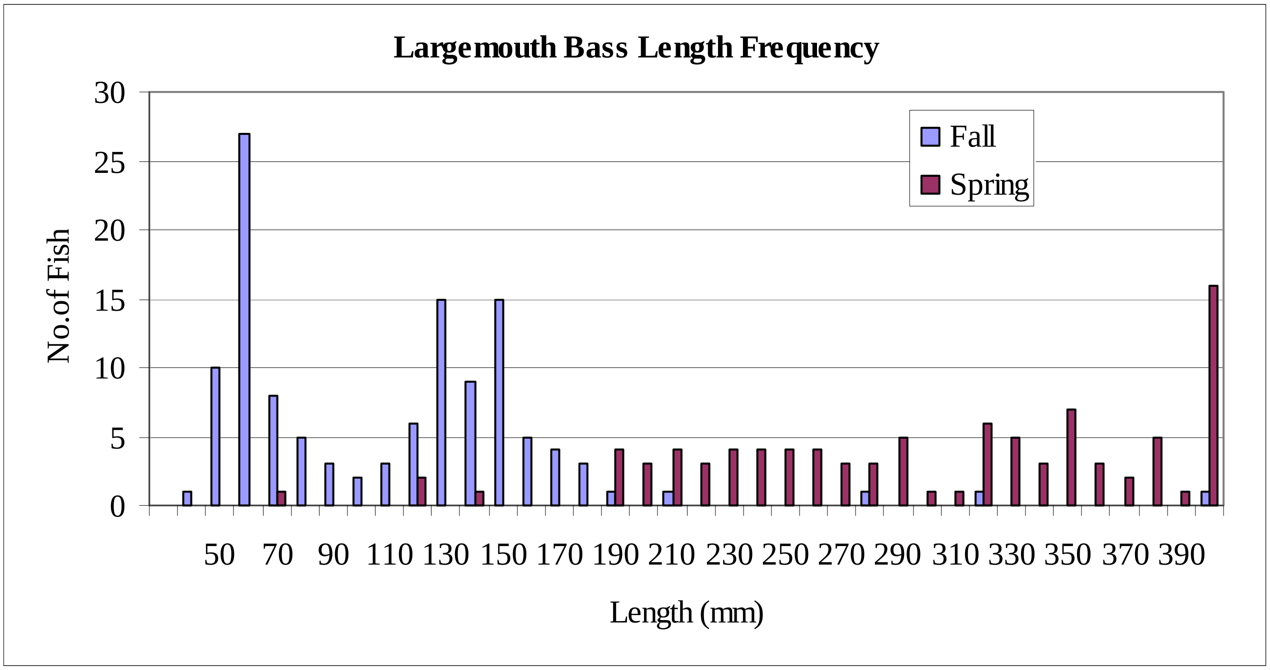

Figure 27. Largemouth bass length frequency for all stations sampled from 1997 to 2001.

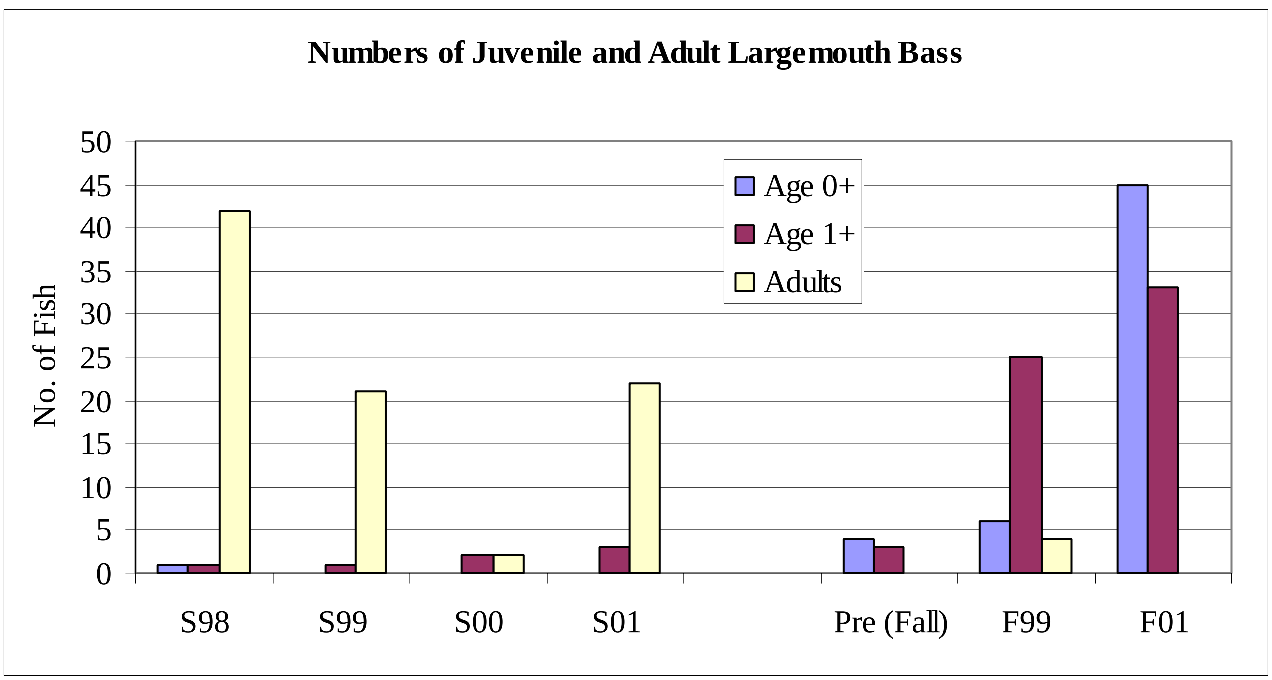

Figure 28. Numbers of juvenile and adult largemouth bass captured during spring and fall sampling periods from 1997 to 2001.

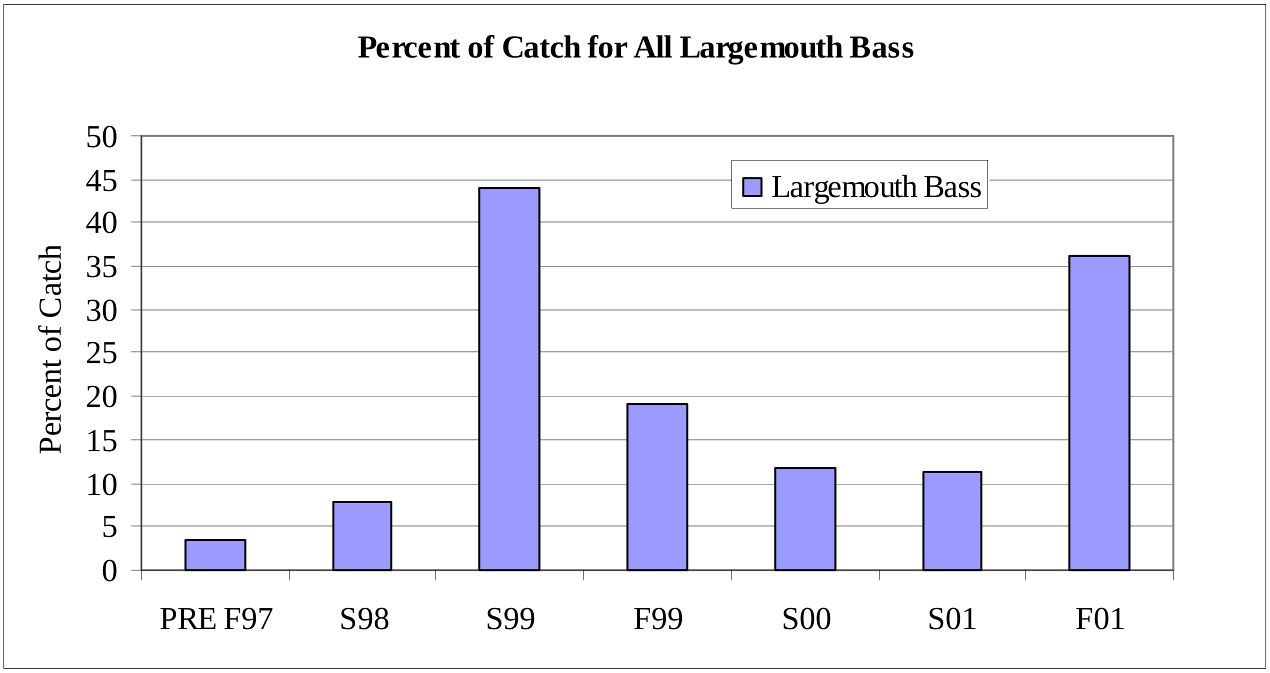

Figure 29. Annual percent of the catch of largemouth bass for all sampling transects.

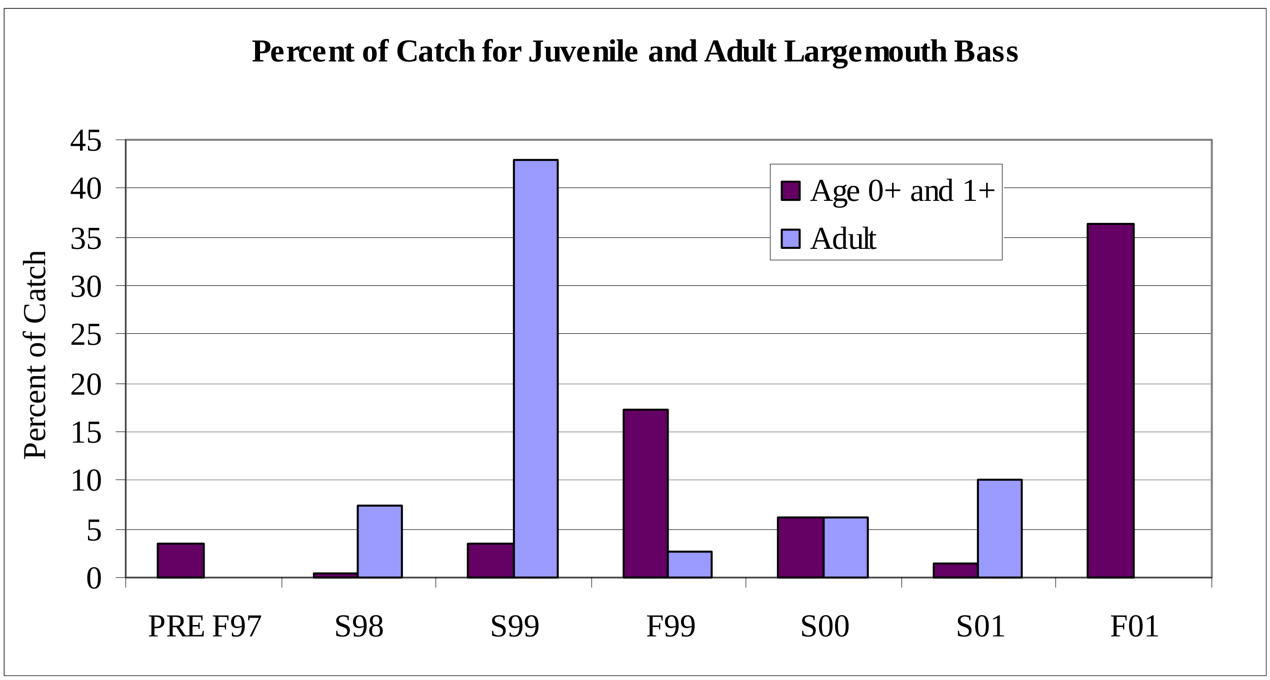

Figure 30. Annual percent of catch for juvenile and adult largemouth bass combining all sampling transects.

Discussion

Bull trout and cutthroat trout habitat assessment

Results from baseline surveys of area streams conducted in 1995 and 1996 showed a general trend: large woody debris densities were relatively low and substrate embeddedness was high. Wood is a primary factor in determining stream channel complexity. Large woody debris provides many important functions to fish populations and stream channels. Wood has a critical role in modifying and maintaining channel morphology, trapping transported sediment, and stabilizing stream banks. Fish use wood for cover and wood provides refugia during extreme flow events. Jakober et al (1998) found bull trout and cutthroat trout preferred habitat with large woody debris. High substrate embeddedness decreases the amount of cover available to overwintering fish (Griffith and Smith 1993). Increased fine sediment in streams can also fill in pools, backwater habitat, and side channels that are important to rearing and overwintering bull trout and cutthroat trout.

It is difficult to distinguish the effects of the restoration among many interacting factors and great natural variability within the physical and biological components of the ecosystem. Aside from catastrophic events, stream processes are generally slow and diminutive. Therefore, much of the restoration implemented may not yield measureable results for several years or decades (Heede 1986). Observer classification of habitat types also introduces further variability (Roper and Scarnecchia 1995). Among KNRD surveyors, a distinct difference in the way habitats with certain characteristics (e.g. velocity, channel shape, and surface turbulence) were consistently classified by different observers was noted. The tendencies were for some observers to classify a habitat as a run while other observers classified the same habitat as a pool. Differences in classification were particularly evident in Whiteman Creek reach 4. Primary pool number in reach 4 increased from one during the pre-assessment to 21 in 2000. Also, pool habitat increased from 7% to 66% while run habitat decreased from 92% to 9%. In 2001, pool habitat increased in all restoration sites relative to the pre-assessment. While differences in habitat classification (observer variability) likely occurred to a lesser degree in all assessments, we have observed a decrease in riffle habitat suggesting that pool habitat is, in fact, increasing.

One trend we have observed is the apparent loss of spawning gravel, particularly in reaches where structures were implemented in 1996. In the spring of 1997, a rain on snow event created flooding that caused significant damage throughout the Lower Pend Oreille Subbasin. Most of the spawning gravel appeared to be lost from 1996 to 1997. High flows likely flushed gravels from these reaches and recruitment from upstream reaches was minimal and/or gravels were deposited out of the bankfull channel. In 2001, we examined restoration reaches in Indian, Cee Cee Ah, and Mineral creeks to determine whether natural gravel recruitment may occur and whether further implementation of instream structures to recruit gravels is warranted (discussions will follow for each stream).

In 2001, we experienced the lowest summer flows since implementation and monitoring began in 1996. As a result, over half (59%, n=13) of the lowest average depths at each site were measured in 2001. However, only 7 of the 22 sites had the highest wetted width to depth ratio compared to previous assessments Low flows could also affect habitat classification. Habitat classified as a run in higher water may be classified as a riffle in low water (due to decreased depth and increased surface turbulence) and result in a lower pool to riffle ratio.

Overall, 2001 substrate embeddedness was lower than pre-assessed values in 19 of the 23 implementation sites (Table 29). Spawning habitat has decreased in 10 of the sites, increased in 5 sites, and was unchanged in 7 sites. Percent pool habitat has increased in all restoration sites. Primary pool frequency has increased in 18 sites, decreased in 1 site, and was unchanged in 4 sites. Total fish densities in 2001 have increased in 16 of the 23 sites relative to pre-assessment densities.

In Cee Cee Ah Creek, limiting factors were identified as overwintering habitat (pools) and spawning habitat (KNRD 1996). Log structures were implemented to create pools and recruit spawning gravel in the tail-outs. Pool habitat appears to be increasing in all of the restoration sites in Cee Cee Ah Creek. In reaches 4, 5, and 6, nine restoration sites were implemented from 1996 to 1998. Seven sites had increases in the number of primary pools, one site had a decrease, and one site was unchanged. The percent of pool type habitat increased in every implementation site. In the 1996 implementation sites, spawning gravel decreased in reaches 4 and 6 from 8.1 m^2 and 6.4 m^2 in the pre-assessment to 0.0 m^2 and 0.5 m^2, respectively, in 2001. Spawning sized substrate generally was located near the margins of the channel. Therefore, in low water years these gravels were not classified as spawning habitat. Total fish density increased in 8 of the 9 restoration sites in Cee Cee Ah Creek. Only two cutthroat trout have been observed in these sites; one cutthroat was observed during pre-assessment snorkeling surveys in 1996 and in 1997.

Pool habitat and substrate embeddedness were identified as limiting factors in reaches 3 and 4 in Indian Creek. In 2001, percent pool habitat and primary pool frequency increased and substrate embeddedness decreased relative to pre-assessment values. Spawning habitat appeared to decrease considerably, from 23.0 m^2 to 0.0 m^2, in reach 3. Gravels are still present in reach 3 of Indian Creek; however, none of the gravel was characterized as spawning habitat. The double wing deflectors constructed in reach 3 of Indian Creek appear to have had little effect on channel scour, but, nonetheless, are concentrating flow to mid-channel. Areas of low velocity are created upstream and downstream of the structures. Water velocities in these areas are too low to categorize the gravels as spawning habitat. Indian Creek is mostly groundwater fed with relatively little watershed in relation to actual stream size. As a result, the hydrograph may be relatively muted and annual peak discharges may not be great enough to scour out the desired pools. Systematic streamflow data collection in Indian Creek was started in the fall of 2001. After the spring 2002 runoff subsides, we will compare the streamflow hydrograph of Indian Creek with similar neighboring streams to determine if discharges in Indian Creek are attenuated. If a flattening of the Indian Creek hydrograph is observed, then the stream power may not be effective at moving bedload and scouring out pools. Therefore, further work (e.g. manually digging out pools or creating dam pools) may be required to further increase pool habitat in reach 3. In 2001, total fish densities decreased in reach 3 and increased in reach 4 compared to pre-assessed densities. In 2001, no native species were observed in either reach 3 or reach 4. Substrate embeddedness decreased dramatically in Reach 4. The 1996 pre-assessed embeddedness was 82% and decreased to 33% in 2001

Table 29. Summary of pre implementation and 2001 limiting habitat attribute values and fish densities.

Stream	Reach	Year*	Embedded %		Pools %		Primary Pools		Cutthroat Density		Total Fish Density	
			Pre	2001	Pre	2001	Pre	2001	Pre	2001	Pre	2001
Cee Cee Ah Cr.	4	1996	48	40	7	38	2	2	0.0	0.0	8.6	7.2
	4	1997	48	44	17	31	0	5	0.0	0.0	4.7	10.2
	4	1998	45	41	0	27	1	5	0.0	0.0	3.9	10.3
Cee Cee Ah Cr.	5	1996	77	38	0	38	2	5	0.8	0.0	7.0	20.9
	5	1997	61	27	8	52	1	2	0.0	0.0	8.5	10.3
	5	1998	62	48	20	44	1	2	0.0	0.0	14.6	18.0
Cee Cee Ah Cr.	6	1996	59	41	9	49	5	4	0.0	0.0	16.6	21.7
	6	1997	67	36	5	36	2	4	0.3	0.0	11.8	23.6
	6	1998	63	37	0	53	1	5	0.0	0.0	4.3	17.8
Indian Cr.	3	1996	80	53	0	50	0	3	0.0	0.0	10.8	5.6
Indian Cr.	4	1996	82	33	0	23	0	4	0.7	0.0	3.4	11.6
Browns Cr.	4	1997	31	29	3	17	0	1	0.0	0.0	4.4	9.2
	4	1998	28	29	0	9	0	4	0.2	0.0	4.5	6.6
Browns Cr.	9	1997	42	47	0	33	2	2	0.8	0.0	21.4	10.2
	9	1998	21	46	0	51	0	1	0.0	4.3	2.2	15.1
Fourth of July Cr.	4	1996	89	99	3	50	3	4	25.9	29.7	25.9	29.7
Fourth of July Cr.	8	1996	82	53	0	36	0	6	8.0	7.9	11.0	9.3
Mineral Cr.	1	1996	53	32	4	14	4	4	14.0	5.2	20.0	7.5
	1	1997	71	46	19	26	2	2	20.0	11.5	28.0	17.8
	1	1998	54	36	15	48	0	4	5.0	10.7	5.0	13.7
Whiteman Cr.	4	1996	95	94	7	62	1	10	0.0	0.1	20.0	26.8
Whiteman Cr.	5	1996	54	34	7	50	0	4	0.5	2.0	6.5	6.9
Whiteman Cr.	6	1996	73	29	0	46	0	3	0.5	2.1	14.5	11.6

*Year of implementation

with an annual range of 16% to 50%. Other factors not identified in the stream survey may also be limiting fish populations in Indian Creek. The KNRD operated adfluvial fish traps on 11 tributaries in the Box Canyon reach of the Pend Orielle River. Of those 11 traps, the Indian Creek trap had the most fish captured in 1998. Adfluvial fish likely represent a portion of the sampled population. Therefore, if a portion of the population is adfluvial, there may be other factors outside of the project watershed influencing the population (e.g. limiting factors for salmonids in Box Canyon Reservoir).

A lack of pool habitat was identified as limiting fish populations in reach 4 of Browns Creek (KNRD 1996). In the 1997 implementation site, pool habitat has increased from 3% to 17%; however, only one primary pool was present in 2001. An increase in pool habitat and primary pool number has been observed in the 1998 restoration site. However, percent pool habitat in these two sites remained relatively low in 2001. Total fish densities in both restoration sites have increased over pre-assessed densities. However, cutthroat trout have only been observed in the pre-assessment of the structures implemented in 1998.

In 1997 and 1998, restoration was implemented in reach 9 of Browns Creek to increase pool habitat. In the 1997 site, no habitat had been classified as pool through 2000. However, 33% of the habitat was classified as pool in 2001. Pool composition also increased in the 1998 implementation site. No habitat was classified as pool in the 1998 pre-assessment and 51% of the habitat was classified as pool in 2001. In the 1997 site, two primary pools were observed in the 1997 pre-assessment site and the 2001 post assessment. In the 1998 implementation site, no primary pools were present in the pre-assessment and 1 was identified in the 2001 monitoring survey. In the 1997 implementation site, total fish density has decreased from 21.4 fish per 100 m^2 in 1997 to 12.9 fish per 100 m^2 in 2001. However, annual increases in fish density have occurred since 1998. Cutthroat trout density increased the 1998 implementation site. No cutthroat trout were observed in the 1998 pre-assessment and 4.3 fish per 100 m^2 were observed in 2001. Increases in pool habitat and primary pools may be resulting increased fish densities in the 1998 restoration site.

Pool habitat and unstable banks were identified as limiting factors in reach 4 of Fourth of July Creek. Unstable banks were the result of cattle trampling; therefore, a riparian exclosure was constructed in 1996. As a result, bank stability has increased from 70% in 1996 to 98% in 2001. Pool habitat has also increased; 3% of the habitat was classified as pool in 1996 and 50% of the habitat was pool in 2001. Despite the low flows of 2001, average depth increased from 17.0 cm in 1996 to 18.4 cm in 2001.

High embeddedness and a lack of pool habitat were identified as limiting factors in reach 8 of Fourth of July Creek (KNRD 1996). High delivery of sediment originating from upstream unstable banks likely resulted in the high embeddedness. Substrate embeddedness was 82% in the 1997 pre-assessment which was just after the construction of the riparian exclosure in reach 4. Embeddedness decreased to 53% in 2001 and was as low as 20% in 2000. Log structures were implemented in 1997 to increase pool habiat. Since 1997, the percent of habitat classified as pool increased from 0% to 36%, and the number of primary pools increased from 0 to 6. The response of the fish population has been mostly favorable. Total fish densities have increased to as high as 37.0 fish per 100 m^2 in 1999. However, cutthroat density was relatively unchanged in 2001 compared to the 1997 pre-assessment. At this site, one bull trout was observed in 1998 and one in

1999. It appears that the structures implemented in Fourth of July Creek have resulted in better habitat and increased fish densities.

Single wing deflectors were constructed in reach 1 of Mineral Creek in 1996 and 1997. High substrate embeddedness and low pool habitat were the limiting factors identified from the baseline survey. Fish densities have decreased in the sites implemented in 1996 and 1997 while the 1998 site has seen an increase. Overall, primary pools have changed little in the 1996 and 1997 restoration areas and increased from 1 to 4 in the 1998 site. Increased wetted width to depth ratio, recent bank instability, and a significant loss of spawning gravel from 1996 to 1997 have occurred in Mineral Creek restoration sites in reach 1. Gravels in reach 1 of Mineral Creek appear to have been deposited out of the bankfull channel due to flooding in the spring of 1997. However, spawning habitat has increased in structures that were implemented in the summer of 1997 while no change in spawning habitat was observed in structures implemented in 1998. Since it appears that spawning gravels may be recruiting naturally, no further instream structures are planned. Competition with introduced brook trout may be significantly impacting native cutthroat trout in Mineral Creek. In the fall of 2001, electrofishing removals of brook trout were conducted over a two-week period in reach 1. A culvert exists at the lower end of reach 1 that likely inhibits (but not necessarily bars) upstream passage of fish. Electrofishing removals in reach 1 will continue in 2002. If electrofishing is successful at suppressing brook trout in reach 1 of Mineral Creek, electrofishing removal of brook trout may be expanded to the entire stream.

A lack of overwinter habitat (pools) and low depths due to channel braiding were identified as the limiting factors in reach 4 of Whiteman Creek. The percent of unstable banks were high and were likely contributing to substrate embeddedness in downstream reaches. Structures were implemented in 1997 to concentrate flows in mid-channel. Reach 4 is also enclosed in a riparian fence that was constructed in 1996. Improved habitat appears to have resulted in increased fish density. Primary pools increased from 1 to 10 and pool habitat from 7% to 62%. Bank stability increased from 51% in the pre-assessment to 93% in 2001. Brook trout was the only species observed in reach 4 from 1995 to 2000. 2001 was the first year a cutthroat trout was observed in reach 4. All post assessment brook trout densities were higher that the pre-assessment density.

Pool habitat was identified as the limiting factor in reach 5 of Whiteman Creek. Boulder structures were implemented to create pool habitat. From 1996 to 2001, percent pool habitat increased from 7% to 50% and the number of primary pools increased from 0 to 4. Relatively high substrate embeddedness (54% in 1996) was also observed in reach 5. Embeddedness decreased to 34% in 2001. The decrease may be attributed to the increase in bank stability upstream in reach 4. Brook trout density increased from 6.0 fish per m^2 in the pre-assessment to 6.7 fish per 100 m^2 in 2001. In the same time period, cutthroat density increased from 0.5 fish per 100 m^2 to 2.0 fish per 100 m^2. As the habitat in reach 5 improves, conditions may tend to favor cutthroat trout over brook trout.

Boulder structures were placed in Whiteman Creek reach 6 as pool habitat was also identified as the limiting factor. From 1996 to 2001 pool habitat increased from 0% to 46% and primary pools increased from 0 to 3. A large decrease in substrate embeddedness was also observed in reach 6: from 73% in 1996 to 29% in 2001. Brook trout density declined from 14.0 fish per 100 m^2 in 1996 to 9.5 fish per 100 m^2 in 2001. However, 2001 cutthroat trout density (2.1 fish per 100 m^2) continued to higher than the pre-assessed density (0.5 fish per 100 m^2). Structures implemented in reach 6 may also create habitat conditions that tend to favor cutthroat trout over brook trout.

Largemouth bass habitat enhancement

Overall, largemouth bass CPUE and percent of catch have increased since bass habitat enhancement structures were placed in 1997. However, distinct differences in seasonal utilization of the structures by juvenile and adult largemouth bass were apparent. 92% of the bass captured in the spring were adults while 97% of the bass captured in the fall were juveniles. The goal for this project is to provide overwinter cover to juvenile largemouth bass. Juvenile bass appear to have relatively low utilization of the structures in the spring. However, total juvenile relative abundance has increased from 7 in the fall of 1997 to 78 in the fall of 2001. In November, macrophytes in the sloughs and mainstem of the Pend Oreille River are likely providing significant cover for largemouth bass. However, in the spring, macrophytes have decomposed and the artificial structures may then be the primary cover component. Adult largemouth bass may seek out the cover of the structures and displace the juvenile bass which are vulnerable to predation. It is not known when the shift between juvenile and adult largemouth bass utilization of the structures takes place. However, given the increase in fall juvenile relative abundance, it appears that the enhancement structures may be resulting in increased overwinter survival for juvenile largemouth bass.

Literature Cited

Ashe, B.L., K.L. Lillengreen, J.J. Vella, L.O. Clark, S. Graves, M.R, Barber, G.J. Nenema, Jr., and A.T. Scholz. 1991. Assessment of the fishery improvement opportunities on the Pend Oreille River. Upper Columbia United Tribes Fisheries Center. BPA Annual report Contract No. DE-A179-88BP39339.

Barber, M.R., B.L. Renberg, J.J. Vella, A.T. Scholz, K.L. Woodward and S. Graves. 1990. Assessment of the fisheries improvement opportunities on the Pend Oreille River. Upper Columbia United Tribes Fisheries Center, Annual Report 1990.

Bennett, D.H. and M. Liter. 1991. Water quality, fish and wildlife characteristics of Box Canyon Reservoir, Washington. Department of Fish and Wildlife Resources College of Forestry, Wildlife and Range Sciences University of Idaho, Section 3: Fish Completion Report 1989-1990.

DeStaso III, J., and F.J. Rahel. 1994. Influence of water temperature on interactions between juvenile cutthroat trout and brook trout in a laboratory stream. Transactions of the American Fisheries Society 123:289-297.

Espinosa, A. 1988. Clearwater Stream Survey Methodology. Clearwater National Forest, Orofino, Idaho.

Griffith, J.S. 1988. Review of competition between cutthroat trout and other salmonids. American Fisheries Society Symposium 4:134-140.

Griffith, J.S., and Smith R.W. 1993 Use of winter concealment cover by juvenile cutthroat and brown trout in the South Fork of the Snake River, Idaho. North American Journal of Fisheries Management 13:823-830.

Heede, B.H. 1986. Designing for dynamic equilibrium in streams. Water Resources bulletin 22:351-357.

Hilderbrand, R.H., and J.L. Kershner. 2000. Conserving inland cutthroat trout in small streams: how much stream is enough? North American Journal of Fisheries Management 20:513-520.

Hillman, T. W. and W. S. Platts. 1993. Survey plan to detect the presence of bull trout. Don Chapman Consultants Inc. Intermountain Forest Industry Association.

Hunter, C.J. 1991. Better trout habitat: A guide to stream restoration and management. Island Press, Washington D. C.

Jakober, M.J., T.E. McMahon, R.F. Thurow, and C.G. Clancy. 1998. Role of stream ice on fall and winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. Transactions of the American Fisheries Society 127:223-235

Kalispel Natural Resource Department and Washington Department of Fish and Wildlife. 1995. Kalispel Resident Fish Project Annual Report. Report to U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Contract number.

Kalispel Natural Resource Department and Washington Department of Fish and Wildlife. 1996. Kalispel Resident Fish Project Annual Report. Report to U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Contract number

Lacy, R.C. 1987. Loss of genetic diversity from managed populations: interacting effects of drift, mutation, immigration, selection, and population subdivision. Conservation Biology 1:143-158.

MacDonald, L.H., A.W. Smart and R.C. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. EPA/910/9-91-001. Developed for Region 10, US Environmental Protection Agency. College of Forest Resources/College of Ocean and Fishery Sciences, University of Washington, Seattle, Washington.

Markle, D.F. 1992. Evidence of bull trout x brook trout hybrids in Oregon. In: Howell, P.J. and D.V. Buchanan eds. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society: 58-67.

Murphy, P. and C.W. Huntington. 1995. Updated Stream Survey Methodology for the Clearwater National Forest. Internal Document. Clearwater National Forest. Orfino, Idaho.

Pearsons, T.N., H.W. Li, and G.A. Lamberti. 1992. Influence of complexity on resistance to flooding and resilence of stream fish assemblages. Transactions of the American Fisheries Society 121:427-436.

Rieman, B.E. and J.D. McIntyre. 1993. Demographic and habitat requirments for conservation of bull trout. U.S. Forest Service General Technical Report INT-302.

Roper, B.B. and D.L. Scarnecchia. 1995. Observer variability in classifying habitat types in stream surveys. North American Journal of Fisheries Management 15:49-53.

Saunders, H.R., R.J. Hobbs, and C.R. Margules. 1990. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5:18-32.

Sedell, J.R., G.H. Reeves, F.R. Hauer, J.A. Stanford, and C.P. Hawkins. 1990. Role of refugia in recovery from disturbances: modern fragmented and disconnected river systems. Environmental Management 14:711-724.

Scholz, A.T., K. O'Laughlin, D. Geist, D. Peone, J. Uehara, L. Fields, T. Kleist, I. Zozaya, T. Peone, and K. Teesatuskie. 1985. Compilation of information on salmon and steelhead total run size, catch, and hydropower related losses in the Upper Columbia River Basin, above Grand Coulee Dam. Upper Columbia United Tribes Fisheries Center Fisheries Technical Report No. 2.

Shaklee, J.B. and S.F. Young. 2000. A microsatellite DNA-based analysis of population structure of cutthroat trout *(Oncorhynchus clarki)* in the Pend Oreille Basin in Washington. Washington Department of Fish and Wildlife Completion Report.