2003 Update for the Englishman River Coho Smolt Enumeration Program

by

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1.0 INTRODUCTION

Since the early 1980s, concern has been voiced about declining returns of coho salmon and other anadromous species to the Englishman River. In 1988, Fisheries and Oceans Canada (DFO) began working to rehabilitate coho salmon and other salmonid populations in the Englishman River through hatchery enhancement and habitat restoration. A major initiative for coho was the construction of two side-channels to provide off-channel spawning and rearing habitat.

During 1998, 1999, 2001, and 2002, the numbers of coho smolt outmigrants from the two side-channels and from the mainstem/tributary area of the Englishman River were assessed in order to determine the contribution of the two side-channels to overall smolt production in the system (Decker et al. 2003). During these study years, total production for the system ranged from 31,005 to 50,622 smolts, with the contribution from the side-channels ranging from 15% to 25%. As part of the Englishman River Salmon Maintenance Plan (ERSMP), this monitoring program was continued in the spring of 2003. The primary objective continues to be to determine the contribution of the two side-channels to overall smolt production and to assess the health of the Englishman River coho stock. Here we present the results for 2003.

2.0 METHODS

The study design and field methods used to estimate coho smolt population from the side-channel and the mainstem/tributary area of the Englishman River in 2003 were similar to those used in 2001 (Decker et al 2003) and 2002 (Decker and Schick 2003). Here, we briefly describe the methods and note deviations from past studies.

2.1 Study area

The Englishman River is situated southwest of the City of Parksville on Vancouver Island (Figure 1). The river is about 28 km in length and drains a watershed area of 324 km^2. Mean annual discharge during 1980 to 1998 was 13.8 cms, with observed maximum and minimum discharges of 454 cms and 0.1 cms, respectively (Water Survey of Canada, unpublished data).

The Englishman River Falls, located approximately 16 km upstream of the mouth, creates a natural migration barrier to all anadromous fish. The main tributaries contributing to anadromous fish habitat are the South Englishman River (4.5 km of accessible habitat; Figure 1), Centre Creek (5.2 km accessible), Morison Creek (2.1 km accessible) and Shelley Creek (3.0 km accessible), for a total anadromous habitat in the watershed of 31 km (see Decker et al. 2003 for a map of the Englishman River watershed). The lower 8 km of the Englishman River and the accessible portions of the tributaries are low gradient (< 2%), and provide the majority of juvenile salmonid habitat.

As part of the ERSMP, two side-channels were constructed in the Englishman River to provide spawning, rearing and overwintering habitat, primarily for coho salmon. The channels are located on the lower Englishman River, with the Timber West Channel

approximately 7 km upstream from the estuary and just below the Morison Creek confluence, and the Weyerhaeuser Channel, about 1 km downstream of that site.

The Timber West Channel was constructed in 1992. It is approximately 1,380 m long, and provides about 11,421 m^2 of side-channel habitat interspersed with 6,288 m^2 of pond habitat, for a total wetted area of 17,709 m^2.

The original Weyerhaeuser Channel was constructed in 1989, and consisted of a 600 m long groundwater-fed channel with a wetted area of approximately 4,000 m^2. In September 1998, improvements were made to this site, including installation of a surface water intake and addition of large woody debris. Also, a new channel section and two shorter, blind channels were added. As a result of this expansion, the channel length was increased to 950 m and the wetted area to 6,000 m^2.

The above side-channels were created by excavating portions of the floodplain parallel to the river mainstem, and are protected from mainstem flooding by set-back dykes. Flow is derived from groundwater upwelling and from controlled surface water diversions from the mainstem. The channel portion of each site resembles a small, low gradient (0.5%) stream. The channels consist of roughly 80% rearing (pool) and 20% spawning (riffle) habitat. Wetted channel width ranges from 2.5 m to 20 m, and channel depth from 20 cm to 60 cm. Pool depth ranges from 0.5 m to 1.5 m. Discharge is low (< 1 cms) and relatively stable year-round. Channel substrate is composed of either native or introduced gravels (size range: 2-10 cm).

2.2 Side-Channel and Center Creek smolt populations

Coho outmigrants from the Weyerhaeuser and Timber West side-channels and Center Creek, a major fish-producing tributary in the lower Englishman River, were enumerated at converging downstream weirs located in the same sites used in previous years (see Decker et al. 2003). Weirs were operated daily from April 8 to June 6 in Center Creek and from April 8 to June 8 in the side-channels. Since no weir failures or overflows were observed, we assumed 100% capture efficiency (CE) for all three weirs. To adjust for the number of smolts in the side-channels below the weirs, for each side-channel, the number of smolts captured at the weir was factored by the ratio of the total wetted area of the side-channel (m^2) to the area of the side-channel above the weir (Timber West = 1.07, Weyerhaeuser = 1.30). No conversion factor was needed for counts from the Center Creek weir since it was situated just upstream of its confluence with the Englishman River.

2.3 Englishman River smolt population estimates

The total abundance of coho smolts in the Englishman River system was estimated using marked smolts from the three weirs (Timber West and Weyerhaeuser side-channels and Center Creek; hereafter referred to as the side-channel mark group). And the numbers of marked and unmarked coho captured in two rotary screw traps (RSTs) in the Englishman River mainstem. The RST's were situated 1.9 km (RST 1) and 4.0 km (RST 2) above the tidewater. Each RST intercepted approximately 25% of total discharge at the site. The

RSTs were checked daily from April 13 to May 25, and every other day from May 26 to June 8.

Different from 2002, there were only two mark groups[1]: the previously described side-channel mark group and smolts captured and marked at the upper RST (RST 2 mark group). For the side-channel mark group, coho smolts received one of three marks that corresponded to three, temporally stratified release periods (see Appendix 1). Smolts captured at RST 2 were given the same mark (unique from the marks used for the side-channel mark group) throughout the sampling period.

2.4 Mark-recapture statistics

To estimate the number of smolts passing RST 2, we used smolts from the side-channel mark group as the marked population, and an estimator appropriate for stratified mark-recapture data (Darroch maximum likelihood; Darroch 1961). We generated two independent estimates of the number of smolts passing RST 1 using the side-channel and RST 2 mark groups. For the RST 2 mark group, with only one release period, we used the pooled Peterson estimate (PPE) in place of the Darroch ML estimate. The principle advantage of the Darroch ML estimator over the PPE is that it accounts for variation in capture efficiency over time, which can be an important source of bias (see Decker et. al. 2003 or Decker and Schick 2003 for a more complete description of the two estimators, the assumptions they rely on, and potential sources of bias).

In summary, we computed three independent estimates of the total number of coho smolts for the Englishman River system: one estimate based on recoveries from the side-channel mark group at the upper RST (RST 2), and two estimates based on recovery of the two mark groups at the lower RST (RST 1). As an example, using recovery data from RST1, the estimate of the number of wild smolts that outmigrated from the entire anadromous portion of the Englishman River including the side-channels and the mainstem area downstream of RST 1 would be

$$N_{Total} = (N_{RST\,1}) \times L_{total} / L_{upstream} \quad (1.1)$$

$$95\%\ CI\ (N_{Total}) = 95\%\ CI\ (N_{RST\,1}) \times L_{total} / L_{upstream} \quad (1.2)$$

where

L_{total} = total anadromous length of the Englishman River system including the mainstem, tributaries, and the side-channels (33.4 km)
$L_{upstream}$ = total length of the Englishman River system upstream of RST 1 (31.5 km).

The estimate of the number of smolts that outmigrated from the mainstem/tributary area of the Englishman River excluding the side-channels would be

[1] Center Creek smolts were marked differently from side-channel smolts in 2002.

$$N_{Mainstem/tributary} = N_{Total} - N_{side\text{-}channels} \quad (1.3)$$

$$95\%\ CI\ (N_{Mainstem/tributary}) = 95\%\ CI\ (N_{Total}) \quad (1.4)$$

3.0 RESULTS AND DISCUSSION

3.1 Side-channels and Center Creek

In 2003, the numbers of coho smolts captured at the Timber West and Weyerhaeuser side-channel weirs were 4,547 and 526, respectively. When these estimates were extrapolated to include the area between each weir and the channel confluence with the Englishman River, the population estimates for the Timber West and Weyerhaeuser channels were 4,865 smolts (3,526 smolts/km) and 684 smolts (720 smolts/km), respectively (Table 1). Total smolt output for the two side-channels in 2003 was 5,549. The estimated number of smolts outmigrating from Center Creek during 2003 was 3,295 (634 smolts/km; (Table 1).

The assumption of population closure appeared to be reasonably well met for Weyerhaeuser Channel: the shape of the daily catch histogram suggested that the majority of smolts outmigrated from the channel during the sampling period, with low daily catches at the beginning and end of the trapping period (Figure 1). This was less true for Timber West Channel and Center Creek where, despite an apparent peak in smolt outmigration during early (Timber West; Figure 1) or late May (Center Creek), substantial daily catches (approx. 50 smolts/day) were still being recorded at the end of the trapping period. Smolt population estimates for Timber West Channel and Center Creek are biased low, but probably not to a large degree.

3.2 Englishman River population estimates

For each mark group, a summary of the number of smolts marked and then recaptured at each RST is provided in Table 2 along with total catches at each RST and estimates of the number of smolts passing each RST, and total smolt estimates for the Englishman River system.

The population estimates for the Englishman River system based on recoveries from the side-channel[1] and RST 2 mark groups at RST 1 were very similar (side-channel mark group: 43,946 ± 3,631 smolts; RST 2 mark group: 44,417 ± 3,651). Capture efficiency was 5% for both mark groups (Table 2), suggesting that the side-channel mark group estimate was not likely biased as a result of different capture efficiency for marked (side-channel and Center Creek) and unmarked smolts, the latter being mostly of mainstem origin, as were smolts from the RST 2 mark group. The similarity of the estimates also

[1]Prior to computing an estimate for the side-channel mark group, the first and second recover periods were pooled due to the low number of recaptures in the first recovery period (Appendix 1).

suggests that the RST 2 mark group estimate, which was based on only one release period, was robust to possible variation in capture efficiency over time.

The smolt population estimate for the Englishman River system based on recoveries from the side-channel mark group at RST 2 (37,488 ± 2,843 smolts; Table 2) was significantly, but not grossly lower than the two estimates for RST 1 (see above paragraph). Capture efficiency at RST 2 (9%; Table 2) was nearly twice that at RST 1. Because only smolts from the side channel mark group were recovered at RST 2, it was not possible to evaluate the similarity in capture efficiency between mark groups at this site. It was unclear as to why the mark-recapture data from the two RSTs produced different estimates of total smolt abundance. The closer proximity of RST 1 to tidewater should not have been a factor since the estimates for each RST were adjusted based on the distance of the RST from tidewater (see Equation 1.1). Smolt estimates from RST 1 were also higher than those from RST 2 in 2002, (Decker and Schick 2003), but the opposite was true in 2001 (Decker et al. 2003). It is possible that, in 2003, smolt density in the roughly 2 km long mainstem section between the RSTs was considerably higher than that in upstream portions of the Englishman River, but this remains conjecture.

Estimates for the Englishman River system were, at least to some extent, biased low because of failure to meet the assumption of population closure at both RSTs. Although there was evidence of a peak in migration at both traps during May (Figure 1), moderate daily catches (approx. 50 per day) continued to be recorded at the end of the trapping period. In a plot of cumulative smolt captured over time, population closure would be indicated by considerable flattening of the slope prior to the end of trapping. There was some indication of this for both marked and unmarked smolts (Figure 2), but the curve remained relatively steep at the end of trapping, indicating a lack of population closure. In future, operation of the weirs and RSTs should continue as long as significant numbers of smolts are still being captured.

We used the estimate derived from the recovery of smolts from the RST 2 mark group at RST 1 (44,417 ± 3,651; Table 2, second line) as the best estimate of the total number of smolts for the Englishman River system for several reasons: the estimate appeared to be reasonably precise (±8%), RST 1 was the lowermost recovery site in the system, and smolts from the RST 2 mark group originated from the same part of the system as unmarked smolts captured at RST 1 (mainly the Englishman River mainstem). The 2003 estimate for the system was within the range observed in previous study years (31,005 to 50,622 smolts; Decker and Schick 2003; Decker et al. 2003). To estimate the number of smolts for the Englishman River mainstem and tributaries, we subtracted smolt numbers for the side-channels (5,073), resulting in a total of 38,868 ± 3,651 smolts (Table 1). This value was also comparable to previous years' estimates (25,192-42,297 smolts). In 2003 an estimated 12.4% of total number smolts that outmigrated from the Englishman River system originated from the Timber West and Weyerhaeuser side-channels (Table 1). This was lower than in previous years when the two side-channels contributed an estimated 15% to 25% of total smolt numbers (Decker and Schick 2003; Decker et al. 2003).

REFERENCES

Darroch, J.N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. Biometrika 48: 241-260.

Decker, S., M.J. Lightly, and A.A. Ladwig. 2003. The contribution of two constructed side-channels to coho salmon smolt production in the Englishman River. Can. Tech. Rep. Fish. Aquat. Sci. 2442.

Decker, S. and J. Schick. 2003. 2002 update for the Englishman River coho smolt enumeration program. Unpublished report prepared for Fisheries and Oceans Canada, Nanaimo B.C., June 2003.

Seber, G.A.F. 1982. The estimation of animal abundance. 2nd ed. Griffin, London.

Table 1. Summary of estimated coho smolt numbers, 95% confidence intervals, densities and proportion of the system-wide smolt run for the Timber West and Weyerhaeuser side-channels, Center Creek, the Englishman River mainstem (including tributaries), and the entire Englishman River system (including side-channels).

Site	Length (km)	Area (m^2)	Estimation method	N smolts	CI (+/-)	CI %	Smolt density /km	Smolt density /m^2	% of smolt run
Timber West	1.38	17,709	Count	4,865	-	-	3,526	0.26	10%
Weyerhaeuser	0.95	6,000	Count	684	-	-	720	0.09	1%
Side-channels total	2.4	23,709	Count	5,549	-	-	2,312	0.23	12%
Center Creek	5.2		Count	3,295	-	-	634	-	7%
Englishman River mainstem and tribs.	31		Darroch	38,868	3,651	9%	1,254	-	88%
Total system	33.4		Darroch	44,417	3,651	8%	1,330	-	100%

Table 2. Summary of the number of coho smolts marked (M) at the Center Creek and side-channel weirs (side-channel mark group) and RST 2 (RST 2 mark group), the total number of smolts caught (C) and the number of marked smolts recovered (R) at the upper (RST 2) and lower (RST 1) rotary screw traps. Capture efficiency (R/M) for each mark group at each RST is also indicated. The number of smolts that passed each RST and the number for the English River system were estimated using individual mark group data and the Darroch maximum likelihood estimator for stratified data[1]. 95% confidence intervals are given for each estimate.

						Number of smolts passing trap site			Smolt estimate for Englishman River		
Trapping site	Mark group	M	C	R	Capture Efficiency (R/M)	N smolts	CI (±)	CI (%)	N smolts	CI (±)	CI (%)
RST 1	Side-channel	8,210	2,203	431	0.05	41,446	3,424	8%	43,946	3,631	8%
	RST 2	3,485	2,203	186	0.05	41,890 [1]	3,444	8%	44,417	3,651	8%
RST 2	Side-channel	8,210	2,849	750	0.09	32,998	2,503	8%	37,488	2,843	8%

[1] Pooled Peterson estimator was used since only one release period

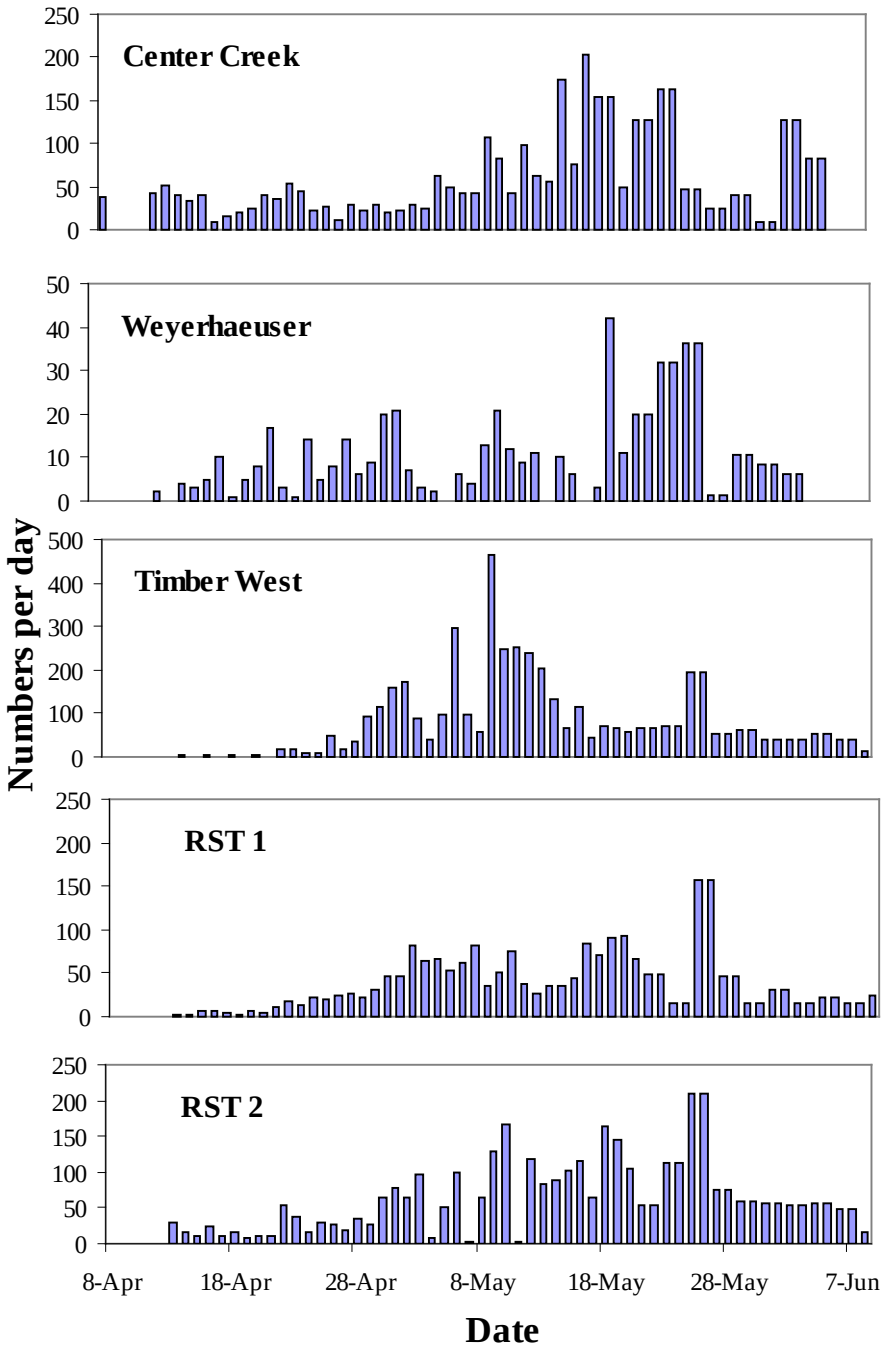

Figure 1. Daily catches of coho smolts at the Timber West and Weyerhaeuser side-channel weirs, the Center Creek weir, and the upper (RST 2) and lower (RST 1) rotary screw traps in the English River.

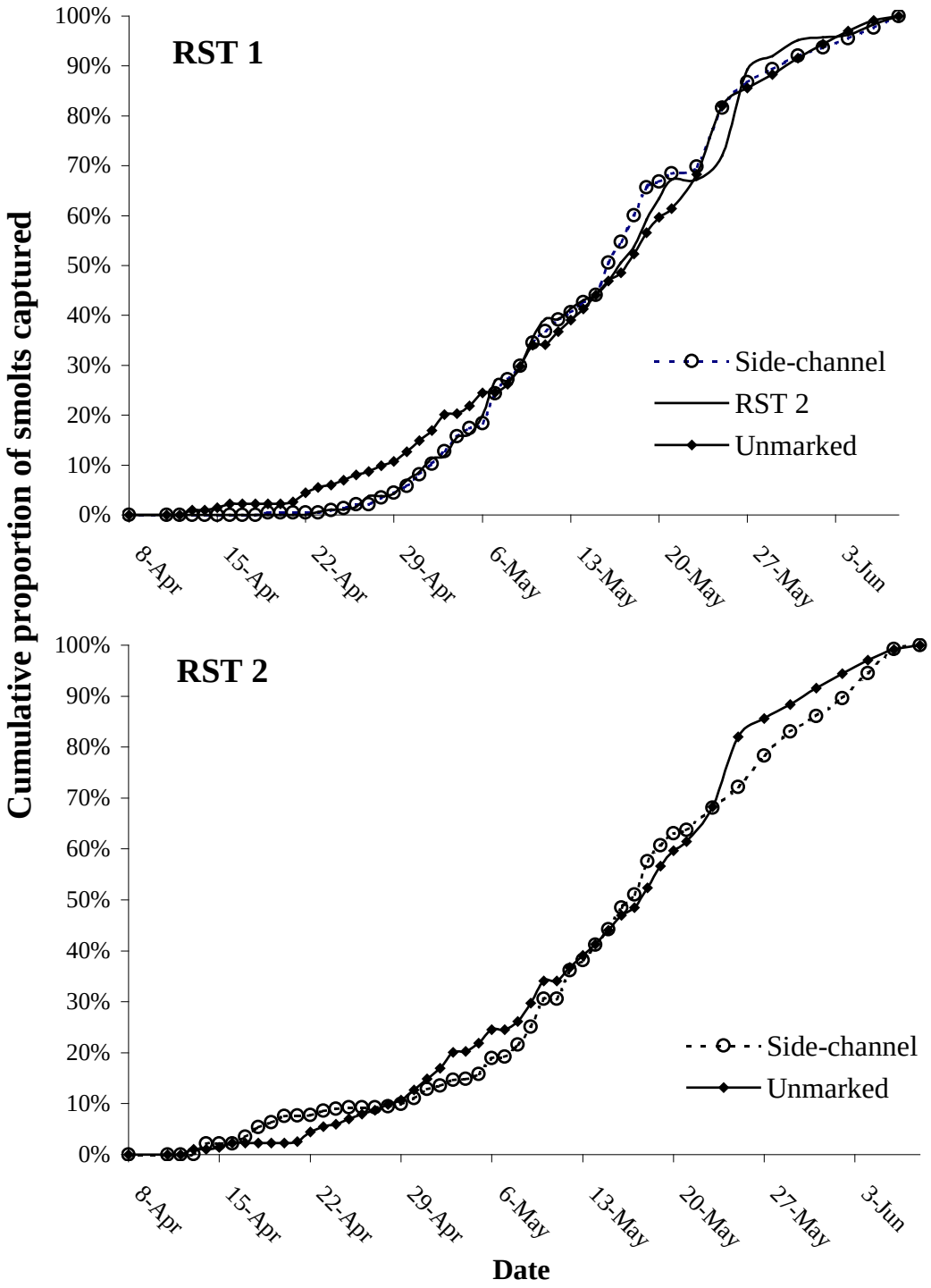

Figure 2. Cumulative daily proportions of coho smolts from the side-channel mark group (smolts marked at the Center Creek or side-channel weirs), the RST 2 mark group (smolts marked at the upper RST) and unmarked smolts that were captured at the lower (RST 1) and upper (RST 2) rotary screw traps in the English River.

Appendix 1. Numbers of coho smolts marked and released (M), numbers of marked and unmarked smolts recovered, percentages of marked smolts recovered (capture efficiency), and the proportion of catch that were marked in each of the three recovery periods for the side-channel mark group (Timber West and Weyerhaeuser side-channels and Center Creek) and the RST 2 mark group (upper RST) at the lower rotary screw trap (RST 1) in the Englishman River, 2003.

A. Side-channel mark group

Release stratum	Date	M	Recovery stratum 1 April 2-April 28	Recovery stratum 2 April 29-May 6	Recovery stratum 3 May 7-June 8	Cap. effic. per release stratum
1	April 2 - April 28	505	2	8	0	2%
2	April 29 - May 6	2,828	0	139	54	7%
3	May 7 - June 8	4,877	0	0	228	5%
Total Catch			77	809	1,317	
Untagged Fish			75	662	1,035	
Proportion of smolts marked			3%	18%	21%	

B. RST 2 mark group

Release stratum	Date	M	Recoveries	Cap. effic.
1	April 2 - June 8	3,485	186	5%
Total catch			2,203	
Untagged Fish			2,017	
Proportion of smolts marked			8%	

Appendix 2. Numbers of coho smolts marked and released (M), numbers of marked and unmarked smolts recovered, percentages of marked smolts recovered (capture efficiency), and the proportion of marked smolts recovered in each of the three recovery periods for the side-channel mark group (Timber West and Weyerhaeuser side-channels and Center Creek) at the upper rotary screw trap (RST 2) in the Englishman River, 2003.

Side-channel mark group			Recovery stratum			
			1	2	3	Cap effic.
Release stratum	Date	M	April 2- April 28	April 29- May 6	May 7- June 8	per release stratum
1	April 2 - April 28	505	21	3	0	5%
2	April 29 - May 6	2,828	0	171	69	8%
3	May 7 - June 8	4,877	0	0	486	10%
	Total Catch		200	800	1,849	
	Untagged Fish		179	626	1,294	
	Proportion of marked smolt		11%	22%	30%	