Exxon Valdez Oil Spill
Restoration Project Final Report

Eastern Prince William Sound Wildstock Salmon Habitat Restoration

Restoration Project 98220
Final Report

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Study History: This report covers the third and final year of the Eastern Prince William Sound Wildstock Salmon Habitat Restoration project. The 96220 Annual Report covers the stream surveys that led to the selection of Plateau Creek for restoration work in 1997. The 97220 Annual Report describes the construction of instream habitat structures for juvenile coho salmon. This report covers the monitoring and evaluation activities in 1998 and a summation of the project and its effect on coho salmon production in Plateau Creek.

Abstract: A coho salmon *Oncorhynchus kisutch* enhancement project was conducted to provide fish for subsistence harvest and to involve local youth in the management of the resources in the Cordova area. Habitat surveys and a limiting factors analysis indicated that coho salmon production in Plateau Creek is most likely limited by the scarcity of suitable winter habitat. In 1997, we built 12 instream structures, creating approximately 195 sq m of additional winter habitat. This could produce an additional 16 to 63 adults annually, beginning in 1999. The original goal for 1998 was to build additional structures. Unexpectedly low escapement in the fall of 1997 showed that existing production is minimal, and it would not be possible to create enough habitat to produce fish for harvest. In 1998, we monitored the use of the structures and improved the existing habitat. Escapement in the fall was low once again. Although harvest goals will not be met, this project should help to protect a marginal coho salmon population. Another benefit was the opportunity for Cordova youth to work on a local natural resource project, learn methods for fisheries studies, and learn about salmon biology and management.

Key Words: *Exxon Valdez*, habitat enhancement, habitat survey, coho salmon, *Oncorhynchus kisutch*, Prince William Sound.

Project Data: Data for 1998 consist of diagrams of the structures that were repaired and modified and the habitat that was created. The diagrams are included in the appendix of this report. *Custodian*: Contact Ken Hodges, USDA Forest Service, Cordova Ranger District. P.O. Box 280 Cordova, AK 99574. (907) 424-7661.

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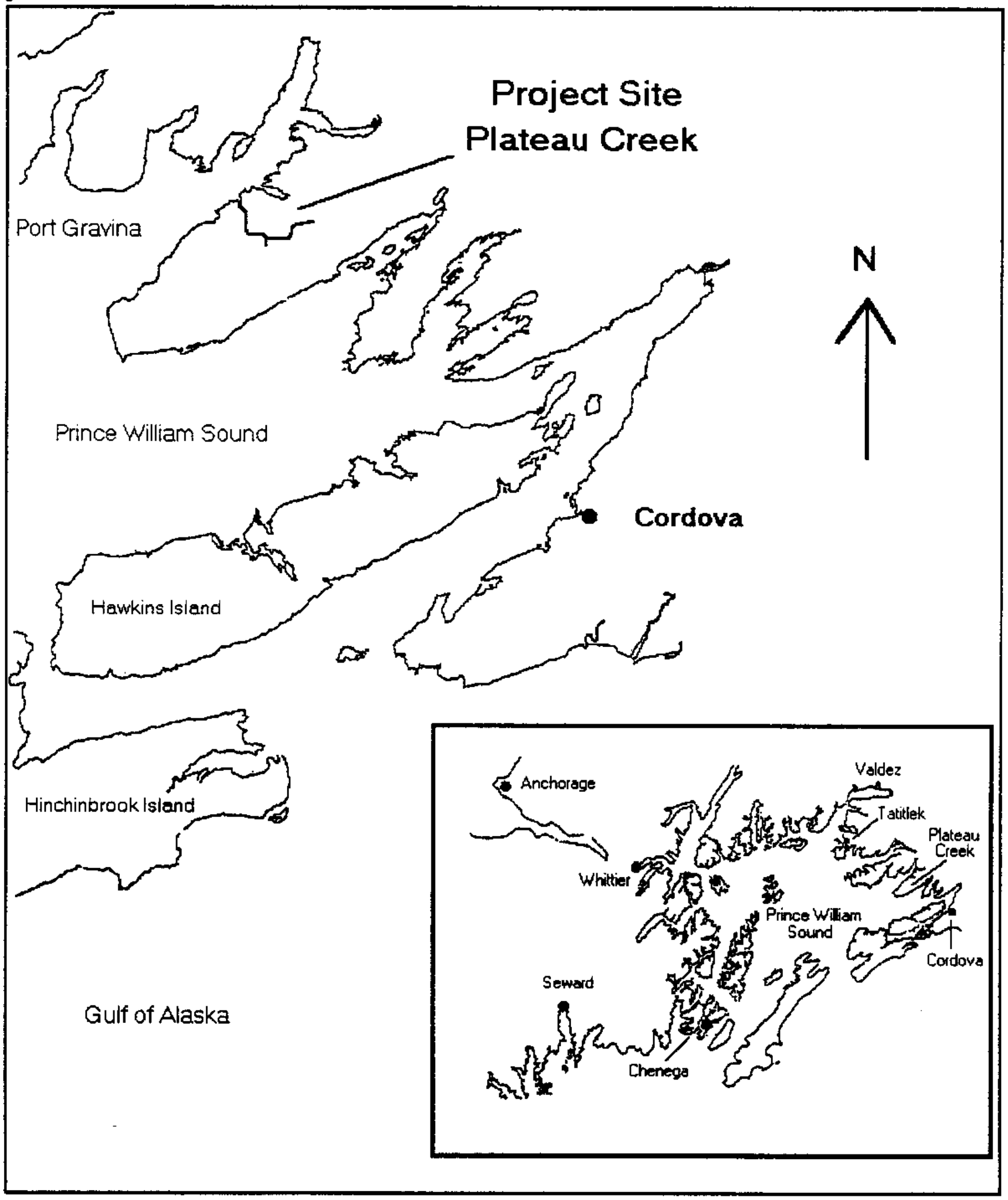

Project Location: Plateau Creek, approximately 30 km northwest of Cordova.

Executive Summary

Following the *Exxon Valdez* oil spill, there was a substantial decrease in subsistence harvests in the Prince William Sound area. The Village of Eyak, working with the USDA Forest Service, proposed a wildstock salmon habitat enhancement project in the streams of eastern Prince William Sound. By improving habitat to enhance salmon populations, additional subsistence opportunities would be provided. The other goal of this project was to get the local youth involved with the management and care of the lands around Cordova. A salmon enhancement project would provide them with an opportunity to work in the field of natural resources, learn more about salmon biology, and work on a project which would benefit the people of the area.

Crews conducted habitat surveys in 11 streams in eastern Prince William Sound in 1996. A limiting factors analysis was then used to determine which streams might be suitable for a coho salmon *Oncorhynchus kisutch* enhancement project. Plateau Creek, in the Port Gravina area, appeared to provide the best opportunity for habitat enhancement because it has a relatively large amount of low-gradient channel, and it is a fairly small system, making it more suitable for the construction of instream habitat structures. Instream structures have been used successfully in a number of projects to increase juvenile coho salmon habitat. The analysis indicated that production in Plateau Creek was most likely limited by the scarcity of suitable winter habitat.

In 1997, 12 instream structures were built to increase winter habitat. The structures were designed to create low-velocity backwaters and deepen or maintain water levels in areas that may go dry during low-flow periods in winter. Logs, brush, and cobble were added to these areas to provide more complex cover. Construction was halted earlier than planned because a large run of pink salmon *O. gorbuscha* entered the system and could not be disturbed under the terms of our permit. The structures created 195 sq m of winter habitat, which could produce an estimated 16 to 63 returning adult coho salmon. In October 1997 we conducted two escapement counts, but did not see any spawners or any sign of redds or carcasses.

Two major objectives were planned for this past year (1998), the final year of the project. The first objective was to assess the overwinter use of the structures by electroshocking the habitat in the spring before the smolts outmigrated. The second was to build additional structures to increase winter habitat and adult production.

We had to change our second objective, however, given the results of the escapement counts in 1997 and the results of the electroshocking in the spring of 1998. Although our counts were limited, they indicated that the existing adult production was minimal and could not be counted on to contribute to a subsistence harvest. To produce enough fish for harvest, considerably more habitat would have to be created than we had planned. The use of the structures was also low; we found only four coho juveniles at the structures and three at 17 natural habitats. None of the fish were smolts. We suspect that the smolts outmigrated earlier

than usual during a period of high flows. However, we still had to consider the possibility that the structures were not being used or some other factor besides winter habitat was limiting production.

Given the apparently low natural production in the system, the need to create considerably more habitat, and some uncertainty about the use of the structures, we felt that the goal of producing enough fish for subsistence harvest was not attainable. Rather than create additional structures as planned, we decided to maintain and improve the existing structures, monitor summer use, and conduct better escapement counts in the fall.

The structure improvements consisted of adding logs, brush, and cobble to create additional area and more complex habitat. Use of the structures varied considerably in the summer, with no fish at one structure, but more than 100 juveniles at another. These counts were made before the maintenance and improvements were done. Escapement was low again in 1998, with only 10 spawners and one freshly killed fish observed from September 9 to October 30. We saw two redds in the main channel and a probable third redd in a tributary, but no spawned-out carcasses or other signs of spawning activity.

Although we will not achieve the goal of providing a subsistence harvest, this project should increase coho salmon production and help bolster a rather marginal population. The limiting factors analysis indicated that winter habitat was the most limiting factor in the system, and we have increased the amount of habitat substantially for a stream of its size. The structures also provide backwater areas for young fry and sheltered areas during high flows in the fall and spring. Thus, even though the structures were intended to increase winter habitat, they should help juvenile coho at all life stages.

We have considered the other factors that might limit production. It is possible that high flows in the spring and fall could scour redds and reduce egg survival. However, the abundance of pink salmon suggests that there is sufficient undisturbed spawning substrate to produce a large number of fry, and in turn, returning adults. Since pink salmon fry hatch and migrate directly to sea, it is possible that coho salmon may be limited by some factor during their freshwater residence rather than egg survival. Food availability should not be a problem, especially if coho juvenile densities are low. The large annual runs of pink salmon provide carcasses and eggs for direct consumption and provide nutrients which should increase the productivity of the system in general.

Ocean survival is an external factor which could limit the number of returning adults. If the return is sufficiently limited, the habitat available in freshwater could be underseeded. We do not have escapement data for 1996 to determine whether this could account for the low number of fish when we electroshocked in the spring of 1998. Generally, however, a relatively small number of spawners is needed to produce sufficient eggs and fry to fill the available habitat.

We have met our second goal - providing local youth with an opportunity to get involved in a natural resource project and learn more about fisheries management and salmon biology. Seven local individuals have worked on the project either as Forest Service employees or under the Resource Apprenticeship Program. One person has worked on the project for all three years. The USDA Forest Service also benefitted from the opportunity to work with and form new ties with others in the community. All of the participants have learned considerably more about the complexities of salmon biology in the smaller streams of the area.

Introduction

Following the *Exxon Valdez* oil spill, there was a substantial decrease in subsistence harvests in the Prince William Sound area. The Village of Eyak, working with the USDA Forest Service, proposed a wildstock salmon habitat enhancement project for streams in eastern Prince William Sound. By improving habitat to restore or enhance salmon populations, additional subsistence opportunities could be provided. The other main goal of the project was to get the local youth involved with the management and care of the lands around Cordova. A salmon enhancement project would provide them with an opportunity to work in the field of natural resources, learn more about salmon biology, and work on a project which would benefit the people of the area.

In 1996, a crew working through the USDA Forest Service conducted habitat inventories in 11 streams to determine the feasibility of salmon enhancement projects. The streams were selected because they were either entirely or partially on Eyak lands. The results of the surveys were used in a habitat-based limiting factors analysis (Reeves et al. 1989) to determine whether coho salmon *Oncorhynchus kisutch* production could be increased with habitat improvement. We decided to concentrate our efforts on coho salmon, since this species is more highly valued than the other species of salmon present in the project area: pink salmon *O. gorbuscha* and chum salmon *O. keta*. Another consideration was that a number of successful coho salmon habitat improvement projects have been implemented using simple instream habitat structures (House and Boehne 1985, Nickelson et al. 1992, Crispin et al. 1993, House 1996).

We found that most of the streams had habitat limitations which could not be changed. Due to the rugged topography of the area, most of the streams are short, steep, and confined in narrow canyons until they near salt water. There were only three streams with more than two kilometers of low-gradient channel. Low-gradient was defined as less than a 3% slope, which is generally the upper limit for coho salmon habitat (Reeves et al. 1989). In addition, the two largest streams, Hartney and East Fork Olsen creeks, are subject to high, flashy flows. We did not feel that instream habitat structures would be successful in these creeks.

Plateau Creek in the Port Gravina area appeared to be the best choice for a coho salmon habitat enhancement project. Although the creek is small, it has 2.2 km of low-gradient channel. The system is also small enough that habitat structures can withstand the high flows during fall storms and the spring snowmelt period. We were unable to get a good preliminary adult escapement count, but the survey crew observed high numbers of juvenile coho salmon in the summer. Most of the other streams had few or no juveniles. The limiting factors analysis indicated that the lack of winter habitat was probably limiting production in Plateau Creek.

In 1997, we built 12 structures designed to increase winter habitat for juvenile coho salmon. We had hoped to build more structures, but a large, early run of pink salmon prevented further work in the stream. The structures created approximately 211 sq m of winter habitat, but bedload deposition following high flows decreased the amount of habitat to 195 sq m. This habitat, according to the limiting factor analysis, could produce 313 smolts. Depending on ocean survival rates, an estimated 16 to 63 adults could return. The limiting factors analysis is intended mainly to identify habitat deficiencies rather than predict production, but we use it here to get a very rough idea of the production potential. Obviously, a large amount of additional habitat would be needed to provide enough fish for subsistence harvest.

Our original plan for 1998 was to monitor the existing structure use and build additional habitat structures. We had to reconsider our plans, however, when we did not see a single spawner in the fall of 1997, and we found only a few fish using the structures in May 1998. Although we assumed that we missed seeing some adults early and late in the spawning season, we had to question whether the existing habitat was being fully seeded, whether some factor other than winter habitat was limiting production, and whether any more structures were really needed. Given these uncertainties, we redirected our plans. Since some habitat area at the structures had been lost due to bedload deposition, we concentrated our efforts on repairing and improving the existing structures, monitoring the use of the structures in the summer, and obtaining better escapement counts in the fall of 1998.

This final report addresses the possible reasons for the low number of spawners and fish overwintering at the structures, and other factors which may be limiting production in the system. Although we have not met the goal of producing sufficient numbers of fish for harvest, the additional habitat may help to enhance and protect a marginal coho salmon population. We also feel that the project was a good learning and work experience for both the Forest Service and the local residents that worked on the crews.

1998 Objectives

1. Repair and improve existing habitat structures.

2. Monitor overwinter use and summer use of structures.

3. Obtain adult escapement counts.

4. Continue to work with local youth.

Methods

Structure Use

On May 14, 1998, we electroshocked the habitat created by the structures to estimate the number of juvenile fish using the sites for overwintering. We had hoped to visit the sites earlier, closer to the actual winter time, but severe weather throughout the spring precluded earlier examination. We had to assume that the fish had not yet smolted and left the system. Studies indicate that coho smolt migration in Prince William Sound and southcentral Alaska generally begins in early to mid May and does not peak until late May and early June (Whitmore et al. 1979, Nelson unpublished USDA Forest Service report 1985, Groot and Margolis 1991).

We electroshocked each site using removal-depletion methods described by Platts et al. (1983). Each site was shocked at least twice, although all of the sites had few or no fish. Captured fish were placed in a bucket to recover and returned to the site after the shocking was completed. As we walked upstream, we shocked an additional 17 natural habitat areas for comparison.

On July 30, we revisited the sites to determine the value of the structures for summer habitat. At a number of structures, the complexity of the habitat and the numbers of fish made it impossible to remove sufficient proportions of the populations with each pass to obtain a valid estimate. The process would have also subjected the remaining fish to repeated shocks, which would increase the chance of injuries (Hollender and Carline 1994, Kocovsky et al. 1997). After one failed attempt to shock where numerous fish were present, we decided to visually count the number of fish present unless few or none were readily apparent. At structure sites where few fish were seen, we used the same electroshocking as before to estimate the population.

Structure Modification, Maintenance

During August we repaired and modified the structures as needed. Because of the low numbers of fish found at the structures (and natural habitats) in May, we were uncertain whether any more winter habitat was needed. Thus, we decided to improve the existing structures rather than create new ones as originally planned. We added additional logs, tree tops, cobble, and brush to the structures to create more complex habitat and sheltered areas.

Spawning Escapement Surveys

Escapement surveys were conducted on September 9, October 6, and October 30, 1998. Two or three crew members walked in the stream from the estuary upstream to the end of reasonable spawning habitat and counted each adult fish. The estuary was surveyed from shore or from a boat. Both the stream and the estuary are shallow and clear, so visual surveys provided accurate counts. Since we did not see any fish on October 6, and the fish we saw October 30 were in fairly good shape (fins not worn, no fungus, fish not extremely red), we assume that the fish seen October 30 were different fish than those seen September 9.

Results

Structure Use

The number of fish using the structures in May was quite low, with only two structures having any fish at all. Structure 1 had one Dolly Varden and structure 12 had four coho salmon and one pink salmon fry (Table 1). The number of fish found in natural habitats was also low, however. Of the 17 natural habitats we sampled, only three areas had fish - one cutthroat trout at a log/boulder habitat, two coho salmon in an undercut bank, and one coho salmon in a brush pile/undercut bank area. None of the coho salmon appeared ready to smolt since their parr marks were still visible and there was no sign of the silver smolt coloration.

The number of coho salmon using the structures in July was higher, ranging from zero to more than 100 (Table 1). At most of the sites we visually counted the number of fish and probably underestimated the number hiding in the areas with denser cover. Almost all of the fish were age-0 coho salmon.

Table 1. Number of fish using habitat structures May 14, 1998 and July 30, 1998. An E or V indicates whether the count was made by electroshocking or by visually estimating. CO is an abbreviation for coho salmon, DV for Dolly Varden, and P for pink salmon. Structure 9 washed out over the winter.

Structure	E/V	N 5/14/98	E/V	N 7/30/98
1	E	1 DV	E	5 CO, 2 DV
2	E	0	V	35 CO
3	E	0	V	12+ CO
4	E	0	E	6 CO, 1DV
5	E	0	E	0
6	E	0	V	29+ CO
7	E	0	V	10 CO, 1 DV
8	E	0	V	100+ CO
10	E	0	V	12 CO
11	E	0	V	5 CO
12	E	4 CO, 1 P	V	10 CO

Structure Modification and Maintenance

Of the 12 structures that had been built in 1997, all but one have held and are generally functioning as intended. One structure failed when its anchor pulled out, and the structure was washed away. There has also been some loss of habitat area due to the deposition of bedload material after high flows and some shifting of the logs.

As mentioned in the methods, due to the low number of fish found at the structures in May, we decided to improve the existing structures rather than create new ones. We added additional logs, tree tops, or brush to structures 1, 4, 5, 10, and added minor amounts of cobble or brush to others. Although we improved most of the structures, the overall habitat area decreased from 211 sq m to 195 sq m (Table 2). Using the limiting factors analysis by Reeves et al. (1989), we estimated that this habitat could produce 313 smolts. Smolt-to-adult survival rates range from 5% to 20% (Groot and Margolis 1991, Bradford 1995), which would produce an estimated 16 to 63 returning adults.

Table 2. Structure types, amount of winter habitat created, and comments.

Number	Structure Type	Area sq m (change)	Comments
1	Downstream Barb	11.7 (+4.7)	Two logs, tree top, cobble. Log, tree top added 1998.
2	Log Jam	27.4	Several logs, brush, cobble
3	Downstream Barb	7.3 (-8.3)	Two logs, cobble
4	Downstream Barb	26.8 (+12.9)	Two logs, tree top, cobble. Log, tree top added 1998.
5	Downstream Barb	10.3 (-18.6)	Two logs, tree tops, cobble. Log, tree top added 1998.
6	Downstream Barb	17.8	Single log, cobble
7	Downstream Barb	14.9	Single log, cobble
8	Full-span Weir	23.6	Numerous backwaters, undercuts flooded. 100+ coho 8/98
9	Full-span Weir	0	Anchor pulled out, structure failed.
10	Cover Log	10.3 (-5.3)	Log, tree top, cobble. More brush added 1998.
11	Downstream Barb	19.0	10-20 juvenile coho observed 9/97, 5 coho 8/98
12	Downstream Barb	26.4	30-40 juvenile coho observed 9/97, 10 coho 8/98

Spawning Escapement Surveys

We conducted three spawning escapement surveys in the fall of 1998. On September 9 we counted six coho salmon in a single pool, along with approximately 40

Dolly Varden. We saw about 20 Dolly Varden in another pool but no other coho salmon. On October 6 we did not see any coho salmon and only one Dolly Varden. We also saw five redds in a tributary, but four of them were small and indistinct. These may have been Dolly Varden redds or coho redds that may have been eroded by high flows. One redd in the tributary was large enough to be a coho salmon redd. In the main channel we saw one large, distinct coho salmon redd. On October 30 we counted four live coho salmon and a dead salmon which had just been killed by a river otter *Lutra canadensis*. We found another coho salmon redd in a different area of the main channel.

Discussion

Involvement of Local Youth

One of the main objectives of this project was to involve local youth in the management of the resources in the area. During the three years of the project, seven Cordova residents have worked on the crews, either as Forest Service employees or through the Resource Apprenticeship Program. One member has been a part of the project for all three years. During the first year the crew members learned about conducting habitat surveys, the habitat needs of salmon, and factors that may limit salmon production in the area. The second year consisted mainly of the actual building of the structures, but while doing so, we emphasized the habitat factors that may be limiting production and how these needs were being addressed. In the final year, the monitoring raised new questions about the winter use of the structures and the possibility of outside factors, such as ocean conditions, affecting the low return of adults. These results forced us to reassess our project goals, but this has been part of the learning experience for everyone.

Speaking for the Forest Service, this project has given us a good opportunity to work more closely with outside groups and the young people in the community. The crew members, we believe, have gained a better understanding of fish biology and career opportunities with resource management agencies.

Coho Salmon Production

The other goal of this project was to increase the production of coho salmon in Plateau Creek to provide fish for subsistence harvest. This goal was reassessed and our efforts redirected, given the apparent lack of returning adults in the fall of 1997 and the low numbers of juvenile fish using the structures in May 1998. Initially we had planned to build additional structures in 1998, but the low use of the existing structures for winter habitat made us question whether or not there were other factors limiting production and whether any more structures were needed. The low escapement also made it evident that there were not enough fish produced naturally in the system to contribute to any harvest. Habitat enhancement would have to be increased considerably to provide for subsistence use.

Because of these issues, we decided to concentrate on maintaining and improving the existing structures rather than trying to create additional habitat. In the following sections we will discuss the implications of the low escapement numbers, and then, the use of the structures and whether there may be factors other than winter habitat limiting production.

Spawning Escapement

The low coho salmon escapement in Plateau Creek upset the initial goal of this project, since it was apparent that the existing population could not be used to support any harvest. Instead, the main benefit of this project may be that the habitat improvement could help prevent the demise of the rather marginal existing population. If the escapement is really as low as it appears to be, a bad winter or other adverse conditions could be disastrous. As we will discuss later, the scarcity of winter habitat may be just one of several factors contributing to the low production in the system, but our structures should help to improve juvenile survival, and hopefully this will result in a larger and more stable return.

Unfortunately, we were unable to get good escapement counts before the project was implemented, but we had assumed that there was a reasonable return of adult fish based on the number of juveniles we observed in the creek. This was a poor assumption. Although we only have one year of good escapement data now, it appears that the annual escapement in Plateau Creek is generally quite low. In 1998, our three escapement counts covered a broader part of the spawning season than in previous years, but we still saw only 10 spawners, one freshly killed fish, and two or three redds. It is also odd that we saw fish relatively early on September 9 and then relatively late at the end of October, but none in early October when spawning is generally at its peak in the streams around Cordova (personal observations).

We probably missed some fish that entered the system, spawned, and died between our counts, which were about four weeks apart. However, the lack of carcasses and the low number of redds suggests that there were few other fish at best. We did see 20 to 30 pink salmon carcasses from earlier in the year, so we doubt that all of the coho carcasses would have been washed out of the system or would otherwise have disappeared if there had been many other returning fish. In addition, coho may spend a few weeks or months in a system before spawning (Groot and Margolis 1991). The time spent at the actual spawning sites is highly variable, but Crone and Bond (1976) found in two years of study that females averaged 11 and 13 days at the site (range 3 - 24 days). Thus, if spawners had entered the system sometime after our initial count, we suspect that we would have seen some live fish on October 6, but again, we did not see any.

The escapement counts in other years are not reliable, but they also suggest that few fish are returning. In 1997, we made counts on October 1 and 16, but saw no fish, carcasses, or redds. Obviously some fish spawned in 1997, however, because age-0 fish were seen the following year. On November 6, 1996 we saw one fish, but no carcasses or other sign. Although the observations in these years were too limited or too late in the season to draw firm conclusions, we should have seen more carcasses or other sign if there had been substantial escapement.

It is possible that the escapement has been lower than normal in 1997 and 1998 due to ocean conditions or other factors which have influenced all of the runs in the Cordova area. In both years adult coho salmon returns have been unusually low in the nearby Copper River and Bering River fishing districts, and the commercial fishery was closed for both seasons. Thus, the return to Plateau Creek may also have been reduced, but we do not know how much greater it may be in a normal year. Whatever the normal number may be, we still cannot justify a subsistence harvest when the base population can drop to a dozen or so fish in the low years.

Structure Use and Limiting Factors

Our initial assumption for this project, based on the limiting factors analysis procedures described by Reeves et al. (1989), was that production is limited by the lack of winter habitat. Thus, if our structures could provide additional usable habitat, winter survival and overall production could be increased. We had hoped to determine the winter use of the structures by electroshocking in the spring of 1998 before the smolts outmigrated. We were unable to get to Plateau Creek until May 14, because of a series of storms throughout April and the first part of May which prevented safe boat travel and instream work. We still thought we could sample before the outmigration, since coho smolt migration in Prince William Sound and southcentral Alaska generally begins in early to mid May and does not peak until late May and early June (Whitmore et al. 1979, Nelson unpublished USDA Forest Service report 1985, Groot and Margolis 1991).

When we did shock the structure areas, we captured only four coho salmon at a single structure, none of which appeared to be smolting. At first we thought that there might be something wrong with the structures. After sampling natural habitats, however, we had found more coho salmon at the one structure than at all of the 17 natural habitats we shocked. There appeared to be an extreme lack of fish in all areas, not just at the structures. Either the smolts had already outmigrated or other factors are limiting juvenile production or survival prior to smolting.

Most likely, we sampled the area after the smolts outmigrated. From May 2 to 12, the weather station at the Cordova airport recorded 19.5 cm (7.68 inches) of rain. Whitmore et al. (1979) and Tripp and McCart (1983) found that peak coho smolt outmigration coincided with higher flows. Since the Plateau Creek channel is generally well confined, and the water levels can rise dramatically when it rains, the smolts may have exited early to take advantage of the flows or to escape adverse flow conditions in the stream.

Although the smolts may have left, we expected to see more age-1 fish that would smolt the following year. Generally in Alaskan streams, about 50% or more of the smolts are age-2 fish (Crone and Bond 1976, Groot and Margolis 1991), with the rest being age-1 fish and a few age-3 fish. Habitat conditions and habitat changes can cause substantial variation within and among streams, however (Hartman et al. 1996). If there has been a severe lack of winter habitat in Plateau Creek, most of the coho may be smolting as age-1 fish rather than competing for habitat or enduring harsh conditions during a second winter.

There may be other factors besides the lack of winter habitat that limit production and would account for the lack of fish using the structures. If adult returns in 1996 were low as we suspect, there may not have been sufficient spawning to fully seed the available habitat. We do not have reliable escapement counts for 1996, however, and it was not until 1997 and 1998 that low coho returns were reported throughout the area.

Adequate seeding and subsequent fry production are generally not problems in most streams because the fecundity of coho salmon is high, with an average of 2300 - 4700 eggs per female in various Alaskan streams (Crone and Bond 1976). In addition, relatively little spawning area is needed to produce large numbers of fry (Reeves et al. 1989), and winter habitat is usually the most limiting factor (Bustard and Narver 1975). In Plateau Creek, however, if the number of spawners is as low as our counts in 1997 and 1998 suggest, underseeding could be a problem, especially if egg survival is also low.

Although we have no empirical evidence, it is possible that egg survival is low due to substrate disturbances during high flows, and that the amount of usable spawning area is lower than we estimated during our initial surveys. Plateau Creek is a small stream with an average bankfull width of about 10 m, but the main channel is generally confined. At high flows the water levels may rise 0.7 m above the normal flow levels. There has been evidence of scouring and a fair amount of bedload movement judging from the deposition of material at some of the structures and gravel bars. Although the redds we saw in the main channel were situated in areas with reduced velocities (a wide pool tailout and a split channel), redds in other locations could be disturbed and the eggs could be displaced or crushed.

Conversely, the redds we saw in the tributary may be subjected to desiccation and freezing because of low flows. In our initial surveys, this tributary was not counted as spawning or overwintering habitat because the flow was minimal, and it was felt that the area would dry up in the winter. Subsurface flows could keep the eggs alive, but the area appears to be marginal for spawning.

We would hesitate to say that Plateau Creek is limited by spawning area and egg survival, however, because substrate and other conditions in the main channel appear to be good. In addition, the abundance of pink salmon suggests that there is sufficient undisturbed spawning substrate to produce a large number of fry, and in turn, returning adults. Since pink salmon fry hatch and migrate directly to sea without an extensive freshwater existence, it seems that coho salmon may be limited by some factor during their freshwater residence rather than egg survival. Most of all, a small number of successful coho redds could fully seed the system. From casual observations, coho fry have always appeared to be abundant, but we cannot tell from this if the system is fully seeded or not.

The high flows in the spring and fall are a concern since they may reduce juvenile survival by causing physical injury, displacement, or excessive energy use to maintain position (Bustard and Narver 1975, Brown and Hartman 1988). However, our habitat surveys and limiting factors analysis indicate that there are sufficient pools and other sheltered rearing habitats available (Hodges and Schmid 1997). In addition, the structures we built, though intended to provide protected wintering areas, would have provided shelter from high flows in the fall of 1997. Thus, we do not suspect that rearing habitat or low juvenile survival during the spring through fall would account for the lack of fish at the structures in May 1998.

One factor the limiting factors analysis by Reeves et al. (1989) does not address is the availability of food. We would not expect food to be a problem if the system is underseeded since competition would be reduced. In addition, Plateau Creek has large runs of pink salmon, especially in odd years. The eggs and carcasses should provide an excellent and abundant food source for coho juveniles and increase their growth and fitness for winter survival (Bilby et al. 1998). The carcasses should also provide a good nutrient base for other organisms, leading to a more productive system in general (Wipfli et al. 1998).

Conclusions

The goal of producing enough coho salmon for subsistence harvest will not be met due to the unexpectedly low number of fish in the existing run. It is not known whether the return in

1998 was normal for the system, or whether unusual ocean conditions or other factors decreased the usual number of returning adults. Although the habitat created by this project could produce an estimated 16 - 63 additional returning adults, there would not be enough fish for harvest without some contribution from the existing run or a several-fold increase in additional habitat, which we could not accomplish. Rather than providing fish for harvest, this project may instead help to bolster the marginal existing population.

The low use of the habitat structures in May 1998 made us question whether winter habitat was actually the limiting factor in the system and whether any more structures were needed. If winter habitat is in short supply, we would have expected to see higher use of the structures by smolts and juveniles. We suspect that we sampled the stream after the smolts had already outmigrated on high flows, although the migration would have been somewhat earlier than normal compared to other systems in southcentral Alaska. A higher percentage of the coho than usual may migrate as age-1 fish, which may also account for the low number of juveniles that we found.

The low number of fish at the structures and natural habitat areas did not disprove our assumption that winter habitat is limiting production in the system. The lack of fish, however, certainly leads us to suspect other factors could be involved. Poor ocean survival could limit the number of spawners and result in an underseeding of the available habitat. The high flows and bedload movement could reduce egg survival, but we have no direct evidence that this is happening or that it limits production. Pink salmon appear to spawn successfully in the system. Once the fry emerge from the gravel, there appears to be sufficient rearing habitat until the winter.

The structures we built should address the lack of winter habitat and also improve rearing conditions throughout the rest of the year. This enhancement effort should increase smolt production, and given reasonable ocean survival, produce additional returning adults. The first return of these fish should be in the fall of 1999. Although funding for this project has ended, monitoring of the structures earlier in the spring and additional escapement counts could provide the data for a better assessment of this project. We should also note that a few additional seasons of escapement counts and observing flow conditions in the system would have enabled us to better understand the system and define more achievable goals prior to project implementation.

Perhaps the greatest benefit of this project was the opportunity for local youth to participate in a natural resource project and learn more about land management practices. The USDA Forest Service also benefitted from the opportunity to work with and form new ties with others in the community. All of the participants have learned considerably more about the complexities of salmon biology in the smaller streams of the area.

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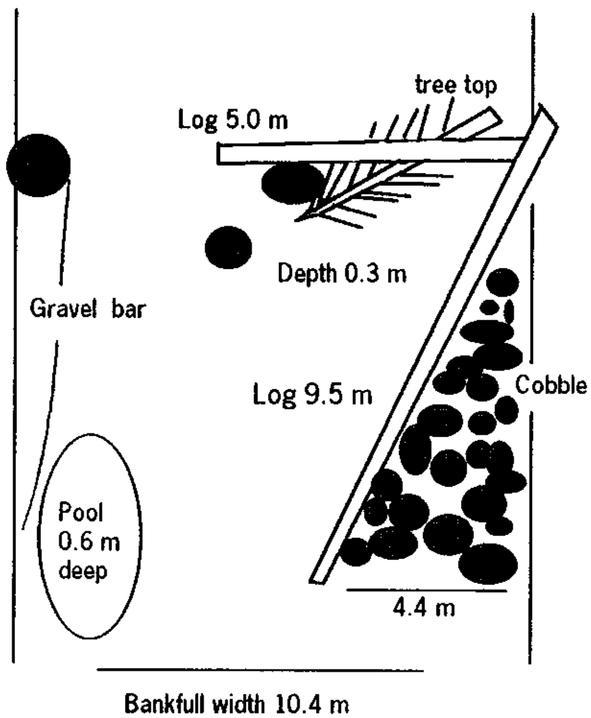
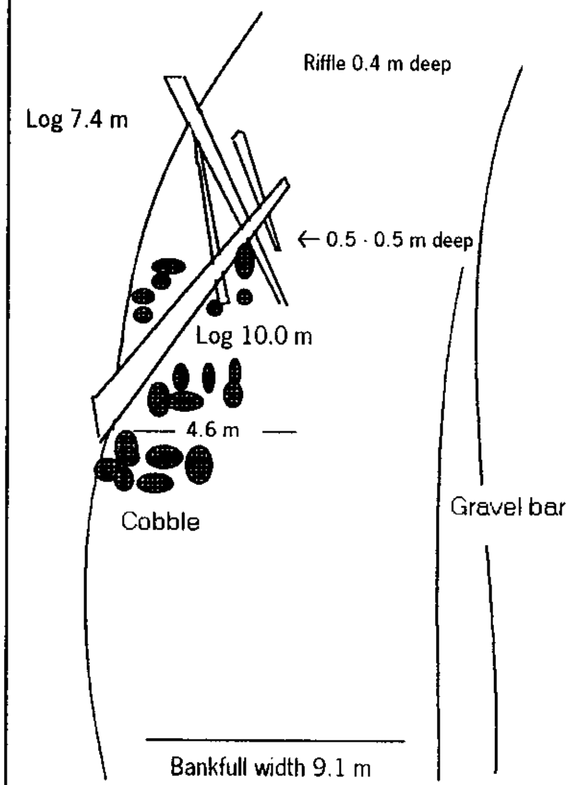
Appendix 1. Diagrams showing structures built, habitat, and stream features.

Structure 1. Logs and tree top create backwater area. Cobble, branches, and tree top provide winter cover. Shorter log and tree top added in 1998.

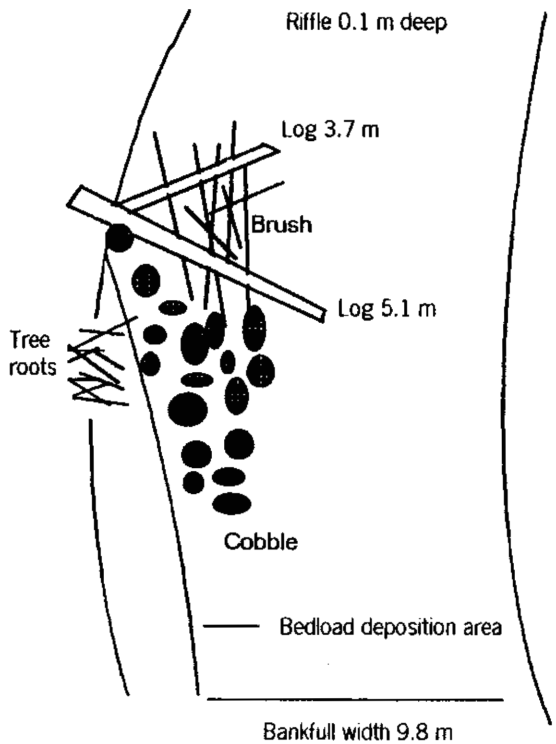


Structure 2. Log jam reduces velocity and creates more complex habitat. Cobble provides cover for juvenile fish.

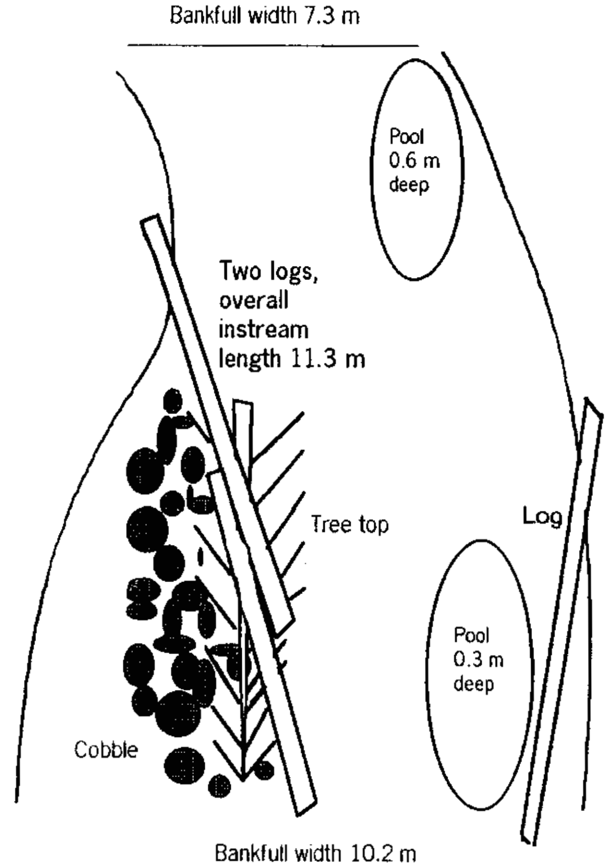


Appendix 1 continued. Diagrams showing structures built, habitat, and stream features.

Structure 3. Logs, cobble, and brush provide complex habitat for juvenile fish. Some area was lost in 1998 due to deposition of sand after high flows.

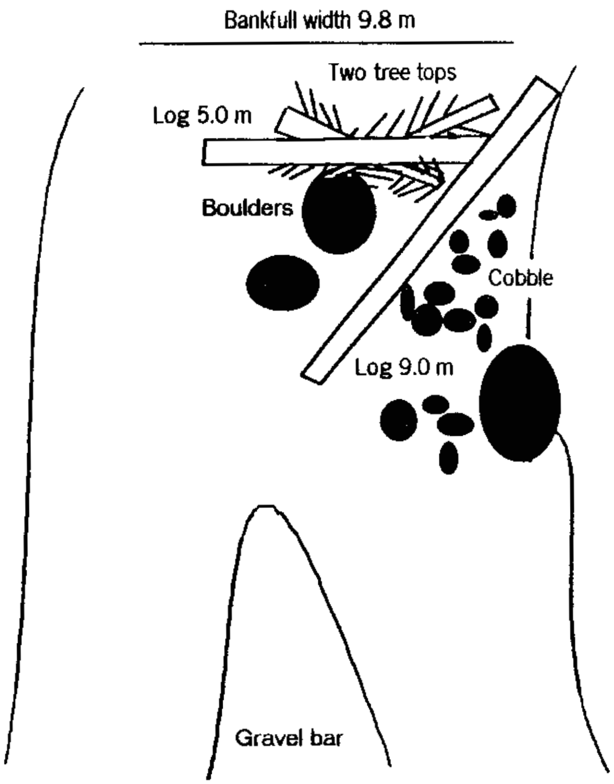


Structure 4. Original log shifted. Second log, tree top added in 1998. Provides backwater and complex winter cover.

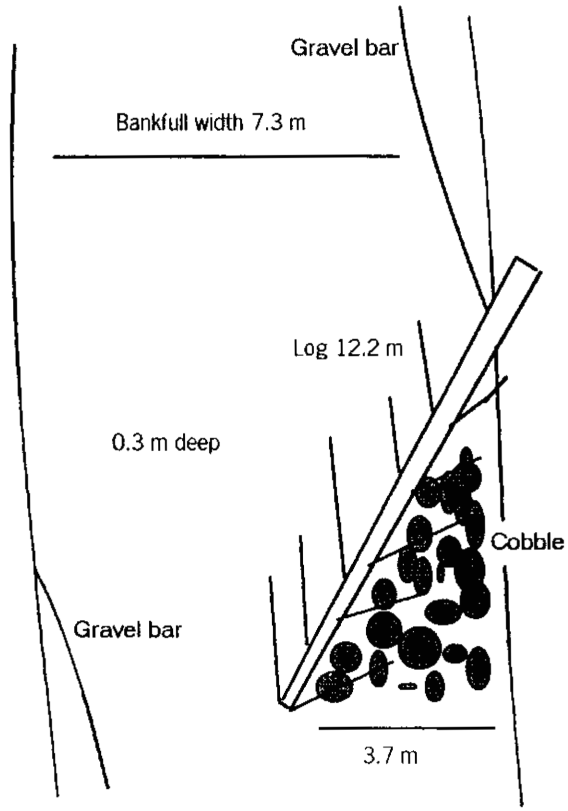


Appendix 1 continued. Diagrams showing structures built, habitat, and stream features.

Structure 5. Logs, boulders, and tree tops create low velocity backwater. Tree tops and cobble provide winter cover. Additional log and tree top added in 1998.

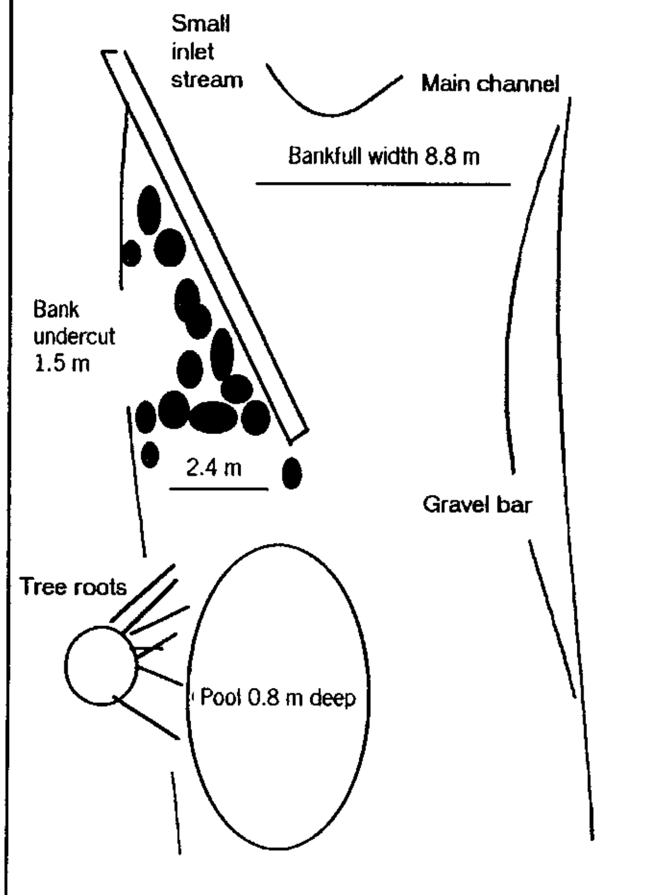


Structure 6. Diagonal log creates backwater area. Limbs and cobble provide cover for juvenile fish.

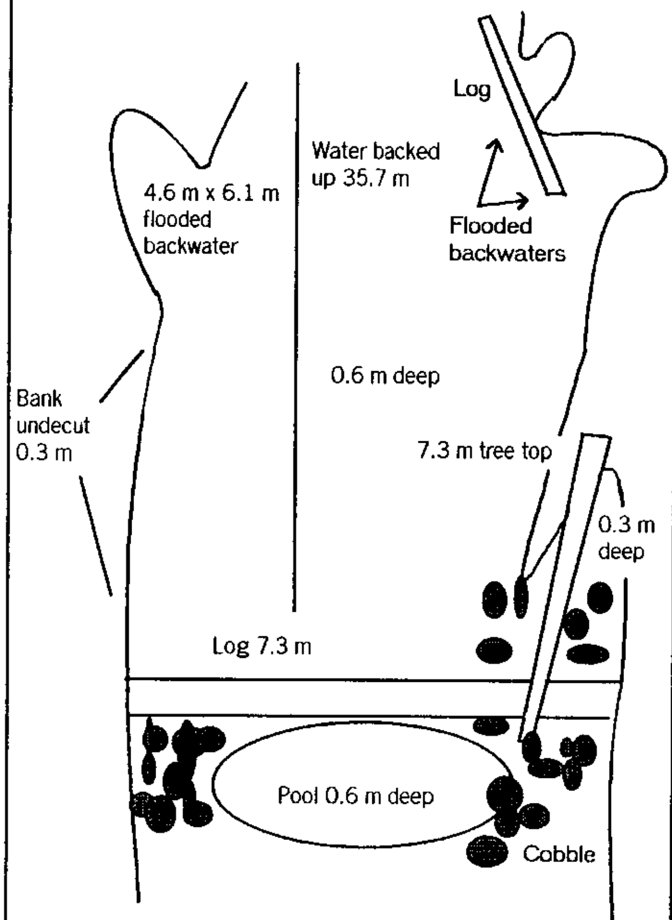


Appendix 1 continued. Diagrams showing structures built, habitat, and stream features.

Structure 7. Diagonal log barb reduces velocity in undercut bank and tree root area, cobble provides additional cover.

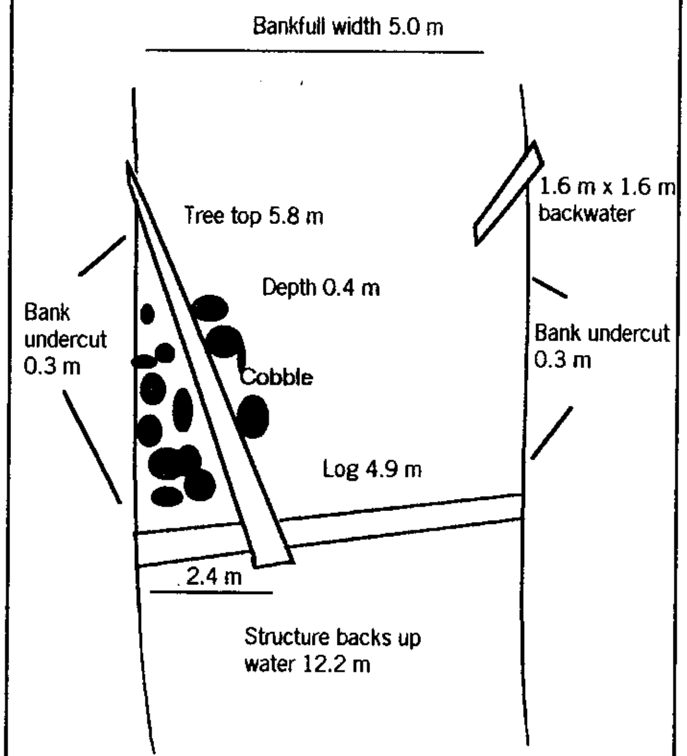


Structure 8. Single log drop structure deepens and maintains water levels in upstream habitat, lowers velocities, creates pool downstream. Tree top and cobble provide cover.

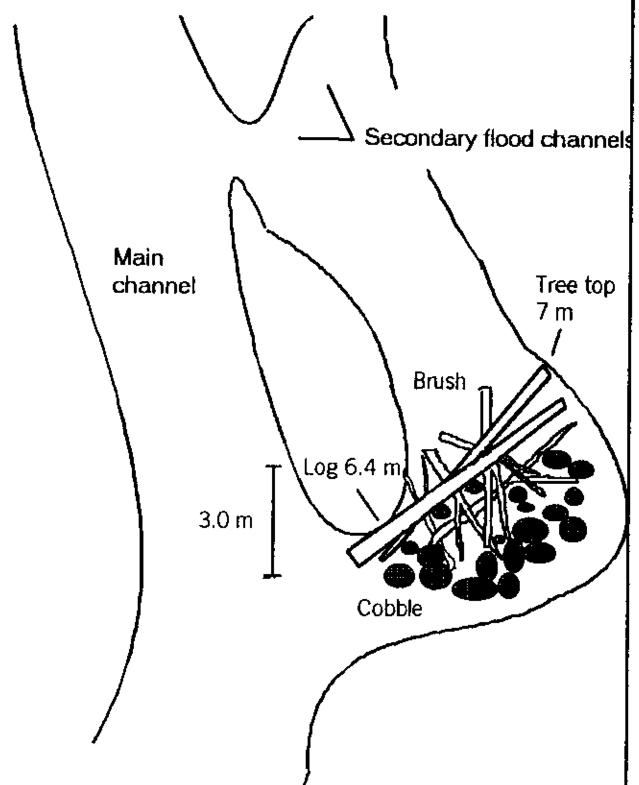


Appendix 1 continued. Diagrams showing structures built, habitat, and stream features.

Structure 9. Anchor pulled, structure failed.

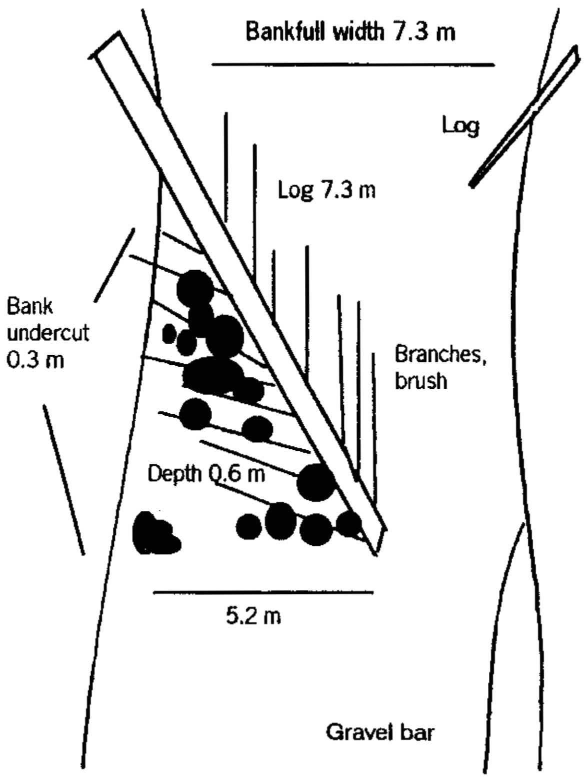


Structure 10. Single log and tree top provide shelter during high spring flows. Cobble provides winter cover. Brush added in 1998 gives additional protection from flows and winter cover.



Appendix 1 continued. Diagrams showing structures built, habitat, and stream features.

Structure 11. Diagonal log barb creates backwater area. Branches, brush, and cobble provide winter cover.



Structure 12. Diagonal log barb and tree top reduce velocities and provide complex habitat. Cobble provides additional winter cover.