Appendix C8. Out-Migrant Smolt Trapping

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C8.1 INTRODUCTION

Juvenile salmonid out-migrant (emigrant) smolt trapping has been conducted on several Plan Area streams since 1999. The out-migrant trapping project is designed to monitor the abundance, size, and timing of out-migrating smolts, and to look for long term trends in any or all of these variables. This trapping program is conducted to obtain annual population estimates on emigrating salmonid smolts (coho salmon, chinook salmon, steelhead trout and coastal cutthroat trout). The results of the out-migrant trapping are used in conjunction with the summer population monitoring to estimate overwinter survival in those streams monitored. The juvenile out-migrant trapping also helps to identify factors affecting smolt emigration timing, and establish baseline and long-term trend data on the abundance of juvenile salmonid populations in the watersheds monitored.

During March through July, 1999 Green Diamond conducted juvenile out-migrant trapping for salmonids on the Lower South Fork of the Little River (LSFLR), Upper South Fork of the Little River (USFLR) and Railroad Creek (RRC). These three creeks are all located in the Little River drainage and in the Little River HPA. During March through June, 2000 Green Diamond again conducted juvenile out-migrant trapping for salmonids on the LSFLR, USFLR and RRC as well as adding Carson Creek (CC) to the monitoring program. Like the other three creeks, Carson Creek is located in the Little River drainage.

C8.2 METHODS

C8.2.1 Trapping

Trapping was conducted using a V-notch weir, pipe, and a live-box to capture the juvenile salmonids (Figure C8-1). A second box was attached to the primary box to reduce in-trap predation. Fine mesh screen separated the entrances between the two boxes to serve as a barrier to separate larger fish from the smaller fish. Additional rock cover was provided within the live boxes to serve as refugia for young of the year (YOY) fish. The weirs were constructed with fence posts and wooden pallets. A weir overflow was constructed to provide adult fish passage upstream. The pipe emptied out onto a McBane ramp that dissipated the velocity of the water and gently guided the fish into the box trap. Inside the trap there is a V-shaped panel which creates a large slack water area in the box. This provides an area where the fish can be protected from the stream's current. In 1999, the trap was operated 24 hours a day and checked daily each morning. In 2000, the traps were checked twice daily, in the morning and in the evening. During periods when significant numbers of out-migrants were captured, the trap was checked more frequently as needed. The captured juvenile fish were anesthetized with Alka Seltzer™, identified, measured (fork length) and most were immediately released below the weir.

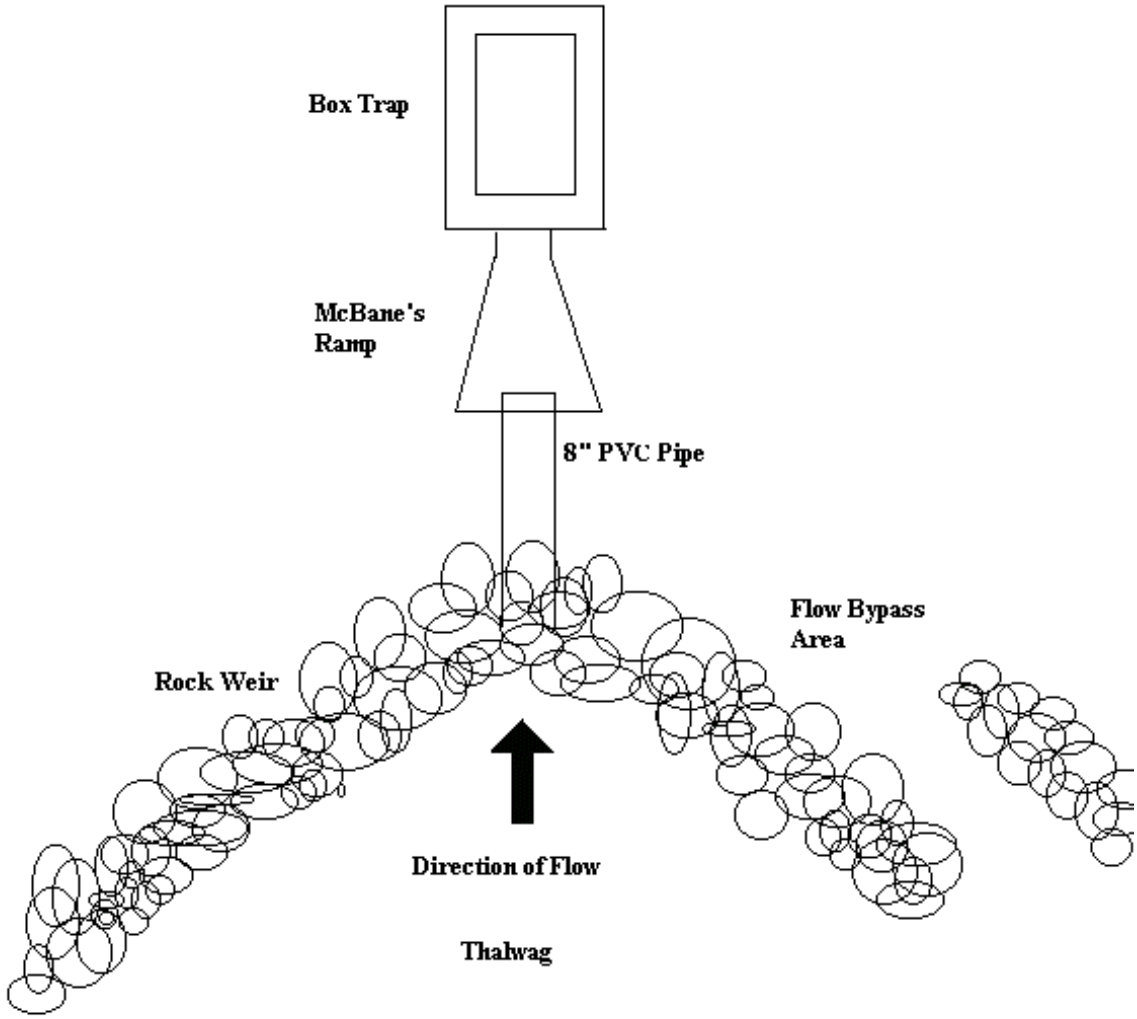

Figure C8-1. Out-migrant fish trapping system (not shown to scale),

Steelhead and cutthroat trout one year or older had their stomachs pumped (gastric lavage) to determine if predation had possibly occurred in the live-box. A subsample of all smolted salmonids were fin clipped (caudal) and released upstream of the weir to determine the trap efficiency. The fin clipped smolts were held in separate live box to determine any possible mortality associated with handling and marking the fish. The smolts were released during the evening trap check period. Recaptured fish from the trap efficiency tests were not used again for subsequent efficiency tests. All caudal fin clip samples from juvenile coho salmon were collected and stored in individual coin envelopes. The samples were air-dried on filter paper and sent to the Bodega Marine Laboratory, University of California. That institution is conducting a study on the genetic variation and population structure of coho salmon in California. Green Diamond is also sending tissue samples from coho carcasses collected during adult escapement surveys to the UC Bodega Bay Marine Laboratory for genetic analyses.

Trap efficiency was calculated by using only species that were actively leaving the drainage on their seaward migration (defined as smolts). Smolts received a fin clip. Four different clips were used throughout the trapping season to test trap efficiency. The easiest clips to identify are caudal fin clips. They were released upstream of the weir in the evening. This allowed the fish ample recovery time and allows for checking for possible mortality from the clipping and handling of them.

C8.2.2 Stomach Pumping (Gastric Lavage)

1+ and older cutthroat and steelhead underwent a stomach pumping procedure to determine predation in the live box. No adult run-back steelhead underwent the pumping procedure. In 1999 the size of the fish that under went gastric lavage ranged from 62-341mm in length. In 2000 the size of the fish ranged from 62-332mm in length. Anesthetized fish were pumped by inserting a small tube down their throat and into their stomach. Water was then pumped into their stomach through the tube. Once the stomach is filled with water, the stomach contents spill out. The contents were then processed. Items were identified to species if possible. After identification the contents were stored in zip-lock bags and preserved with isopropyl alcohol. The pumped fish were placed in a recovery bucket and monitored for approximately one hour prior to their release downstream of the weir. Any stomach pumped smolts were held in a live trap and released during the evening trap check.

C8.3 RESULTS

C8.3.1 Drainage Area and Length of Streams Trapped

A summary of the 1999 project stream drainage area and lengths of utilized habitat above the traps is provided in Table C8-1. In 1999, Green Diamond also quantified habitat conditions in these three streams to assess the survival of juvenile populations in varying freshwater habitats. A summary of the stream drainage and length of utilized habitat above the out-migrant trap during the 2000 out-migrant-trapping project is provided in Table C8-2.

Table C8-1. Drainage area and length of utilized habitat above the trap location for each creek in the 1999 out-migrant trapping study.

	USFLR	LSFLR	Railroad Creek
Drainage area (sq. miles)	5.70	5.31	2.75
Length of available habitat (miles)	1.50	2.16	1.21

Table C8-2. Drainage area and length of utilized habitat above the trap location for each creek in the 2000 out-migrant trapping study.

	USFLR	LSFLR	Railroad Creek	Carson Creek
Drainage area (sq. miles)	5.70	5.31	2.75	3.81
Length of available habitat (miles)	1.1	2.2	0.5	≈2.0

C8.3.2 Population Estimates

Out-migrant smolt population estimates were generated using a preliminary version of software for analysis of stratified mark-recapture data (Bjorkstedt, 2000). The summary of the smolt out-migrant population estimates and their 95% confidence intervals are shown in Table C8-3.

Table C8-3. Summary of the out-migrant population estimated for the years 1999 and 2000.

Coho	**1999**		**2000**	
	Estimate	95% CI	Estimate	95% CI
LSFLR	293	± 21	1,682	± 60
USFLR	27	± 13	147	± 25
Carson Ck	Did Not Trap		1,802	± 30
Railroad Ck	21	± 4	68	± 1
Steelhead	**1999**		**2000**	
	Estimate	95% CI	Estimate	95% CI
LSFLR	103	± 27	46	± 43
USFLR	50	± 7	72	± 3
Carson Ck	Did Not Trap		12	± 3
Railroad Ck	46	± 16	14	± 1
Cutthroat	**1999**		**2000**	
	Estimate	95% CI	Estimate	95% CI
LSFLR	108	± 28	22	± 4
USFLR	35	± 10	13	± 7
Carson Ck	Did Not Trap		60	± 6
Railroad Ck	50	± 5	23	± 1

C8.3.3 Over Wintering Survival

Overwintering survival is calculated by dividing the winter population by the summer population. One of the key assumptions with overwintering survival is that none of the fish in the summer population estimate migrate prior to the downstream migrant trapping being installed. The summer and winter population estimates are shown in Table C8-4.

Table C8-4. Summary of the summer and winter population estimates for the tributaries of the Little River for 1998-1999 and 1999-2000.

Stream	Coho (YOY) Summer Population	Coho Smolts Winter Population	Overwintering Survival Estimate	Drainage Area (Sq. miles)	Miles of Habitat	Summer Fish/Mile	Winter Fish/Mile
	1998	**1999**					
USFLR	738	27	3.7%	5.70	1.5	492	18
LSFLR	3,610	293	8.1%	5.31	2.2	1,641	133
RR Ck	249	21	8.4%	2.75	1.2	208	18
	1999	**2000**					
USFLR	1,230	147	12.0%	5.70	1.1	1,118	134
LSFLR	7,903	1,682	21.3%	5.31	2.2	3,592	765
RR Ck	339	69	20.4%	2.75	0.5	678	138
Carson Ck	NA	1,802	NA	3.81	≈2.0	NA	901

C8.3.4 Species Composition

In 1999 juvenile out-migration trapping captured several different fish (and amphibian) species within the Little River drainage (Table C8-5). The majority of the fish captured were in the genus *Oncorhynchus*. However, there was incidental capture of non-target species mostly lamprey and amphibians. Table C8-6 summarizes the total number of salmonid smolts that were captured and recaptured for all streams in 1999. From these results the Lower South Fork Little River was the most productive coho stream of those trapped in 1999. Trapped fish were identified to species when possible. Due to the similarities between YOY steelhead and YOY cutthroat trout these were grouped into the trout category. All coho, chinook and trout (YOY cutthroat and steelhead) were YOY fish, while all steelhead and cutthroat trout were 1+ fish or older. Some of the 1+ steelhead were determined to be run-back steelhead returning to the ocean. The total numbers of all salmonids trapped in 1999 are summarized below (Table C8-7). The USFLR and LSFLR produced significant numbers of trout and chinook in addition to coho salmon. Table C8-8 summarizes the total number of salmonid smolts that were captured and recaptured for all streams in 2000. From these results Carson Creek was the most productive coho stream trapped.

In 2000 adult cutthroat trout were defined as fish >200mm and not showing signs of smoltification. The total numbers of all salmonids captured in 2000 are shown in Table C8-9. The Lower South Fork Little River and Carson Creek were the most productive coho streams, while both the Upper South Fork Little River and Lower South Fork Little River produced significant numbers of trout and chinook.

There were some mortalities associated with the trapping process. The summary of the trapping mortality in 1999 and 2000 are provided in Tables C8-10 and C8-11 respectively. This summary also includes the mortalities associated with the stomach pumping (gastric lavage) procedure Tables C8-12 and C8-13. Improvements in trap design and trapping procedures were made throughout the trapping season in an effort to reduce these mortalities.

Table C8-5. Species captures during out-migrant trapping in the Little River drainage in 1999 and 2000.

Common Name	Scientific Name	1999	2000
Coho Salmon	*Oncorhynchus kisutch*	X	X
Chinook Salmon	*Oncorhynchus tshawytscha*	X	X
Steelhead	*Oncorhynchus mykiss*	X	X
Coastal Cutthroat Trout	*Oncorhynchus clarki clarki*	X	X
Pacific Lamprey	*Lamperta tridentata*	X	X
Western Brook Lamprey	*Lamperta richardsoni*	X	X
Pacific Giant Salamander	*Dicamptodon ensatus*	X	X
Tailed Frog	*Ascaphus truei*	X	X
Prickly Sculpin	*Cottus asper*		X
Three-Spined Stickleback	*Gasterosteus aculeatus*		X

Table C8-6. Trapping totals for clipped and recaptured smolts in 1999.

Stream	Clipped Smolts			Recaptured Smolts		
	Coho	Steelhead	Cutthroat	Coho	Steelhead	Cutthroat
LSFLR	220	36	40	187	13	19
USFLR	15	30	18	9	20	10
Railroad Ck	15	18	35	12	10	25
Total	250	84	93	208	43	54

Table C8-7. Trapping totals for unclipped fish in 1999.

Stream	Unclipped Fish				
	Coho	Steelhead	Cutthroat	Trout	Chinook
LSFLR	3,543	454	57	10,435	5,812
USFLR	599	778	112	14,503	4,133
Railroad Creek	422	281	88	4,131	0
Total	4,564	1,513	257	29,069	9,945

Table C8-8. Trapping totals for captured and recaptured smolts in 2000.

Stream	Captured Smolts			Recaptured Smolts		
	Coho	Steelhead	Cutthroat	Coho	Steelhead	Cutthroat
LSFLR	1,104	34	15	522	19	13
USFLR	100	57	7	72	42	5
Carson Ck	1,408	7	43	612	4	31
Railroad Ck	63	12	21	56	10	16
Total	2,675	110	86	1,262	75	65

Table C8-9. Trapping totals for unclipped fish in 2000.

Stream	Unclipped Fish				
	Coho (YOY)	Steelhead	Cutthroat	Trout (YOY)	Chinook (YOY)
LSFLR	1,911	509[a]	50[e]	4,911	3,680
USFLR	140	960[b]	31[f]	5,451	5,277
Carson Ck	131	504[c]	296[g]	1,481	874
RRC	763	850[d]	44[h]	1,228	0
Total	2,945	2,823	421	13,071	9,831

Notes
[a] 16 of steelhead were adult
[b] 17 of steelhead were adult
[c] 2 of steelhead were adult
[d] 6 of steelhead were adult
[e] 7 of cutthroat were adult
[f] 4 of cutthroat were adult
[g] 23 of cutthroat were adult
[h] 6 of cutthroat were adult

Table C8-10. 1999 in-trap mortality.

Stream	In-Trap Mortality				
	Coho (YOY)	Steelhead (1+)	Cutthroat (1+)	Trout (YOY)	Chinook (YOY)
LSFLR	23	4	0	155	56
USFLR	3	1	1[a]	318	58
Railroad Creek	3	2	1[a]	157	0
Total	29	7	2	630	114

Note
[a] These fish were killed in the gastric lavage procedure

Table C8-11. 2000 in-trap mortality.

Stream	In-Trap Mortality					
	Coho Smolts	Coho (YOY)	Steelhead (1+)	Cutthroat (1+)	Trout (YOY)	Chinook (YOY)
LSFLR	4	7	5	0	77	23
USFLR	1	1	5	0	105	74
CC	8	7	4	1	46	19
RRC	1	3	2	0	24	0
Total	14	18	16	1	252	116

Table C8-12. 1999 predation mortality determined from gut contents from stomach pumping.

Stream	Predation Mortality				
	Coho (YOY)	Steelhead (1+)	Trout (YOY)	Chinook (YOY)	Salmonids (YOY)
LSFLR	112	6	934	361	105
USFLR	30	3	1,731	329	119
Railroad Creek	82	1	1,162	0	50
Total	224	10	3,827	690	274

Table C8-13. 2000 predation mortality determined from gut contents from stomach pumping.

Stream	Predation Mortality					
	Coho (Smolt)	Coho (YOY)	Steelhead (1+)	Trout (YOY)	Chinook (YOY)	Salmonids (YOY)
LSFLR	9	89	5	157	133	84
USFLR	1	4	2	578	265	153
Carson Ck	15	11	9	141	244	49
Rail Road Ck	2	39	7	212	0	44
Total	27	143	23	1,088	642	330

Contents from stomach pumping conducted during the 1999 and 2000 trapping program were identified to species if possible (Tables C8-12 and C8-13). Some of the items were digested to a point to which species could not be determined but fish were positively identified as juvenile salmonids. All preyed on coho, chinook, trout and salmonids were young of the year (YOY) fish. The preyed on steelhead were 1+ fish. Some of the other contents identified from stomach pumping from the 1999 trapping included: aquatic invertebrates, salmonid eggs, Pacific giant salamanders, tailed frog tadpoles and one mouse.

C8.3.5 Size and Condition

Salmonid growth increases at varying rates depending on the abundance of aquatic insects and plant life during critical rearing periods (Murphy and Meehan 1991). Size can also be influenced by density related competition. The fork lengths of the first 20 YOY coho (fork length) were measured to the nearest mm. The remaining individuals were counted but not measured. All smolts were measured. Table C8-14 shows the range of coho lengths measured in 1999 as well as their average length by age for each stream. All fish handled appeared to be in good condition and length of YOY fish increased steadily as the trapping season progressed. Table C8-15 shows the range of coho lengths and weights as well as their average length by age for each stream as measured in 2000. All fish handled appeared to be in good condition and lengths and weights of YOY fish increased steadily as the trapping season progressed.

Table C8-14. Average and range of lengths (mm) of coho salmon in USFLR, LSFLR, and Railroad Creel in 1999.

Length	USFLR		LSFLR		Railroad Ck	
	Smolts	YOY	Smolts	YOY	Smolts	YOY
Range (mm)	96-114	34-50	81-136	32-58	98-124	31-49
Avg. Length (mm)	102.9	37.5	104.6	39.3	110.6	37.9

Table C8-15. Average range of lengths and weights of coho salmon trapped in USFLR, LSFLR, Carson Creek, and Railroad Creek in 2000.

	USFLR		LSFLR		Carson Creek		Railroad Ck	
	Smolts	YOY	Smolts	YOY	Smolts	YOY	Smolts	YOY
Length Range (mm)	80-120	34-59	65-139	29-64	68-135	28-51	78-115	31-69
Avg. Length (mm)	103.0	46.9	94.3	42.5	97.9	40.5	96.0	45.5
Weight Range (gms)	5.8-22.4	0.4-2.1	3.3-27.7	0.1-2.9	3.4-24.0	0.4-1.6	5.3-16.3	0.2-2.3
Avg. Weight (gms)	12.7	1.1	9.9	0.7	10.3	0.7	9.8	0.9

C8.3.6 Migration Timing

In 1999 the migration of coho smolts began in April and continued into June (Figure C8-2). Factors that affect the timing of migration include the size of the fish, flow conditions, water temperature, dissolved oxygen levels, day length, and availability of food (Shapovalov and Taft 1954). The peak days of migration within USFLR and LSFLR were determined to be May 19, 1999 and April 24 within Railroad Creek. The peak period of migration lasted from the last week of April to the end of May. Migration tapered off after approximately May 3rd. This slow down coincided with a rain storm event. Figure C8-3 shows the flow of the Little River during the period of smolt migration.

In 2000, migration of coho smolts began in March and continued into June (Figure C8-4). The migration peak for Carson Creek and LSFLR occurred on April 4th 2000 and on April 14th 2000 respectively. The LSFLR had an additional peak on April 26th 2000. There were no significant peaks on Railroad Creek and USFLR in 2000. There were two periods approximately April 17th and May 11th when migration tapered off, coinciding with a storm event. Figure C8-5 shows the flow of the Little River during the period of coho smolt out-migration.

C8.4 DISCUSSION

Lower trapping efficiency is experienced during peak flow events. As shown on Figure C8-2 reduced numbers of fish are trapped during peak flow events (Figure C8-3). In 1999 a large number of smolts were trapped just prior to a peak event on May 3rd and large number were again trapped a few days after that peak event. Green Diamond believes that there are a large number of fish emigrating from the streams during these peak events.

During 1999 there was some mortality associated with the trapping. These losses were reduced by continually improving the trapping methodology and trapping equipment throughout the trapping season. It was determined that on trapping days where there was high volumes of debris loading into the traps there was a corresponding higher trap mortality. To reduce this mortality, an extra screen to catch and filter out debris was added to the traps. Traps were checked and debris was cleaned out in the evening as well as mornings on rainy or windy days. This effort helped to reduce mortality and was continued in 2000. During 1999 some mortalities were observed when fish were stranded onto dry portions of the McBane ramp. A plastic splash shield was installed that immediately solved this stranding problem.

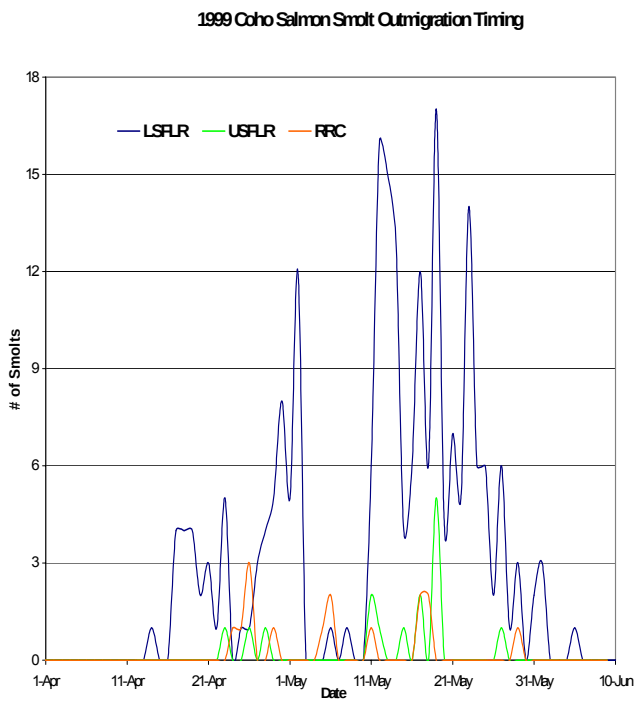

Figure C8-2. Migration timing for smolts for the 1999 trapping study in Little River.

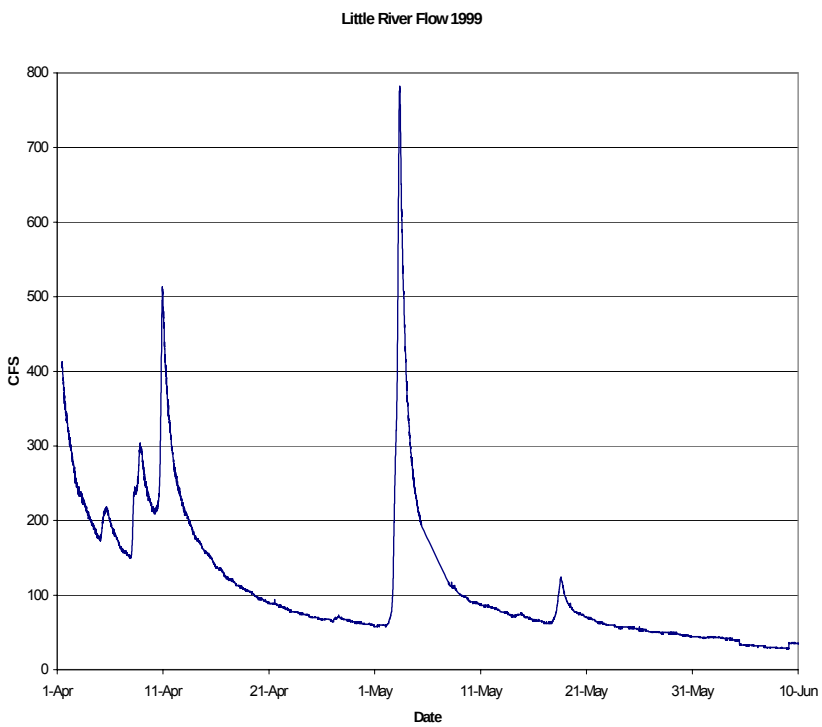

Figure C8-3. Little River flow (CFS) during 1999 peak smolt out-migration.

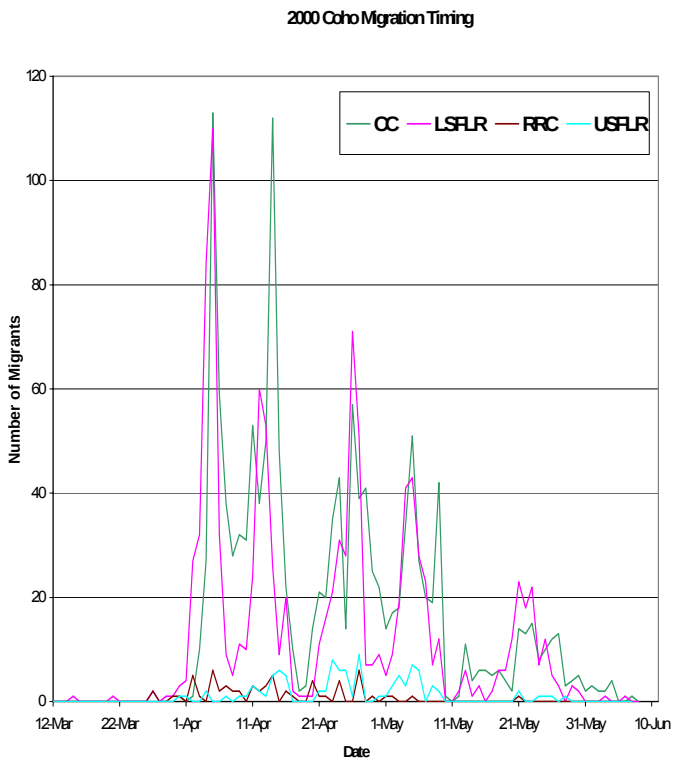

Figure C8-4. Migration timing for smolts for the 2000 trapping study in the Little River.

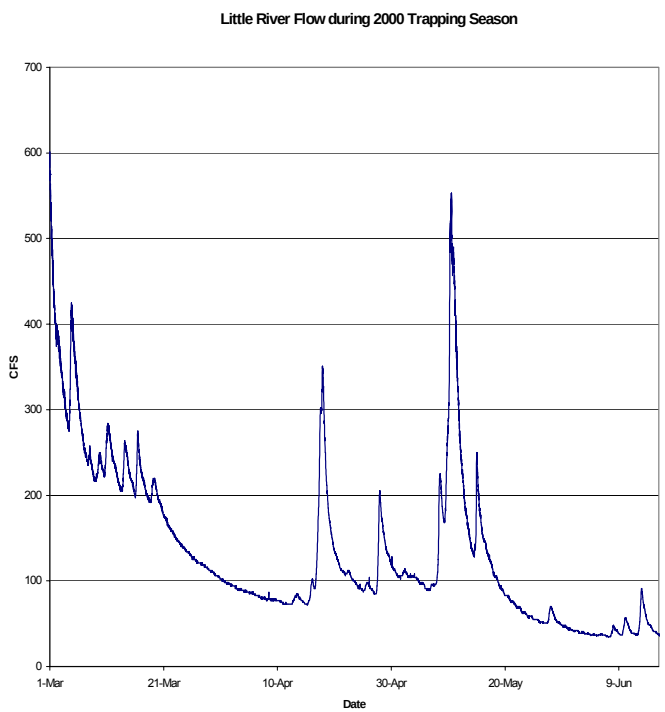

Figure C8-5. Little River flows (CFS) during peak out-migration in 2000.

Most of the trapping mortality was from loss of YOY fish. No smolts of any species were lost during trapping in 1999. There were only 2 mortalities from the stomach pumping procedure in 1999 (Table C8-12). Both of these mortalities were from improper insertion of the pumping tube while a new employee was learning the procedure.

During the 2000 trapping project lower sampling efficiency during peak flow events were again noted. Reduced numbers of fish (Figure C8-4) illustrates this during peak flow events (Figure C8-5). A good number of smolts were trapped just prior to peak events and a few days after the peak event. It is likely that a large number of fish leave the systems on these peak events because the creeks are confined channels with no flood plains. During these events the fish may be flushed out when the flows and velocities are high and the traps are relatively inefficient.

Over wintering survival rates were better in 2000 than in 1999. The increased survival rates may be higher due to the smolts leaving during the peak flow events. To determine an over-winter survival rate from the summer and winter population estimates it must be assumed that there is a closed population. This is not necessarily true. The first few days of trapping in 2000, in the LSFLR, several pre-smolt coho salmon were captured. From this observation, it appears that a portion of the coho began emigrating prior to the installation of the weir. Early pre-smolt migration violates the closed population assumption prior to pre-weir installation. In the future, trapping weirs will be installed earlier in the season to determine if a significant portion of the population begins emigration prior to the completion of smoltification. If a large number of coho are actively dispersing downstream during the winter rather than actively emigrating following smoltification during the spring, this would account for a relatively low over-winter survival rate. At the present time the survival rate of fish that disperse downstream as pre-smolts during the winter months is unknown.

In 2000, there were large numbers of mortalities associated with predation during trapping. In an effort to minimize predation during trapping, extensive refuge (cover) was provided for the YOY fish as they moved to the rear trapbox. The provision of this cover will exclude the predatory fish while provide refuge to the smaller YOY fish. Green Diamond is continuing its effort to reduce in trap predation by working with a graduate student from Humboldt State University (HSU) to develop an improved live trap box design. The student is conducting experiments to see if differently designed boxes that have different mesh separating devises help reduce predation mortality. Students from HSU are also looking at predation outside of the live boxes to determine how many of the prey items were eaten prior to being trapped. At the present time it is unknown whether the fish that are evaluated for predation are consuming their prey prior to entering the trap or while in the trap. In many cases the advanced stages of deterioration of the material within the stomach of the predatory fish indicates that it is likely that the preyed upon fish were consumed prior to being trapped.

There was also some continuing mortality associated with the trap design in 2000. Improvements were incorporated throughout the trapping season. On days where there were high amounts of organic debris loading in the traps, an increased mortality is expected. There was also some continuing mortality of fish stranding themselves onto a dry portion of the McBane ramp or into a debris deposit after coming out of the pipe. To reduce this mortality two new design elements were developed. An extra screen, to catch and filter out debris, and plastic sheeting on the McBane ramp, which prevented debris accumulation during lower flow conditions, were added to each trap. Also, the

traps were checked in the evening on rainy or windy days to clean out the debris on the filter screen and inside the box trap. This combination of efforts significantly reduced mortality of YOY fish and thus will be continued and fine tuned in the future.

In 2000, from the stomach analysis, it was determined that the most common prey was YOY trout. This was followed, in order, by: YOY chinook salmon, YOY un-identified salmonids, YOY coho salmon, coho salmon smolts and 1+ steelhead. The coho smolts and 1+ steelhead were eaten by large predatory cutthroat trout. It was determined that during trapping, prey consumption followed the same order as fish abundance. The most abundant fish (YOY trout) were also most commonly recovered from the stomachs of the fish that were pumped. The only exception to this was the unidentifiable YOY salmonids. This finding suggests that there was no prey item preferred and actively selected over another.

C8.5 CONCLUSION

The use of out-migrant trapping is an excellent tool for collecting downstream migrants and is Green Diamond's best opportunity to collect information pertaining to coho production in the Little River drainage. The use of a box trap, McBane ramp, pipes and weir trapping system efficiently trap streams during low and normal flow. The out-migrant trapping program is in its preliminary stages and it is too early to determine population trends.

C8.6 REFERENCES

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