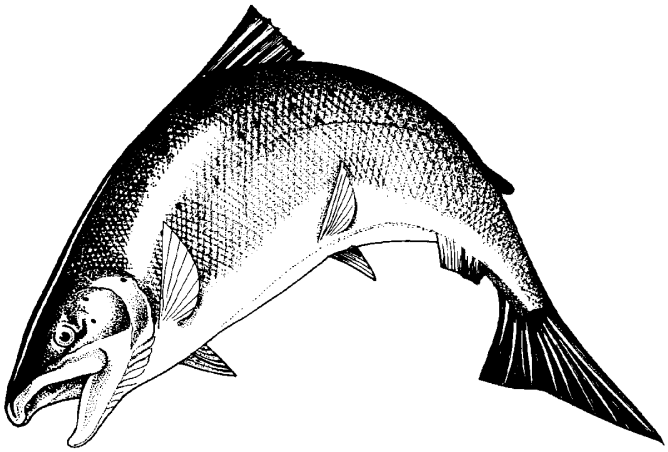
2003 Juvenile Salmonid Production Evaluation and Adult Escapement:

Intensively Monitored Watersheds (IMW)

Annual Report



Dave Seiler, Greg Volkhardt, Laurie Peterson,
Lindsey Fleischer, Steve Neuhauser,
Pat Hanratty, and Lori Kishimoto

Washington Department of Fish and Wildlife
Fish Science Division

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Acknowledgments

Hood Canal IMWs

Measuring juvenile salmon production and adult escapements for the Hood Canal Intensively Monitored Watersheds involves a tremendous amount of work. Key to developing these estimates are the long hours of trap operation provided by our dedicated and highly capable technician, Mat Gillum. Mat was assisted during the juvenile trapping period by technician Karen Shields.

In addition to our staff, we also thank Gordie George and the University of Washington for their assistance and facilities management at the University's Big Beef Creek Field Research Station.

Lower Columbia IMWs

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Executive Summary

Since the Endangered Species Act listing of numerous salmon and steelhead populations in the Pacific Northwest in the 1990's, millions of dollars have been dedicated to the restoration of freshwater habitat. Little is known about the effectiveness of these efforts in restoring salmon populations. Scientists have concluded that the most effective means of determining the contribution of restoration projects to salmon recovery is to implement experimental, watershed-scale evaluations that include the measurement of freshwater (smolt) production. Several organizations in the Pacific Northwest have begun to establish such projects. The Intensively Monitored Watersheds (IMW) Project evolved in 2003 from the joint Washington Department of Fish and Wildlife and Washington Department of Ecology Index Watershed Monitoring Project. A complete description of the watersheds and progress made on the IMW project during its first year is described in IMWSOC (2004). IMW monitoring activities include the measurement of freshwater production and escapements into IMW streams. This report presents the 2003 smolt production estimates for the Hood Canal and Lower Columbia IMWs and the 2003 escapement estimates for the Hood Canal IMWs. It also details the field work and analytical steps taken to produce these estimates.

Hood Canal IMWs

The Hood Canal IMWs are comprised of Big Beef, Little Anderson, Seabeck, and Stavis Creeks located in western Kitsap County. Downstream migrant (smolt) trapping is conducted using temporary fence weirs located near the mouths of Little Anderson, Seabeck, and Stavis Creeks. A permanent weir is located at the mouth of Big Beef Creek and three fan traps attached to the weir during the spring capture all downstream migrants. Adult coho and chum salmon returning to Big Beef Creek are trapped and counted each fall.

2003 Downstream Migrant Production

Traps were installed in late March or early April in all streams and were operated until the end of May or early June when smolt catches declined. A total of 34,463 coho smolts were captured in Big Beef Creek. Based on typical migration timing at this site, we estimated that an additional 800 coho migrated before/after the period of trap operation. Adding these to the catch along with an estimated 797 naturally-reared smolts from the University of Washington Fishery Research Institute (FRI) channels and ponds results in a total production estimate of 36,060 smolts. Of these, 31,355 were coded wire tagged (CWT) prior to release. Coho catches in Little Anderson, Seabeck, and Stavis Creeks were 226, 1,518, and 7,454 smolts, respectively. Assuming the same run timing as Big Beef coho, we estimate total coho production at 240 smolts for Little Anderson Creek, 1,565 smolts for Seabeck Creek, and 7,757 smolts for Stavis Creek. Steelhead and cutthroat smolts were also caught at all of the sites. As with coho, the steelhead production from Big Beef Creek was much larger than in the other streams (1,232 smolts vs. 83 combined smolts from the other three streams). The cutthroat migration was similar in all streams with 1,206, 891, 405, and 1,557 smolts caught in Big Beef, Little

Anderson, Seabeck, and Stavis Creeks, respectively. In addition to these catches, 24,000 chum and 350 chinook fry were captured in Big Beef Creek. Chum are present in the other three streams, but the fence weirs are designed to preclude capturing them. Chinook found in Big Beef Creek are of FRI origin and are not found in the other streams.

Coho fork length was measured from a sample of the captured fish. Big Beef coho averaged 104 mm, whereas those from Seabeck and Stavis Creeks averaged 5mm smaller and those from Little Anderson Creek averaged 9mm smaller.

2003 Escapements

The adult trap was operated from mid-August 2003 through January 2, 2004. All fish entering Big Beef Creek were enumerated by species, age, sex, mark status and condition before being released upstream. All adipose marked (ad-marked) hatchery coho were killed to preclude their spawning in Big Beef Creek. Unmarked coho were checked for a CWT. Of the unmarked coho that tested positive for a CWT, approximately 5% of the males and 25% of the jacks were sacrificed to estimate the number of tagged Big Beef fish returning and the incidence of unmarked, tagged hatchery fish. Tags were also recovered from carcasses on the spawning grounds. All unmarked coho not sacrificed for CWT recovery were passed upstream. Fork length and a scale sample were taken from approximately 20% of the unmarked returning coho. Scale sampling was used to estimate the number of unmarked hatchery fish that were passed upstream as well as for age determination.

A total of 5,105 adult coho and 361 jacks were captured between September 20 and December 13, 2003. These included 357 adults and 11 jacks that were ad-marked. Roughly two thirds of the unmarked adult coho (3,185) contained CWTs, as did 257 unmarked jacks. Of these, we sacrificed 96 adults and 72 jacks for tag recovery. A total of 4,647 unmarked adults and 279 unmarked jacks were released upstream. Five adult coho died either in the trap or below the weir.

Scale sampling indicated that 98.6% of the unmarked adult and 96.9% of the unmarked jack returns were naturally-reared fish. CWTs were recovered from 96 unmarked/tagged adults from the trap and 237 from adult carcasses on the spawning grounds. Of these tags, 334 were from natural origin Big Beef coho and 3 were from hatchery fish. Similar results were found from the unmarked/tagged jacks with 80 of the 81 recovered tags being from natural origin Big Beef coho. Good corroboration was found between scale-based and CWT-based estimates of the unmarked naturally-reared and hatchery components of the run. Both approaches estimated the survival from smolts to adult returns for the 2000 brood at 18.3%. Some 2000 brood Big Beef coho were harvested in fisheries. Marine survival (survival from smolts to age-3 recruits) was estimated at 19.3% based on preliminary tag data.

In addition to coho, 3,744 adult chum salmon, 896 summer chum and 2,848 fall chum, returned to Big Beef Creek. The chum migration began on September 6 and extended to December 24, 2003. Two adult steelhead were captured in the Big Beef trap in late December and 69 cutthroat were captured between October 10 and December 24. These represent an unknown portion of the total steelhead and cutthroat returns since the trapping ceased on January 2, before their

migrations were completed. Also, a number of adult chinook returned to Big Beef Creek. These were the progeny of FRI releases and the adults were returned to their facility.

Adult coho escapements into Little Anderson, Seabeck, and Stavis Creeks were estimated by multiplying their respective 2000 brood smolt productions by the ratio of the total Big Beef adult return to the 2000 brood Big Beef smolt production. This approach estimates the 2003 escapements at 52, 316, and 1,480 adults into Little Anderson, Seabeck, and Stavis Creeks, respectively. These estimates assume that hatchery stray rates into these streams were the same as estimated for Big Beef Creek. It is further assumed that smolt-to-adult survival is the same for all of the streams.

Lower Columbia IMWs

The Lower Columbia IMWs consist of Mill, Abernathy, and Germany Creeks located in Cowlitz and Wahkiakum Counties west of Longview, Washington. The downstream migrant production of coho and steelhead are estimated from each stream using a 1.5-m diameter rotary screw trap located near its mouth. Unlike the traps in the Hood Canal IMWs, these traps capture a portion of the outmigrating smolts. Production is estimated by conducting a series of mark-recapture experiments to determine the proportion of the downstream migrating juveniles from each species captured in each trap.

The traps were operated from April 4 to June 19, 2003 on all three streams. The traps operated continuously except on Abernathy Creek, when debris prevented the trap from operating on four occasions.

Catches in the Abernathy trap totaled 2,324 coho, 3,779 steelhead (603 natural origin and 3,176 hatchery), and 139 cutthroat smolts. Of the hatchery steelhead smolts, 124 were tagged with Passive Integrated Transponder (PIT) tags, 2,815 were tagged with CWTs, and 237 were unmarked. Interpolation was used to estimate the catch that would have occurred during the four periods when debris halted trap operation. This analysis estimated 10 coho and 2 steelhead of natural origin would have been caught during those periods. To estimate trap efficiency, 2,145 coho and 530 natural origin steelhead captured in the trap were marked using partial fin clips and released upstream. To estimate cutthroat efficiency, we were assisted by USFWS who PIT tagged 110 cutthroat captured in the trap and released them above their instream antenna array at river kilometer 2.9.

The trap position was moved on April 22 and weir panels were added on May 19 to divert more flow and fish into the trap. These changes in trap operations resulted in three trap efficiency strata: original position, 2nd position, and 2nd position with weir panels. Average trap efficiency for coho and steelhead was estimated for each efficiency stratum based on results from the mark-recapture experiments. Total migration during each efficiency stratum was estimated and summed across strata to estimate total production. Using this approach we estimated 9,626 coho, 4,141 natural origin steelhead, 21,713 hatchery steelhead, and 531 cutthroat emigrated from the stream.

Catches in Germany Creek totaled 2,832 coho, 1,859 steelhead, and 178 cutthroat smolts over the trapping period. A total of 2,560 coho and 1,757 steelhead were marked with a partial fin clip and released above the trap to assess trap efficiency. Too few cutthroat were captured to assess trap efficiency for this species, so the steelhead efficiency was used since cutthroat and steelhead smolts were similarly sized. The season average trap efficiency was used to estimate a total production of 5,775 coho, 5,936 steelhead, and 563 cutthroat smolts.

On Mill Creek, 4,168 coho, 253 steelhead, and 115 cutthroat smolts were captured. Of those captured, 3,363 coho and 229 steelhead were marked with a partial fin clip and released upstream to assess trap efficiency. As with Germany Creek, too few cutthroat were captured to assess cutthroat efficiency directly, so steelhead efficiency was used to estimate the cutthroat production. Weir panels were installed upstream of the trap on May 6 to divert more flow and fish through the trap. This change in operation resulted in two efficiency strata: before weir panels and after weir panels. Mean trap efficiency was calculated for each stratum and used to estimate migration. Total production was estimated at 10,514 coho, 1,383 steelhead, and 574 cutthroat smolts.

Introduction

Since the Endangered Species Act listing of numerous salmon and steelhead populations in the Pacific Northwest in the 1990's, millions of dollars have been dedicated to the restoration of freshwater habitat. Little is known about the effectiveness of these efforts in restoring salmon populations. Scientists have concluded that the most effective means of determining the contribution of restoration projects to salmon recovery is to implement experimental, watershed-scale evaluations that include the measurement of freshwater (smolt) production. Several organizations in the Pacific Northwest have begun to establish such projects. The Intensively Monitored Watersheds (IMW) Project evolved in 2003 from the joint Washington Department of Fish and Wildlife and Washington Department of Ecology Index Watershed Monitoring Project. A complete description of the watersheds and progress made on this project during its first year are described in IMWSOC (2004). IMW monitoring activities include the measurement of freshwater production and escapements into IMW streams. This report presents the 2003 freshwater smolt production estimates for the Hood Canal (Figure 1) and Lower Columbia (Figure 2) IMWs and the 2003 escapement estimates for the Hood Canal IMWs. It also details the field work and analytical steps taken to produce these estimates.

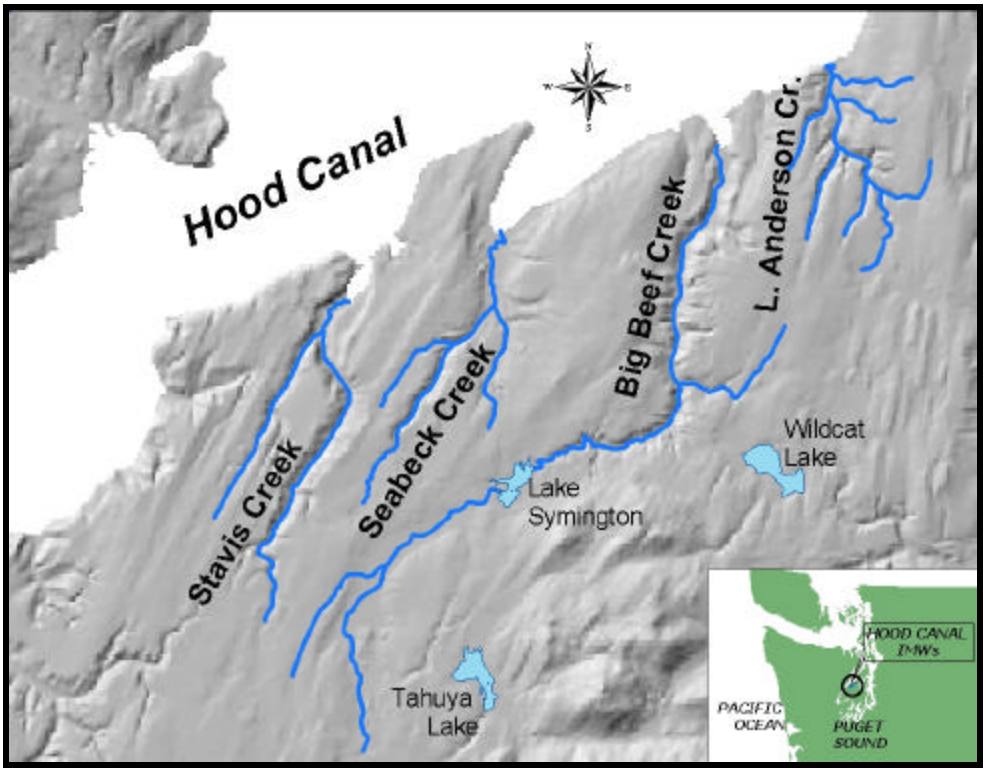

Figure 1. Map showing the location of the four Hood Canal IMWs: Little Anderson, Big Beef, Seabeck, and Stavis Creeks.

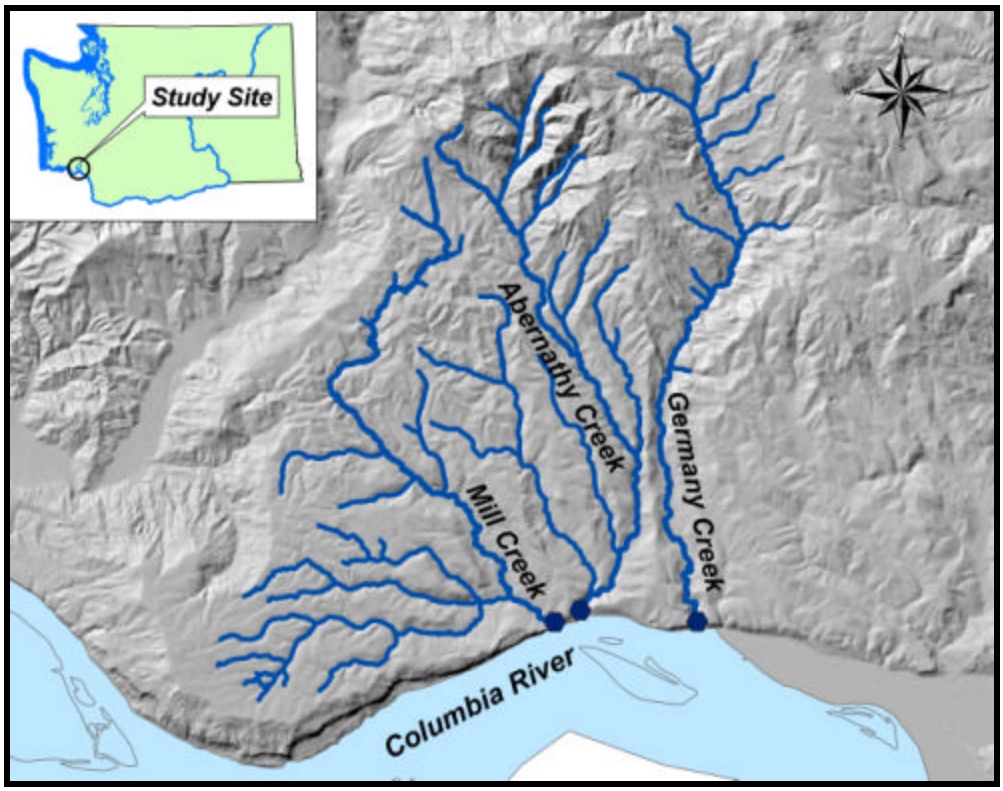

Figure 2. Map showing the location of the three Lower Columbia IMWs: Mill, Abernathy, and Germany Creeks.

Hood Canal IMW Downstream 2003

Methods

Big Beef Creek

The downstream trapping facility and trap operations at Big Beef Creek have been described previously in Seiler *et al.* (1981). Downstream migrants, including newly emerged fry, were captured by means of three fan traps, which screen the entire stream flow during the spring outmigration.

Downstream migrants were removed from the live box and enumerated at least once per 24-hour period, but more frequently as required by large numbers of fish or heavy debris. Coho smolts were retained for coded-wire tagging, while other downstream migrants were enumerated and released. Fork lengths were measured from a random sample of coho smolts over the season.

Coded-wire tagging methods were identical to those reported in previous years (Seiler *et al.* 1981, 1984), except natural origin smolts are no longer adipose fin-clipped (ad-marked) prior to tagging. We stopped ad-marking tagged smolts starting in the spring of 1998 because at that time hatchery facilities began mass-marking most hatchery production by applying the ad-mark. In addition to direct enumeration of smolts captured in the downstream traps, each year we estimate total coho smolt production, including the period before and after the trapping interval, using a smolt migration timing model. This model is based on migration data collected over four "model years" when we operated the trapping facility from early-March through late-June. This model also includes yearly smolt counts from the University of Washington Fisheries Research Institute's (FRI) spawning channel and ponds. Smolt counts, from years when the ponds and channel outlet were trapped, were analyzed and calculated as a percent of the total production from the stream. These yearly rates were averaged and applied to smolt productions from the stream to estimate the number of smolts emigrating from the spawning channel and ponds.

Stavis, Seabeck, and Little Anderson Creeks

Smolt fences (Blankenship and Tivel 1980) are used to monitor freshwater production from Little Anderson, Seabeck and Stavis Creeks. Each day we enumerated and released all downstream migrants captured in these fence traps. Also we measured fork lengths on a random sample of the coho smolts captured.

We estimated total coho smolt production from these streams by assuming that smolt emigration timing is identical to that of Big Beef Creek. We used the Big Beef Creek timing model to estimate the number of smolts emigrating from these streams before and after the trapping period.

Results

Trap Operation

Big Beef Creek

We installed the downstream migrant traps and assembled the weir on March 28. The weir and traps were fish tight and we began operation at 1430 hours that day. The traps screened the entire stream flow through June 9 at 0830 hours, when we dismantled the weir.

Seabeck Creek

We installed the trap just above tidewater on April 3 at 1400 hours. We operated the trap without any outages through June 10 at 0845 hours, capturing all downstream migrants.

Little Anderson Creek

We installed the trap 100 feet above tidewater. Trap operation began on April 4 at 1600 hours. We continued operating the trap without any outages through May 28 at 1230 hours, capturing all downstream migrants.

Stavis Creek

We installed the trap in the same location as in past years. Trap operation began on April 8 at 1300 hours. We operated the trap without any outages through June 10 at 1200 hours, capturing all downstream migrants.

Fish Counts and Estimated Production

Big Beef Creek

Coho Smolts

Over the season, we caught a total of 34,463 coho smolts at Big Beef Creek (Table 1). The coho smolt migration increased steadily during April to an initial daily high of 2,059 on April 30, followed by a higher peak of 2,246 smolts on May 2 (Figure 3). After this peak, the migration dropped and then rose again to 1,782 smolts captured on May 5 and 1,810 captured on May 9. Thereafter, the migration decreased gradually through the end of the season.

We estimated that 610 and 190 coho smolts emigrated before and after trapping (Table 2). Adding these estimates to the number of smolts caught during the trapping period (34,463), and including an estimated 797 smolts from the FRI channels and ponds, yields a total production estimate of 36,060 coho smolts. This smolt production resulted from a spawning escapement of 1,511 males and 1,807 females released upstream in Fall 2001. Average production was estimated at 20.0 smolts per female.

Other Salmonids

Other downstream migrant salmonids captured at Big Beef Creek included 1,232 steelhead smolts, 1,206 cutthroat smolts, 1,136 trout parr, 24,364 chum fry, 350 chinook fry, and 393 coho fry (Table 1). In addition, we caught eight steelhead adults (five males and three females) and 49 cutthroat adults (30 males and 19 females).

Table 1. Downstream migrant salmonids captured at Big Beef, Stavis, Seabeck, and Little Anderson Creeks, Spring 2003.

Species/Age	TOTAL CATCH			
	Big Beef Creek	**Little Anderson Creek**	**Seabeck Creek**	**Stavis Creek**
Coho smolts	34,463	226	1,518	7,454
Coho fry	393	0	1	0
Chum fry	24,364	0	0	0
Chinook fry	350	0	0	0
Trout parr	[a]1,136	[d]575	[f]140	[h]218
Steelhead adults	[b]8	0	0	0
Steelhead smolts	1,232	12	30	41
Cutthroat adults	[c]49	[e]13	[g]10	[i]38
Cutthroat smolts	1,206	891	405	1,557

[a] Includes 568 steelhead parr and 568 cutthroat parr.
[b] Includes 5 males and 3 females.
[c] Includes 30 males and 19 females.
[d] Includes 15 steelhead parr and 560 cutthroat parr.
[e] Includes 11 males and 2 females.
[f] Includes 2 steelhead parr and 138 cutthroat parr.
[g] Includes 5 males and 5 females.
[h] Includes 3 steelhead parr and 215 cutthroat parr.
[i] Includes 19 males and 19 females.

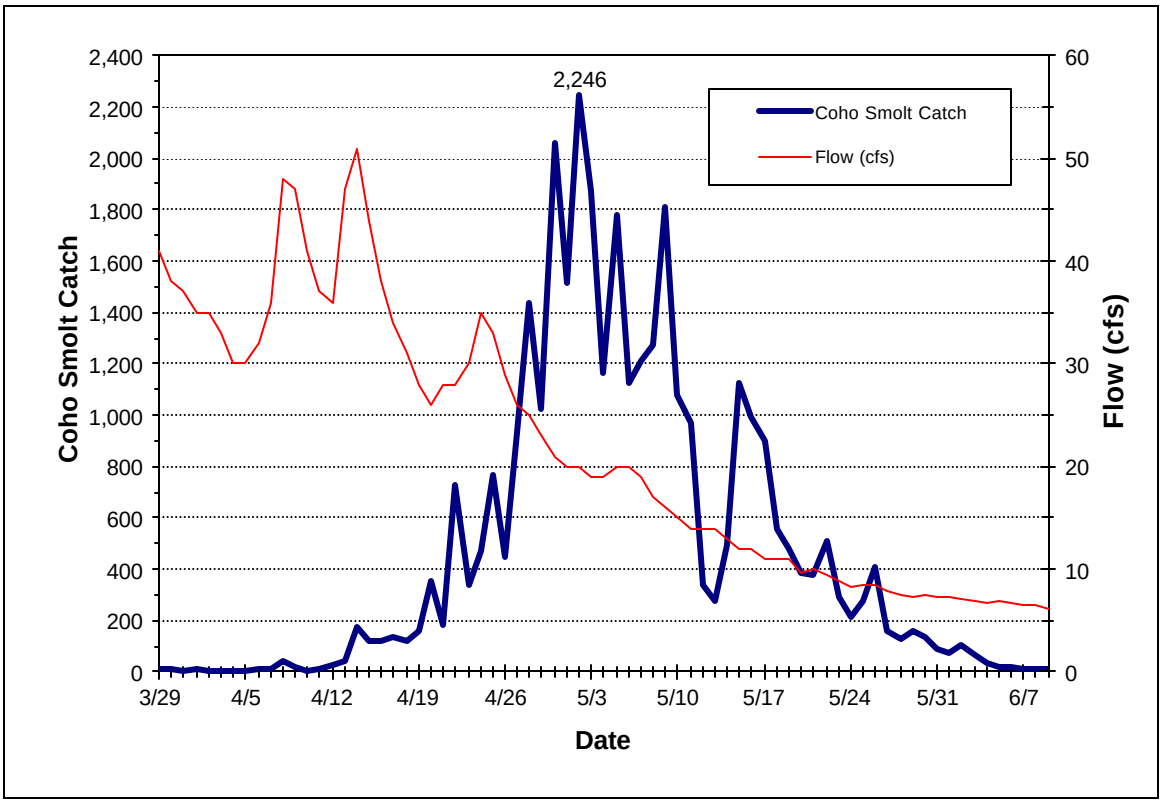

Figure 3. Daily coho smolt catch and daily mean flow (cfs), Big Beef Creek 2003.

Table 2. Total estimated coho smolt migration from Big Beef, Stavis, Seabeck, and Little Anderson Creeks, Spring 2003.

Trap Site	BEFORE TRAPPING [a]		AFTER TRAPPING [a]		Total Catch During Trapping	Total Estimated Production
	Dates	Number Estimated	Dates	Number Estimated		
Big Beef Creek	3/1-3/28	610	6/9-6/30	190	34,463	[b]36,060
Stavis Creek	3/1-4/8	261	6/10-6/30	42	7,454	7,757
Seabeck Creek	3/1-4/3	39	6/10-6/30	8	1,518	1,565
Little Anderson Creek	3/1-4/4	6	5/28-6/30	8	226	240

[a] Before and after trapping estimates based on four model years.
[b] Includes 797 smolts estimated from the FRI spawning channels and ponds.

Little Anderson, Seabeck, and Stavis Creeks

Over the season we caught a total of 7,454, 1,518, and 226 coho smolts at Stavis, Seabeck, and Little Anderson creeks, respectively (Table 1). Adding the estimated number of smolts migrating before and after the trapping period yielded total production estimates of 7,757, 1,565, and 240 (Table 2). These streams produced relatively few steelhead smolts -- only 41, 30 and 12 were captured at Stavis, Seabeck, and Little Anderson creeks, respectively. In contrast, we captured 2,853 cutthroat smolts from the three streams combined.

Migration Timing

Timing of the coho smolt migration at Stavis, Seabeck and Little Anderson creeks was generally similar to that of Big Beef Creek (Figure 4). Initially, during the month of April, a higher proportion of smolts out-migrated from Little Anderson and Seabeck creeks compared to that in Stavis and Big Beef Creeks. Seabeck smolts continued their early migration trend throughout the season, with fifty percent of the coho smolts captured by April 29. The median migration dates for Big Beef, Seabeck, and Little Anderson ranged from 6 to 10 days later (Figure 4).

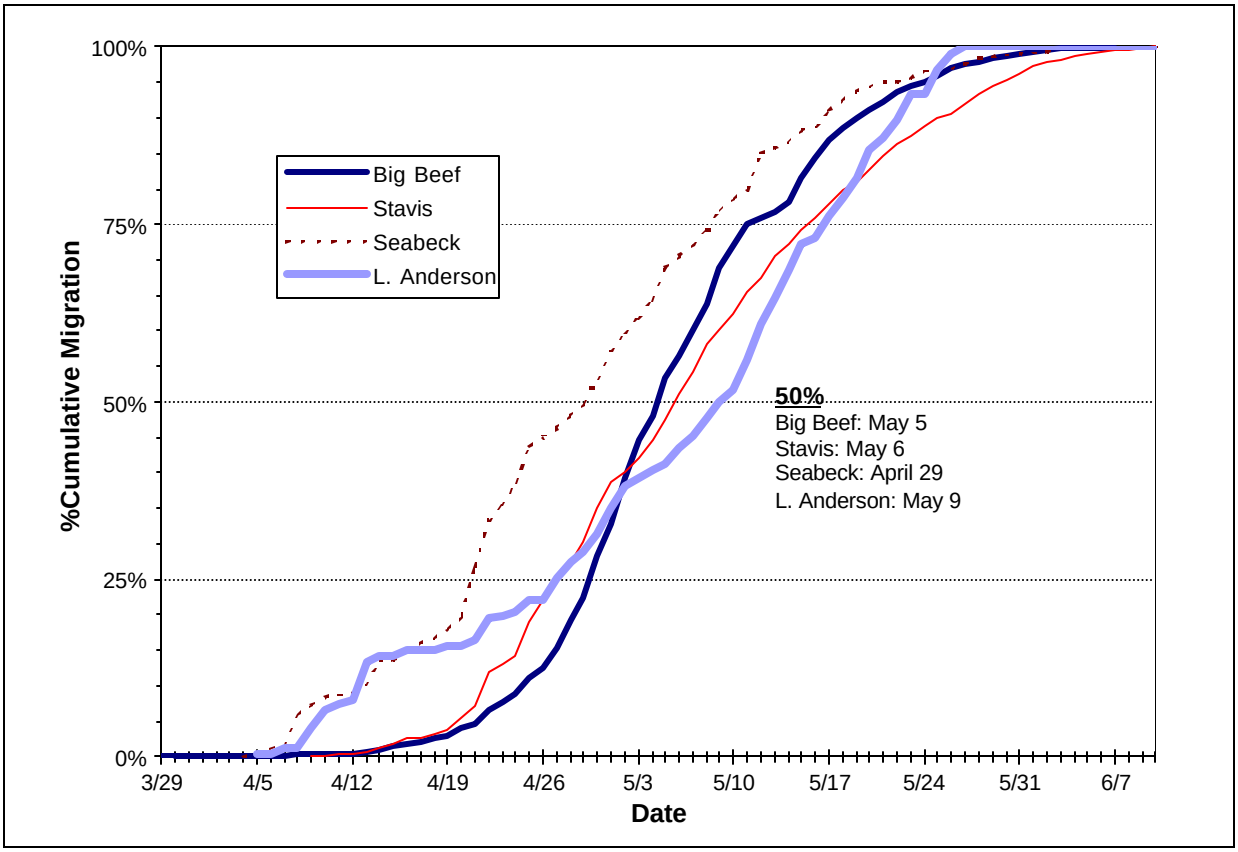

Figure 4. Percent cumulative coho smolt migration at Big Beef, Stavis, Seabeck, and Little Anderson Creeks, Spring 2003.

Coded-wire Tagging

We coded-wire tagged (CWT) 31,553 coho smolts (tag code 63-16/70) at Big Beef Creek (Table 3). The remaining coho smolt catch (2,864) was released untagged. Only 0.13% of the smolts died due to trapping, tagging and other factors (Table 3). The tagging rate for coho smolts, not accounting for tagging-related mortality, is estimated at 87.5% (total number tagged applied to total estimated production of 36,060).

Table 3. Disposition of the coho smolt catch, Big Beef Creek 2003.

Disposition	Number	Percent
Released untagged		
Before/after tagging	634	1.84%
Poor condition	1,036	3.01%
Escaped during transfer	205	0.59%
Too small/large	57	0.17%
Donated to U.W.	0	0.00%
Other	932	2.70%
Total	2,864	8.31%
Mortality		
Trap mortality	31	0.09%
Sacrificed for tag placement	15	0.04%
Total	46	0.13%
Tagged and Released	[a] 31,553	91.56%
TOTAL CATCH	34,463	100.00%

[a] Tag code 63-16/70

Size

Over the season, we randomly selected 955 coho smolts for fork length measurement at Big Beef Creek. Weekly mean fork lengths ranged from a low of 100.2 mm to a high of 163.0 mm (Table 4). The season average fork length, weighted by catch, was 104.0 mm and the standard deviation was 9.00 mm (Table 4). On average, coho smolts from Big Beef Creek were larger than the other streams trapped. Mean fork length (weighted by catch) was 100.5 mm, 99.7 mm, and 95.2 mm at Little Anderson, Seabeck, and Stavis creeks, respectively (Table 5, Table 6, and Table 7).

Table 4. Mean fork length (mm), standard deviation, range, number of coho smolts sampled for fork length, and total catch, by statistical week, Big Beef Creek 2003.

STAT WEEK			Mean	SD	RANGE		Number Sampled	Total Catch	Sample Rate
No.	Begin	End			Min	Max			
14	03/31	04/06	163.0	58.28	96	202	3	35	8.6%
15	04/07	04/13	107.0	27.51	76	208	36	143	25.2%
16	04/14	04/20	109.0	14.91	83	146	30	1,185	2.5%
17	04/21	04/27	107.9	13.27	86	150	97	3,865	2.5%
18	04/28	05/04	106.2	9.94	83	146	277	11,321	2.4%
19	05/05	05/11	101.0	6.77	84	127	187	9,255	2.0%
20	05/12	05/18	100.2	6.71	82	117	133	4,689	2.8%
21	05/19	05/25	101.8	6.41	89	118	74	2,539	2.9%
22	05/26	06/01	105.2	7.97	83	135	102	1,152	8.9%
23	06/02	06/08	106.6	11.55	74	121	16	257	6.2%
SEASON TOTAL			**[a]104.0**	**[a] 9.00**	**74**	**208**	**955**	**[b]34,441**	**2.8%**

[a] Weighted by catch.

[b] In addition, we caught 15 smolts before fork length sampling began (week 13) and 7 smolts after sampling (week 24).

Table 5. Mean fork length (mm), standard deviation, range, number of coho smolts sampled for fork length, and total catch, by statistical week, Little Anderson Creek 2003.

STAT WEEK			Mean	SD	RANGE		Number Sampled	Total Catch	Sample Rate
No.	Begin	End			Min	Max			
15	04/07	04/13	108.5	0.71	108	109	2	29	6.9%
16	04/14	04/20	--	--	--	--	0	5	0.0%
17	04/21	04/27	100.7	12.42	75	109	7	22	31.8%
18	04/28	05/04	--	--	--	--	0	34	0.0%
19	05/05	05/11	107.5	4.95	104	111	2	35	5.7%
20	05/12	05/18	95.3	5.32	82	106	18	52	34.6%
21	05/19	05/25	97.3	6.50	89	108	6	41	14.6%
22	05/26	06/01	89.6	4.83	84	97	5	7	71.4%
SEASON TOTAL			**[a] 100.5**	**[a] 5.61**	**75**	**111**	**40**	**[b]225**	**17.8%**

[a] Weighted by catch.

[b] In addition, we caught one coho smolt before fork length sampling began (week 14).

Table 6. Mean fork length (mm), standard deviation, range, number of coho smolts sampled for fork length, and total catch, by statistical week, Seabeck Creek 2003.

STAT WEEK			Mean	SD	RANGE		Number Sampled	Total Catch	Sample Rate
No.	Begin	End			Min	Max			
15	04/07	04/13	101.9	9.78	77	118	15	136	11.0%
16	04/14	04/20	95.1	11.21	78	119	40	146	27.4%
17	04/21	04/27	101.3	13.84	82	125	21	403	5.2%
18	04/28	05/04	--	--	--	--	0	274	0.0%
19	05/05	05/11	99.6	10.33	80	125	68	235	28.9%
20	05/12	05/18	99.0	10.19	82	123	94	192	49.0%
21	05/19	05/25	--	--	--	--	0	65	0.0%
22	05/26	06/01	95.0	10.82	83	104	3	36	8.3%
SEASON TOTAL			**[a] 99.7**	**[a] 11.60**	**77**	**125**	**241**	**[b] 1,487**	**16.2%**

[a] Weighted by catch.

[b] In addition, we caught 18 smolts before fork length sampling began (week 14) and 13 smolts after sampling (week 23).

Table 7. Mean fork length (mm), standard deviation, range, number of coho smolts sampled for fork length, and total catch, by statistical week, Stavis Creek 2003.

STAT WEEK			Mean	SD	RANGE		Number Sampled	Total Catch	Sample Rate
No.	Begin	End			Min	Max			
15	04/07	04/13	101.3	16.92	88	126	4	42	9.5%
16	04/14	04/20	94.6	12.78	75	133	80	370	21.6%
17	04/21	04/27	96.1	10.69	77	131	72	1,491	4.8%
18	04/28	05/04	94.1	7.34	81	119	44	1,419	3.1%
19	05/05	05/11	96.3	11.44	74	131	72	1,555	4.6%
20	05/12	05/18	95.8	9.46	78	129	116	1,065	10.9%
21	05/19	05/25	93.7	7.74	80	118	43	755	5.7%
22	05/26	06/01	92.7	7.56	80	109	25	556	4.5%
SEASON TOTAL			**[a] 95.2**	**[a] 9.61**	**74**	**133**	**456**	**[b] 7,253**	**6.3%**

[a] Weighted by catch.

[b] In addition, we caught 201 smolts after fork length sampling ended (weeks 23 and 24).

Hood Canal IMW Upstream 2003

Methods

Trap Operation

The Big Beef Creek trapping facility has been described previously in Seiler *et al.* (1981). The weir is a conventional adult barrier, screening the entire stream flow through vertical picket sections with 25 mm openings. Upstream migrating adults are trapped in a V-slot trap in the center of the weir.

During the 2003 season, the upstream trap and weir were refurbished and installed in mid-August. We operated the trap continuously through January 2, 2004. Throughout this interval, the weir remained intact and all returning migrants were enumerated.

Fish Counts

Upstream migrants were removed from the trap and enumerated by species, age, sex, mark status and condition before being released upstream. To minimize the delay in migration and stress caused by crowding, the fish were processed within 12 hours of entering the trap, or immediately during peak migration periods.

CWT Detection and Recovery

Coho returning to Big Beef Creek include unmarked, untagged natural origin coho from Big Beef Creek and possibly wild strays from other streams, unmarked coho with CWTs that may be of Big Beef Creek or hatchery (double index tagged or DIT fish) origin, ad-marked coho with CWT's of hatchery origin, and ad-marked, untagged coho of hatchery origin. Annual goals included determining the origin of fish captured and excluding hatchery origin coho from spawning in Big Beef Creek.

All returning adult and jack coho were visually inspected for an ad-mark and then scanned with a portable electronic tag detector to determine CWT presence or absence. Of the unmarked coho that detected positive for a CWT, we sacrificed approximately 5% of the males and 25% of the jacks for tag recovery. A few tagged unmarked females were also sacrificed. All unmarked adults and jacks not sacrificed for tag recovery were released upstream.

All returning ad-marked coho were assumed to be hatchery strays, the recipients of the mass-mark. These were killed to preclude their spawning in Big Beef Creek. Tags were recovered from those ad-marked adults and jacks that detected positive for a CWT.

In addition to sampling adult coho for coded-wire tags at the trap, we also electronically sampled carcasses found on the spawning grounds for tags.

We expected unmarked/tagged adult returns to primarily include natural origin fish (brood year 2000) that we tagged and released as smolts in Spring 2002 (21,256 total released with tag code 63-12/89), plus a small number of strays from hatchery DIT groups. Similarly, we expected unmarked/tagged jack returns to predominantly consist of natural origin fish (brood year 2001) that we tagged and released as smolts in Spring 2003 (31,553 total released with tag code 63-16/70), plus a minimal number of strays from hatchery DIT groups.

Size and Age

We measured fork length on every fifth unmarked adult. We also collected scales from these fish to determine their age and origin. To determine the age of small males, we collected scales from all unmarked males ranging from 35 cm to 45 cm fork length. In addition, we systematically measured and collected scales from approximately one-third of the unmarked jack return.

A small number of scale samples were taken from ad-marked/CWT'd males, females, and jacks for verification of scale reading results as compared to coded-wire tag results. We did not measure fork lengths or collect scales from ad-marked/untagged coho.

Estimating Hatchery and Natural origin Returns

Smolts produced from the 2000 brood spawners in Big Beef Creek were not ad-clipped. In addition to ad-marked hatchery strays, some unmarked hatchery coho (untagged as well as tagged DIT coho) also stray into Big Beef Creek. Thus, we could not rely solely on visual counts of ad-marks to differentiate hatchery versus natural origin fish. To estimate the hatchery and naturally produced components of the adult return, we applied and compared a combination of scale analysis, CWT results, and visual observations of mark status. Scale samples were taken from approximately 25% of the unmarked coho captured in the trap.

Estimating Escapements into Little Anderson, Seabeck, and Stavis Creeks

The survival-to-return rate (smolt-to-adult survival) was estimated for Big Beef Creek coho by the estimated escapement of 2000-brood coded wire tagged natural origin Big Beef coho divided by the number of 2000 brood tagged smolts (adjusted for tag loss and delayed mortality) released from this stream. We assumed coho smolts leaving Little Anderson, Seabeck, and Stavis Creeks experienced the same survival-to-return rate as Big Beef Creek smolts. Since coho escapements into Little Anderson, Seabeck, and Stavis Creeks include stray hatchery fish, we further assumed that hatchery stray rates into these streams were the same as for Big Beef Creek. Therefore, we estimated total escapements into Little Anderson, Seabeck, and Stavis Creeks by 1) multiplying their respective 2000 brood coho smolt productions by the Big Beef Creek survival-to-return rate and 2) dividing the product by the estimated proportion of the total Big Beef Creek escapement comprised of natural origin coho.

Results

Coho Catch and Migration Timing

Coho were first observed moving into the upper estuary in mid-September. We trapped and released the first jack coho above the weir on September 20 and the first adult on September 21. The coho migration began increasing gradually in early October, as flows began to rise (Figure 5). The migration first peaked on October 12, with 1,089 adults and 28 jacks captured, followed by a second, higher peak on October 16, with 1,100 adults and 59 jacks trapped. This peak migration coincided with the first significant freshet (Figure 5). By the evening of October 16, over 57% of the natural origin coho and 61% of the hatchery coho run had returned. After this peak, the coho catch decreased steadily through the end of the season. On December 13 we trapped the last returning adult coho, an unmarked wild male. The run appeared to be finished on this date, as we did not catch any coho from December 14 through the end of the trapping period (January 2, 2004).

Over the season, we trapped a total of 5,105 adult coho (2,761 males and 2,344 females) and 361 jacks (Table 8). The adult return consisted of 4,748 (93%) unmarked and 357 (7%) ad-marked coho. The jack return included 350 (97%) unmarked and 11 (3%) ad-marked jacks (Table 8).

Of the 4,748 unmarked adults trapped, 3,185 (67%) detected positive for a CWT. From these, we sacrificed 90 males and 6 females for CWT recovery (Table 8). We also sacrificed 72 unmarked/tagged jacks, 28% of the 257 that returned. We killed all 357 ad-marked adults that returned, of which 31 males and 20 females detected positive for a CWT. Also we killed 10 of the 11 ad-marked jacks that returned (one was mistakenly released upstream), of which one detected positive for a CWT (Table 8).

A total of 4,647 unmarked adults were released upstream (Table 8). Of these, 2,500 (54%) were males and 2,147 (46%) were females. We also released 279 jacks upstream (278 unmarked and one ad-marked).

We observed five dead adult coho in the trap or below the weir. Two unmarked adults (one untagged male and one tagged female) died in the trap, while three unmarked adults (two untagged males and one tagged female) were found dead below the weir (Table 8).

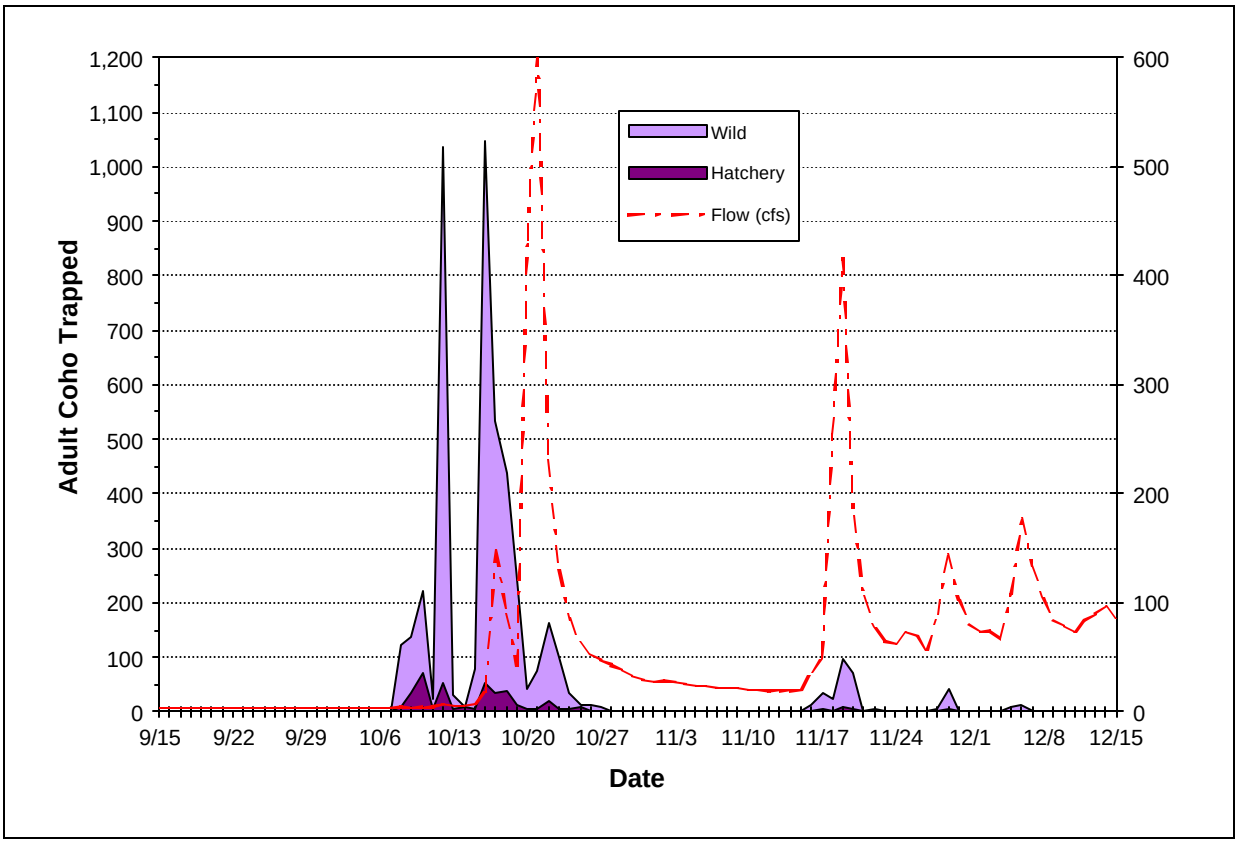

Figure 5. Natural and hatchery origin adult coho trapped at Big Beef Creek by day, and mean daily flow (cfs), Fall 2003.

Table 8. Disposition of coho returning to Big Beef Creek, Fall 2003.

Disposition	Un-marked										Ad-marked										Total Coho			
	Adults							Jacks			Adults							Jacks			Adults			Jacks
	Male			Female			Total				Male			Female			Total				Male	Female	Total	
	+	-	Tot	+	-	Tot		+	-	Tot	+	-	Tot	+	-	Tot		+	-	Tot				
Total Return	1,710	883	**2,593**	1,475	680	**2,155**	**4,748**	257	93	**350**	31	137	**168**	20	169	**189**	**357**	1	10	**11**	**2,761**	**2,344**	**5,105**	**361**
Trap Mortalities	0	1	**1**	1	0	**1**	**2**	0	0	**0**	0	0	**0**	0	0	**0**	**0**	0	0	**0**	**1**	**1**	**2**	**0**
Dead Below Weir Spawned	0	2	**2**	1	0	**1**	**3**	0	0	**0**	0	0	**0**	0	0	**0**	**0**	0	0	**0**	**2**	**1**	**3**	**0**
Sacrificed	90	0	**90**	6	0	**6**	**96**	72	0	**72**	31	137	**168**	20	169	**189**	**357**	1	9	**10**	**258**	**195**	**453**	**82**
Total Upstream	1,620	880	**2,500**	1,467	680	**2,147**	**4,647**	185	93	**278**	0	0	**0**	0	0	**0**	**0**	0	1	**1**	**2,500**	**2,147**	**4,647**	**279**

Note: The plus sign (+) indicates a positive detection for a CWT (sampling equipment beeped). The minus sign (-) indicates that no CWT was detected (sampling equipment did not beep).

Contribution of Hatchery Fish to Escapement

Each fall, the coho return to Big Beef Creek has included hatchery fish. Our ability to measure the production and survival of naturally produced Big Beef Creek coho is compromised if we cannot accurately estimate the numbers of naturally produced returning adults due to an unknown number of hatchery fish.

Prior to 1991, we relied exclusively on expanding coded wire tag recoveries from the weir and spawning grounds to estimate the number of hatchery strays into Big Beef Creek. Since hatchery tags typically comprised a very small proportion of the total tagged return, the small sample of tags recovered each year yielded imprecise estimates of the hatchery/natural origin composition.

To improve these estimates, scale sampling was initiated in 1991. During the 2003 season, we continued to sample scales from returning fish to better estimate the hatchery and naturally produced components of the coho return to Big Beef Creek. Even with mass marking of hatchery coho, we could not rely solely on counts of ad-marks to determine origin (hatchery or naturally produced) as hatchery coho were not 100% ad-marked at hatchery facilities. For example, the 2000-brood hatchery releases from federal and tribal programs (e.g., Quilcene National Fish Hatchery and Quilcene Bay Sea Pens) included a high number of unmarked coho (Table 9). An estimated 17% of all 2000 brood hatchery coho smolts were released unmarked.

The 2000-brood hatchery fish that returned as adults in Fall 2003 included coho released as smolts in Spring 2002 from the Quilcene National Fish Hatchery, George Adams Hatchery, Quilcene Bay Sea Pens, Port Gamble Sea Pens, and Agate Pass Sea Pens. These hatchery and net pen releases totaled over 1.8 million smolts (Table 9).

Scale Analysis

We collected scale samples from 1,146 unmarked adults, 24.1% of the total unmarked return (Table 10). Thirty-four of these samples were unreadable due to regeneration, leaving 1,112 for analysis. Projecting the sample results to estimate the naturally produced and hatchery components of the unmarked adult return estimated a total of 4,682 (98.6%) natural origin and 66 (1.4%) hatchery origin fish.

We also collected scales from 95 unmarked jacks, 27% of the unmarked jack return. This sampling resulted in 94 readable samples, of which 91 were natural origin and three were hatchery origin (Table 10). Projecting these sample results to the total jack return estimated 339 (96.9%) natural origin and 11 (3.1%) hatchery origin jacks in the unmarked jack return (Table 10).

Table 9. Numbers of 2000-brood hatchery and sea pen-reared coho smolts released into Hood Canal in 2002.

Release Site		Stock	Tag Code	DIT: Related Group ID [a]	RELEASE NUMBERS				
					Coded-wire tagged		Untagged		Total
					Ad-mark	Unmark	Ad-mark	Unmark	
Hatchery Releases	Quilcene National Fish Hatchery	Big Quilcene	05-05-91	072002WC80B3	12,564		77,151		**89,715**
			05-05-92			12,435		2,020	**14,455**
			05-05-93	072002WC80B5	11,659		73,329		**84,988**
			05-05-94			11,863		1,927	**13,790**
			05-05-95	072002WC80B8	12,596		78,837		**91,433**
			05-05-96			11,870		2,014	**13,884**
			05-05-97	072002WC80D6	12,494		76,358		**88,852**
			05-05-98			12,625		1,932	**14,557**
			Total		**49,313**	**48,793**	**305,675**	**7,893**	**411,674**
	George Adams Hatchery	Purdy Creek	63-05-91	420021014	43,687	87	441		**44,215**
			63-05-92			43,518		897	**44,415**
			NA	NA			411,294	808	**412,102**
			Total		**43,687**	**43,605**	**411,735**	**1,705**	**500,732**
Sea Pen Releases	Quilcene Bay Sea Pens	Quilcene NFH	05-05-99	142002DI04		45,880		116,447	**162,327**
			05-06-64		46,542		1,738		**48,280**
			Total		**46,542**	**45,880**	**1,738**	**116,447**	**210,607**
	Port Gamble Sea Pens	Big Quilcene	21-01-93	142002DI05	44,707	910	333,088	7,475	**386,180**
			63-09-77			45,664		317	**45,981**
			Total		**44,707**	**46,574**	**333,088**	**7,792**	**432,161**
	Agate Pass Sea Pens	Minter Creek	21-01/95	NA	50,067	606	268,001	4,072	**322,746**
TOTAL RELEASED					**234,316**	**185,458**	**1,320,237**	**137,909**	**1,877,920**

[a] Hatchery double index tag (DIT) group pairs are indicated by their related group identification code in PSMFC's Regional Mark Information System (RMIS) database.

Table 10. Results of coho scale sample analysis for stock identification, Big Beef Creek 2003.

Sex/Mark Group		Total Return	Number Sampled	Sample Rate	Sample Results			Total Estimated	
					Regen.[a]	Natural origin	Hatch	Natural origin	Hatch
Adults	Unmarked								
	Males >45 cm	2,349	448	19.1%	14	424	10	2,297	52
	Males 35-45 cm	244	244	100.0%	5	239	0	244	0
	Females	2,155	454	21.1%	15	436	3	2,141	14
	Total Adults	**4,748**	**1,146**	**24.1%**	**34**	**1,099**	**13**	**4,682**	**66**
Jacks	Unmarked	350	95	27.4%	1	91	3	339	11
	Total Jacks	**350**	**95**	**27.4%**	**1**	**91**	**3**	**339**	**11**

[a] Regenerated scales were assumed natural origin.

CWT Recovery

Adults

Unmarked/tagged coho comprised 67.0% of the total unmarked adult return (Table 8). This tag rate, however, does not estimate the proportion of tagged natural origin coho returning because unmarked/tagged hatchery fish also entered Big Beef Creek.

Over the season, we sacrificed 96 unmarked adult coho (90 males and 6 females) for CWT recovery at the trap, and all of these contained tags. In addition, we recovered one tag from an unmarked female that was dead in the trap, and another from an unmarked female that was dead below the weir. In total, these recoveries consisted of 96 Big Beef Creek natural origin fish (code 63-12/89), one hatchery coho released at the Big Quilcene National Fish Hatchery (code 05-05/94), and one hatchery coho from the Quilcene Bay Sea Pens (code 05-05/99) (Table 11).

In addition, we killed a total of 357 ad-marked adults (168 males and 189 females) at the trap, of which 31 males and 20 females detected positive for a CWT. Forty-nine of these fish contained tags; 45 were hatchery origin tags and four were Big Beef Creek natural origin tags from coho that had missing adipose fins. Two snouts from ad-marked adults that had detected positive for a tag contained none (Table 11).

We also collected snouts from 246 unmarked adult carcasses during stream surveys, of which 237 contained tags (Table 11). Tag recoveries consisted of 236 Big Beef Creek natural origin fish (code 63-12/89) and one hatchery fish from the Port Gamble Sea Pens (code 63-09/77). We could not recover CWT's from the remaining 9 coho snouts obtained during stream surveys because five of the snouts were lost, one tag was lost in the lab, and three snouts did not contain tags. In addition, two carcasses were recovered from the weir, and both of these contained Big Beef Creek natural origin tags.

Jacks

Unmarked/tagged jacks comprised 73.4% of the unmarked jack return (Table 8). As with adults, this mark rate does not estimate the proportion of tagged natural origin jacks returning because unmarked/tagged hatchery jacks also entered Big Beef Creek.

We sacrificed a total of 73 jacks (72 unmarked and 1 ad-marked) for CWT recovery at the trap, and all of these contained tags (Table 12). Tag recoveries from unmarked jacks included 71 Big Beef Creek natural origin tags (code 63-16/70) and one tag from the Lower Elwha Hatchery (code 21-03/45). The one ad-marked/tagged jack was from the Port Gamble Sea Pens (code 21-03/98).

Table 11. Coded-wire tag recoveries from unmarked and ad-marked adult coho (2000 brood), Big Beef Creek 2003.

Group	Tag Code	Origin	CWT RECOVERIES					
			Sacrificed at Trap	Stream Surveys	Carcasses From Weir	Trap Mortality	Dead Below Weir	Total
Unmarked	63-12/89	Big Beef Creek	94	236	2	1	1	**334**
	63-09/77	Port Gamble Sea Pens		1				**1**
	05-05/94	Quilcene Nat'l Fish	1					**1**
	05-05/99	Quilcene Bay Sea Pens	1					**1**
	Lost Snouts			5				**5**
	Lost Tags			1				**1**
	No Tags			3				**3**
TOTAL UNMARKED ADULTS			**96**	**246**	**2**	**1**	**1**	**346**
Ad-marked	63-12/89	Big Beef Creek	4					**4**
	63-05/79	South Sound Sea Pens	2					**2**
	63-02/87	South Sound Sea Pens	1					**1**
	63-03/90	Forks Creek Hatchery	1					**1**
	63-12/86	Wallace River Hatchery	1					**1**
	63-05/91	George Adams Hatchery	1					**1**
	05-05/91	Quilcene Nat'l Fish Hatchery	1					**1**
	05-05/93	Quilcene Nat'l Fish Hatchery	1					**1**
	05-06/64	Quilcene Bay Sea Pens	4					**4**
	18-35/62	Goldstream River, CDFO	1					**1**
	21-01/87	Lower Elwha Hatchery	1					**1**
	21-01/93	Port Gamble Sea Pens	6					**6**
	21-01/95	Agate Pass Sea Pens	25					**25**
	No tags		2					**2**
TOTAL AD-MARKED ADULTS			**51**					**51**

In addition, during stream surveys we collected snouts from the carcasses of 9 unmarked/tagged jacks. All nine jacks had Big Beef Creek natural origin tags (code 63-16/70) (Table 12).

Table 12. Coded-wire tag recoveries from unmarked and ad-marked jack coho (2001 brood), Big Beef Creek 2003.

Group	Tag Code	Origin	CWT RECOVERIES		
			Sacrificed at Trap	Stream Surveys	Total
Unmarked	63-16/70	Big Beef Creek	71	9	**80**
	21-03/45	Lower Elwha Hatchery	1		**1**
TOTAL UNMARKED JACKS			**72**	**9**	**81**
Ad-marked	21-03/98	Port Gamble Sea Pens	1		**1**
TOTAL JACKS			**73**	**9**	**82**

Estimation of Tag Loss

Tag loss of the 2000-brood adults and 2001-brood jacks returning in 2003 could not be estimated due to the absence of an external mark identifying the natural origin coho that we tagged and released as smolts from the Big Beef Creek trap. All returning natural origin adults and jacks should have been unmarked (tagged and untagged). Thus, to estimate survival to return, we assumed the tag loss rate was equal to the average tag loss rate of 3.5% that we have measured from 1991 to 1998 at the Big Beef Creek station when all tagged natural origin smolts were ad-marked and scale sampling was used to separate ad-marked hatchery strays from the returning ad-marked natural origin adults.

CWT Expansion

Adults

We collected 341 snouts from unmarked/tagged adults, of which 338 contained Big Beef Creek tags (includes four tagged adults with natural ad-marks) and three contained hatchery tags (Table 13). Expansion of these tag recovery results to the total unmarked/tagged return of 3,185 estimates 3,157 Big Beef Creek tags and 28 hatchery tags in the total unmarked/tagged return (Table 13). Adding the 51 ad-marked/tagged coho counted at the trap to the 28 unmarked/tagged hatchery coho estimated via CWT expansion estimates that a total of 79 tagged hatchery adults strayed into Big Beef Creek.

Estimating total hatchery strays (untagged and tagged) based on CWT recoveries requires two expansions, one for the sampling rate of tagged coho at the trap and another expansion based on the tagging rate at release from the hatchery. Due to the small number of recovered tags from each tag group, the mix of ad-marked and unmarked hatchery coho returning, and because of discrepancies in reported mark rates, tag loss, and numbers of unmarked/untagged coho released

from hatcheries in Hood Canal, we could not calculate a reliable estimate of total contribution from each hatchery source. .

Jacks

We collected 81 snouts from unmarked/tagged jacks, of which 80 contained Big Beef Creek tags (Table 14). Expansion of these tag recovery results to the total unmarked/tagged jack return of 257 estimates a total of 254 Big Beef Creek tags and three hatchery tags in the unmarked jack return (Table 14).

Table 13. Coded-wire tags recovered from natural origin and hatchery adults (2000 brood) and estimated total tagged adults returning, Big Beef Creek 2003.

Group	Tag Code	Origin	Observed Tag Recoveries	Estimated Total Tags
Unmarked	63-12/89	Big Beef Creek	[a]338	[b]3,157
	63-09/77	Port Gamble Sea Pens	1	
	05-05/94	Quilcene Nat'l Fish Hatchery	1	
	05-05/99	Quilcene Bay Sea Pens	1	28
		Total	**341**	**3,185**
Ad-marked	63-05/79	South Sound Sea Pens	2	
	63-02/87	South Sound Sea Pens	1	
	63-03/90	Forks Creek Hatchery	1	
	63-12/86	Wallace River Hatchery	1	
	63-05/91	George Adams Hatchery	1	
	05-05/91	Quilcene Nat'l Fish Hatchery	1	
	05-05/93	Quilcene Nat'l Fish Hatchery	1	
	05-06/64	Quilcene Bay Sea Pens	4	
	18-35/62	Goldstream River, CDFO	1	
	21-01/87	Lower Elwha Hatchery	1	
	21-01/93	Port Gamble Sea Pens	6	
	21-01/95	Agate Pass Sea Pens	25	
	No tags		2	
		Total	**51**	**51**

[a] Includes 4 natural origin tagged adult coho with natural adipose marks.

[b] Big Beef Creek (BBC) tagged adult sample expansion is: 3,185 total unmarked/tagged adults returning and 341 snouts dissected, of which 338 contained BBC tags (338/341 = .9912 x 3,185 = 3,157 estimated BBC tags in the total return).

Table 14. Coded-wire tags recovered from natural origin and hatchery jacks (2001 brood) and estimated total tagged jacks returning, Big Beef Creek 2003.

Group	Tag Code	Origin	Observed Tag Recoveries	Estimated Total Tags
Unmarked	63-16/70	Big Beef Creek	80	[a]254
	21-03/45	Lower Elwha Hatchery	1	3
		Total	**81**	**257**
Ad-marked	21-03/98	Port Gamble Sea Pens	1	**1**

[a] Big Beef Creek (BBC) tagged jack sample expansion is: 257 total unmarked/tagged jacks returning and 81 snouts dissected, of which 80 contained BBC tags (80/81 = .9877 x 257 = 254 estimated BBC tags in the total return).

Tag Rate Estimates

Scale analysis indicated there were 714 tagged natural origin adults and 7 tagged hatchery strays in the scale sample of 1,146 unmarked adults (Table 10). This estimates 99% of the tagged return was comprised of natural origin fish. Applying this rate to the total unmarked/tagged return of 3,185 adults estimates that 3,154 tagged adults were of natural origin. Dividing this number by the estimated 4,682 total unmarked naturally produced adults returning (Table 10) yields a natural origin tag rate of 67.4% (3,154/4,682).

In comparison, we estimated the tag rate upon smolt out-migration at 87.3% (21,256/24,352) without adjusting for differential survival or tag loss. Applying the assumed tag loss rate (3.5%) and estimated trapping and tagging-related mortality rate (16%; Blankenship and Hanratty 1990) to the number of smolts tagged yields an estimated tag rate of 70.8% (17,230/24,352), slightly higher than the rate of 67.4% estimated at adult return.

The tag rate for naturally produced jacks that returned in 2003 was estimated at 74.9% (254/339), based on the total estimated tags (Table 14) and the total estimated unmarked natural origin jack return from scale sample results (Table 10). In comparison, in Spring 2003 we estimated the tag rate upon smolt out-migration at 87.5% (31,553/36,060)(see Hood Canal IMW Downstream beginning on page 3), without adjusting the tag group size for trapping and tagging mortality (16%) and tag loss (3.5%). With these adjustments, the tag rate upon smolt out-migration is estimated at 70.9% (25,577/36,060), slightly lower than the rate estimated from the jack return to the trap.

Survival to Adult Return

Adults

Survival of the 2000-brood Big Beef Creek coho tag group from smolt emigration in Spring 2002 to return as adults in Fall 2003 was estimated via two methods, CWT analysis and scale results. Based on CWT results, we estimated that 3,157 tagged naturally produced adults returned (Table 13). Dividing these by the estimated 17,230 natural origin smolts tagged in Spring 2002 (adjusted for tag loss [3.5%] and delayed tagging mortality [16%])(Table 10) yields a survival-to-return rate of 18.3%. In comparison, dividing the scale-based estimate of 3,154 BBC tags returning by the adjusted estimate of 17,230 natural origin smolts tagged in Spring 2002 yields a survival-to-return rate of 18.3%, the same rate as the CWT-based estimate.

Jacks

The same method was used to estimate the survival-to-return of tagged natural origin jacks (2001-brood). We estimated that 254 tagged natural origin jacks returned via expanding in-sample CWT results (Table 14). Dividing these 254 tags by an adjusted estimate of 25,577 natural origin smolts tagged in Spring 2003 (adjusted for tag loss and delayed mortality from a total tagged release of 21,553), yields a survival-to-return estimate of 0.99%.

We sampled scales from a total of 95 unmarked jacks (Table 10). Scale results revealed there were 91 tagged natural origin jacks and 3 tagged hatchery strays in this sample, yielding a natural origin tag rate of 96.8%. Applying this rate to the total unmarked/tagged jack return of 257 estimates that 249 tagged natural origin jacks returned. Dividing this estimate by the 25,577 (adjusted) smolts tagged in Spring 2003 yields a survival-to-return rate of 0.97%, nearly identical to the CWT-based estimate.

Marine Survival

Based on preliminary data in the coastwide CWT recovery database (PSMFC's Regional Mark Information System), we estimated that 167 Big Beef Creek tags (2000 brood) were caught in 2003 fisheries (preliminary estimate): 150 in Puget Sound sport and mixed net/seine fisheries (combined), one from a test fishery in Puget Sound, and 16 from the treaty troll fishery in the ocean (Table 15). Adding the estimated escapement of 3,157 tagged natural origin coho to this harvest, and dividing this sum by the adjusted number of smolts tagged in Spring 2002, yields a preliminary estimated marine survival rate of 19.3% ([167 + 3,157]/17,230) (Table 15). We will compute a final estimate of marine survival for natural origin 2000-brood Big Beef coho once the final estimates of total tags and catch in ocean and Puget Sound fisheries have been reported in the PSMFC's Regional Mark Information System (RMIS) database.

Table 15. Estimated marine survival of Big Beef Creek natural origin adult coho (2000 brood), based on the estimated catch and escapement of tagged natural origin adults during 2003 (Preliminary).

Area		Fishery Type	Total Estimated BBC Tags in the Adult Coho Return (2000 Brood) (Tag Code: 63-12/89)
HARVEST	***Ocean (WA)***	Treaty Troll	16
	Puget Sound	Sport + Mixed Net/Seine (combined) [a]	150
		Test Fishery Seine	1
		Total Puget Sound	**151**
	ESTIMATED HARVEST OF BBC TAGS (Preliminary) [b]:		**167**
ESCAPE-MENT	**Big Beef Creek Trap**	Return of natural origin tags to trap [c]	**3,157**
	ESTIMATED ESCAPEMENT OF BBC TAGS:		**3,157**
SUMMARY		**TOTAL RUN (Harvest + Escapement)**	**3,324**
	Total Smolts Tagged (tag code 63-12/89)		21,256
	Total Adjusted Smolts Tagged [d]		17,230
	Harvest Rate (Total Harvest/Total Run)		[b e] 5.0%
	Escapement Rate (Total Escapement/Total Run)		95.0%
	MARINE SURVIVAL (Total Run/Total Adjusted Smolts Tagged)		**19.3%**

[a] This is our preliminary estimate of total Big Beef Creek tag recoveries from sport and mixed net/seine fisheries in Puget Sound (including Hood Canal), based on observed recoveries and preliminary expansions. Final estimates of total tags by fishery are not yet available due to unreported catch information.

[b] Estimated harvest of Big Beef Creek tags is preliminary. The final estimated harvest will be documented once all tag recoveries and catch in Ocean and Puget Sound fisheries have been reported in the PSMFC's Regional Mark Information System (RMIS) database.

[c] Estimated via expanding coded-wire tag results for code 63-12/89 to the total unmarked/tagged adult return.

[d] Adjusted by the effect of trapping and tagging on survival (16% per Blankenship and Hanratty 1990) and the assumed tag loss rate of 3.5%.

[e] Preliminary harvest rate; currently biased low due to unreported catch data from fisheries.

Hood Canal Treaty Fishery Sampling

During Fall 2003, we conducted daily on-the-water monitoring of the treaty coho fishery in Hood Canal, to enumerate the total catch and determine the CWT incidence and disposition. We focused our sampling effort in area 12, where the treaty beach seine fishery occurred adjacent to the Big Beef Creek estuary and near the estuaries of other tributaries. WDFW biologists and sampling personnel traveled by boat throughout the open fishing area and asked to examine the landed catch of tribal fishers. For each landing sampled, the entire coho catch was enumerated

and electronically detected for coded-wire tags. The snout was removed from each tagged fish and then labeled for subsequent processing at the WDFW coded-wire tag lab. We also recorded the total number of coho examined, and measured fork lengths on a portion of the coho captured.

Treaty fisheries in area 12 were open from September 21 through October 26 (Table 16). During this period, the tribal beach seine fishery was active in the nearshore area on one day only, September 21. On this day, we electronically sampled a total of 227 coho, of which 64 detected positive for CWT's, and 56 of these contained tags (24.7% tag rate; Table 17). Disposition of the 56 tags was as follows: 34 Big Beef Creek (60.7%), seven hatchery tags from the George Adams Hatchery (12.5%), eight from the Port Gamble Sea Pens (14.3%), five from the Quilcene Bay Sea Pens (8.9%), and two from the Big Quilcene National Fish Hatchery (3.6%) (Table 17).

An estimate of the total tags captured in the Hood Canal treaty coho fishery will not be possible until Fall 2004, when we expect tag expansion estimates to be finalized in the RMIS database. Our preliminary estimate of 150 Big Beef Creek tags captured in Puget Sound sport and mixed net/seine fisheries combined (Table 15) includes estimated BBC tags captured in Hood Canal.

Table 16. Number of days open by area for treaty coho fisheries (set net and beach seine) in Hood Canal, Fall 2003.

Area	Dates Open	Total Days
12	9/21-9/27, 9/28-10/4, 10/5-10/11, 10/12-10/18	28
12B	9/21-9/27, 9/28-10/4, 10/5-10/11, 10/12-10/18	28
12C	9/21-9/27, 9/28-10/4, 10/5-10/11, 10/12-10/26	36

Table 17. Coded-wire tags recovered from sampling the Hood Canal (area 12) treaty coho beach seine fishery on September 21, 2003.

Tag Code	Origin	#CWT Recoveries	Total Fish Sampled	% Tagged
63-12/89	Big Beef Creek	34		
63-05/92	George Adams Hatchery	3		
63-05/91	George Adams Hatchery	4		
63-09/77	Port Gamble Sea Pens	6		
21-01/93	Port Gamble Sea Pens	2		
05-06/64	Quilcene Bay Sea Pens	1		
05-05/99	Quilcene Bay Sea Pens	4		
05-05/95	Quilcene Nat'l Fish Hatchery	1		
05-05/92	Quilcene Nat'l Fish Hatchery	1		
	TOTAL	56	227	24.7%

Coho Escapement Estimates: Hood Canal Tributaries

We estimated natural origin coho escapement to Stavis, Seabeck, and Little Anderson Creeks at 1,290, 275, and 45 adults, respectively (Table 18). These estimates were derived via applying the survival-to-return rate for 2000-brood Big Beef Creek natural origin coho (18.3%) to the 2002 smolt migration estimates from Stavis, Seabeck, and Little Anderson Creeks. This approach assumes that natural origin coho returning to these tributaries have the same survival-to-return rate as natural origin coho returning to Big Beef Creek.

Since hatchery fish were not excluded from these other streams, like they were from Big Beef Creek, total escapements were estimated by dividing the natural origin escapement estimates by the proportion of natural origin coho in the total Big Beef Creek return. This proportion was estimated at 91.7% (4,682 natural origin coho [Table 10]/5,105 total coho [Table 8]); yielding total escapement estimates of 1,407, 300, and 49 coho, respectively (Table 18).

Table 18. Escapement estimates for 2000-brood adult coho returning to Stavis, Seabeck, and Little Anderson Creeks in 2003, based on 2002 smolt migration estimates and preliminary estimated Big Beef Creek return rates.

Stream	2000 Brood Smolt Migration Estimate	Big Beef Survival to Return	Estimated Natural Origin Escapement	Proportion of Returning Natural origin Coho in the Big Beef Escapement	Estimated Total Escapement
Stavis Creek	7,050	18.3%	1,290	91.7%	1,407
Seabeck Creek	1,504	18.3%	275	91.7%	300
Little Anderson Creek	247	18.3%	45	91.7%	49
TOTAL	**8,801**		**1,610**		**1,756**

Size Analysis

We measured fork lengths on all unmarked adult coho sampled for scales, which included 448 males (larger than 45 cm), 244 males in the 35 cm to 45 cm size range, and 454 females (Table 10). For the size analysis, we used a random systematic approach to sub-sample the unmarked males in the 35 cm to 45 cm size range (initially sampled at a rate of 100%) to equal the sample rate of males larger than 45 cm (20%). Also, we included only those coho whose origin (hatchery or natural) could be determined. This sample of natural origin adults consisted of 310 unmarked/untagged coho (160 males and 150 females) and 597 unmarked/coded-wire tagged coho (311 males and 286 females) (Table 19).

Over the season, natural origin unmarked males were slightly smaller than unmarked females, averaging 55.6 cm and 58.2 cm, respectively (Table 19). In comparing the size of males from untagged versus tagged groups, the overall means were identical (55.5 cm and 55.6 cm). Similarly, untagged and tagged females had equal means over the season (58.0 cm and 58.3 cm).

The smallest male in this sample was 37 cm, and the largest was 77 cm. The smallest female was 45 cm, while the largest was 76 cm (Table 19).

Size and Age

Scale samples were taken from all unmarked male coho in the 35 cm to 45 cm size range to determine their age and origin, resulting in a total of 281 samples. Scale analysis determined that 244 were three-year-old males and 37 were two-year-old jacks. Of these, 238 adults and 34 jacks were of natural origin. The remaining samples (excluded from Table 19) consisted of one male and two jacks that were hatchery fish, and five males and one jack that had regenerated scales.

Prior to the intensive scale sampling we began in 1991 for the purpose of stock identification, all of the size overlap between jacks and adult males occurred in the 35 cm to 45 cm size range. With this additional sampling we have found a few adults smaller than 35 cm. In 2003 we measured two adult males at 34 cm. The largest jack was 40 cm.

Table 19. Mean fork length (cm), range, standard deviation, and sample rate of natural origin unmarked adult coho, by statistical week and sex, Big Beef Creek 2003.

Statistical Week			MALES							FEMALES						
No.	Begin	End	Mean	Range Min	Range Max	s.d.	n	Catch	Sample Rate	Mean	Range Min	Range Max	s.d.	n	Catch	Sample Rate
Untagged/Unmarked																
41	10/08	10/12	53.5	39	75	7.92	60	329	18.2%	56.8	45	71	5.90	43	192	22.4%
42	10/13	10/19	57.2	37	75	9.20	75	407	18.4%	58.6	47	73	6.00	74	342	21.6%
43	10/20	10/26	56.2	42	67	8.12	17	79	21.5%	61.1	51	72	5.63	19	78	24.4%
44	10/27	11/02	--	--	--	--	0	1	0.0%	64.0	64	64	--	1	2	50.0%
45	11/03	11/09	--	--	--	--	0	0	0.0%	--	--	--	--	0	0	0.0%
46	11/10	11/16	49.0	49	49	--	1	3	33.3%	--	--	--	--	0	6	0.0%
47	11/17	11/23	53.1	43	72	9.62	7	49	14.3%	54.4	50	67	5.48	9	49	18.4%
48	11/24	11/30	--	--	--	--	0	10	0.0%	55.5	54	57	2.12	2	7	28.6%
49	12/01	12/07	--	--	--	--	0	5	0.0%	51.0	47	55	5.66	2	4	50.0%
Total			55.5	37	75	8.74	160	883	18.1%	58.0	45	73	6.06	150	680	22.1%
CWT'd/Unmarked																
41	10/08	10/12	53.3	37	74	8.19	125	699	17.9%	57.7	47	70	5.35	74	328	22.6%
42	10/13	10/19	57.4	40	77	8.59	142	809	17.6%	58.8	46	76	5.92	165	852	19.4%
43	10/20	10/26	55.3	39	76	9.80	28	117	23.9%	56.6	48	70	5.88	25	164	15.2%
44	10/27	11/02	--	--	--	--	0	5	0.0%	58.0	58	58	--	1	9	11.1%
45	11/03	11/09	--	--	--	--	0	0	0.0%	--	--	--	--	0	1	0.0%
46	11/10	11/16	--	--	--	--	0	3	0.0%	51.0	51	51	--	1	4	25.0%
47	11/17	11/23	57.2	46	74	8.62	13	47	27.7%	58.6	52	74	6.84	16	88	18.2%
48	11/24	11/30	60.7	54	73	10.69	3	18	16.7%	57.0	55	60	2.65	3	17	17.6%
49	12/01	12/07	--	--	--	--	0	7	0.0%	62.0	62	62	--	1	10	10.0%
Total			55.6	37	77	8.73	311	1,705	18.2%	58.3	46	76	5.80	286	1,473	19.4%
Total Unmarked			**55.6**	**37**	**77**	**8.73**	**471**	**2,588**	**18.2%**	**58.2**	**45**	**76**	**5.89**	**436**	**2,153**	**20.3%**

Notes:
The sample rate of males in the 35 cm to 45 cm size range was adjusted to 20%, to equal the sample rate of males greater than 45 cm.
Lengths from coho with regenerated scales were excluded.

Run Timing

Hatchery and natural origin coho returning to Big Beef Creek exhibited nearly identical migration timing, except during the period from October 7 through October 18, when hatchery fish returned slightly earlier (Figure 6). Both runs reached 50% of their migration by October 16. Hatchery coho completed their migration by December 6, whereas natural origin coho finished their migration a week later, on December 13. We have observed this trend in most past years of upstream trapping at Big Beef Creek.

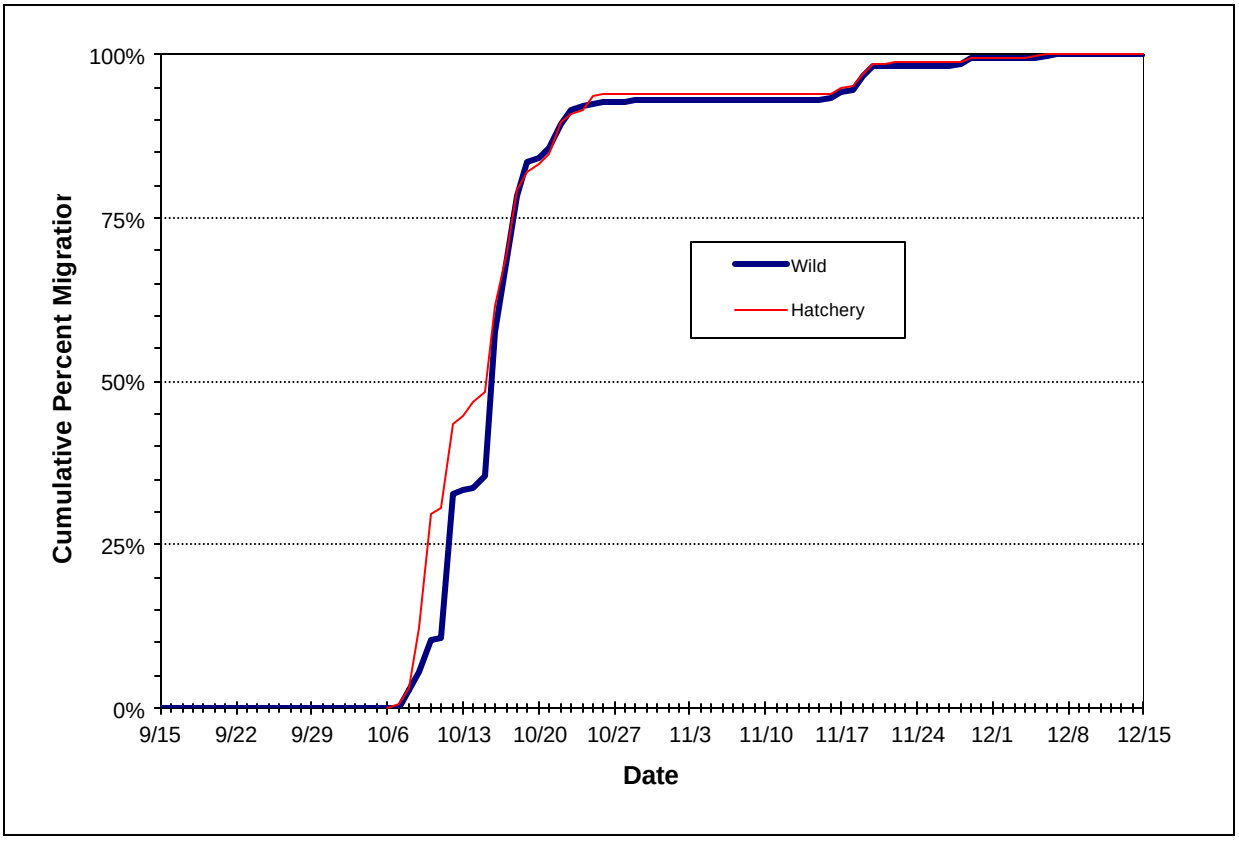

Figure 6. Migration timing of natural origin and hatchery adult coho returning to Big Beef Creek during Fall 2003.

Other Species

Chum

The chum return totaled 3,744 adults; 896 summer chum and 2,848 fall chum (Table 20). The first chum was captured on September 6 and the last on December 24 (Table 21). Migration timing of summer and fall chum stocks overlapped during October. To differentiate counts of summer and fall chum returns to the trap, we designated October 15 as the separation date between the two stocks; those returning before this date were considered summer chum, while those returning on or after October 15 were designated as fall chum.

Most returning chum were released upstream to spawn naturally (86.2% of the summer chum and 85.1% of the fall chum). A small percentage of summer (5.8%) and fall (6.1%) chum spawned below the weir. In addition, 8.0% of returning summer chum were transferred to the University of Washington's (UW) hatchery for artificial production. Also 8.8% of the fall chum were released into the UW spawning channel unspawned (Table 20).

The last native adult summer chum returned to Big Beef Creek in 1987. A program to reintroduce summer chum to the stream began in Winter and Spring 1996 with 200,000 chum fry (1995-brood Big Quilcene River stock) reared and released from the Big Beef Creek Research Station. These releases have continued each year through brood 2003.

Table 20. Disposition of chum returning to Big Beef Creek, 2003.

Disposition		Male	Female	Total	Percent
Summer Chum	Released upstream unspawned	447	325	772	86.2%
	Spawned below weir	23	29	52	5.8%
	Transferred to hatchery	38	34	72	8.0%
	Total Return Summer Chum	**508**	**388**	**896**	**100.0%**
Fall Chum	Released upstream unspawned	1,582	842	2,424	85.1%
	Released into UW spawning channel unspawned	154	96	250	8.8%
	Spawned below weir	96	78	174	6.1%
	Total Return Fall Chum	**1,832**	**1,016**	**2,848**	**100.0%**
TOTAL CHUM		**2,340**	**1,404**	**3,744**	**100.0%**

Chinook

Returning chinook were transferred to the FRI hatchery for artificial propagation. Numbers of chinook captured and transferred to the hatchery during the 2003 season will be reported by the UW Fisheries Research Institute.

Steelhead

Two steelhead were captured in late December (Table 21). However, this catch represents an unknown portion of the total steelhead return. We opened the weir on January 2, 2004, and it remained open through March 2004, when we installed the downstream migrant traps.

Cutthroat

The first upstream migrating cutthroat trout was captured on October 10, and the last on December 24. In total, we captured and released upstream 45 males and 24 females (Table 21). As with steelhead, this is an unknown portion of the total return

Table 21. Numbers of chum salmon, steelhead, and cutthroat trout trapped by week, Big Beef Creek trap, Fall 2003.

Statistical Week			Summer Chum			Fall Chum			Steelhead			Cutthroat		
Begin	**End**	**No.**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
9/6	9/7	36	4	2	**6**			**0**			**0**			**0**
9/8	9/14	37	13	5	**18**			**0**			**0**			**0**
9/15	9/21	38	207	145	**352**			**0**			**0**			**0**
9/22	9/28	39	154	120	**274**			**0**			**0**			**0**
9/29	10/5	40	75	63	**138**			**0**			**0**			**0**
10/6	10/12	41	55	53	**108**			**0**			**0**	3	4	**7**
10/13	10/19	42			**0**	15	2	**17**			**0**	17	7	**24**
10/20	10/26	43			**0**	37	15	**52**			**0**	19	9	**28**
10/27	11/2	44			**0**	206	85	**291**			**0**			**0**
11/3	11/9	45			**0**	139	98	**237**			**0**			**0**
11/10	11/16	46			**0**	449	226	**675**			**0**			**0**
11/17	11/23	47			**0**	487	257	**744**			**0**	1		**1**
11/24	11/30	48			**0**	227	166	**393**			**0**	2		**2**
12/1	12/7	49			**0**	193	122	**315**			**0**	2	2	**4**
12/8	12/14	50			**0**	72	41	**113**			**0**	1	1	**2**
12/15	12/21	51			**0**	4	2	**6**			**0**			**0**
12/22	12/24	52			**0**	3	2	**5**	1	1	**2**		1	**1**
TOTAL			508	388	**896**	1,832	1,016	**2,848**	1	1	**2**	45	24	**69**

Lower Columbia IMW Downstream 2003

Methods

Trap Operation

Screw traps (Kennen et al. 1994) were used to capture a portion of migrating salmonids in Abernathy, Germany, and Mill Creeks. The 1.5-m diameter traps were located near the mouth in each stream (Figure 2). Trapping began in early April and ended in mid-June when catches of all migrants were low. Trap efficiency tests were conducted on all three creeks. Groups of coho, steelhead, and cutthroat smolts were anesthetized with tricaine methanesulfonate (MS 222), and marked with a unique partial fin clip. Marked fish were allowed to recover in fresh water before being placed in buckets, transported upstream, and released upstream of the trap. Capture rates were estimated by the proportion of marked fish that were recaptured in the trap after release.

Production Estimate

Production was estimated in two steps. Since the traps did not operate continuously over the entire trapping period, the first step involved estimating by interpolation catch for periods when the traps did not fish. The second step involved estimating capture rates or trap efficiencies.

To interpolate catch for periods when the trap was not fishing, diel differences in migration rates were evaluated. Salmonids often migrate at different rates between day and night periods (Seiler *et al.* 1981), therefore, fishing periods were stratified into daytime, nighttime, and combined periods. Catch during trapping intervals not fished were estimated by interpolating between catch rates from the previous and following fishing periods in the same diel stratum, and then expanding by the hours not fished. When a trapping interval was interrupted by debris, catch was either estimated for the entire night or, if available, catches for the outage interval was estimated based on the expected number of trap rotations (rotations/minute x fishing time) compared to the count on the rotation counter. Catch rates were estimated by;

$$\hat{R}_{fj} = \frac{C_{fj}}{T_{fj}} \qquad \text{Equation 1}$$

where:

R_{fj} = the catch rate during fishing period f in diel stratum j,

C_{fj} = catch during fishing period f in diel stratum j, and

T_{fj} = the duration of fishing period f in diel stratum j.

The variance of the catch rate interpolated for the outage period (mean catch rate) was estimated by;

$$V(\overline{R}_{fj}) = \frac{\sum(\hat{R}_{fj} - \overline{R}_{fj})^2}{n(n-1)} \qquad \text{Equation 2}$$

Catch during the un-fished interval, C_{uj}, was then estimated by multiplying this catch rate by the hours not fished (T_{uj}). The catch variance was then estimated by;

$$V(\hat{C}_{uj}) = V(R_{fj})\hat{T}_{uj}^{\,2} \qquad \text{Equation 3}$$

In order to estimate the capture rate of the trap, groups of similarly marked migrants were released upstream of the trap and subsequently recaptured. The capture rate was calculated for tests using;

$$\hat{e}_i = \frac{r_i}{m_i} \qquad \text{Equation 4}$$

where;

$\hat{e}_i$ = the capture rate estimated for trap efficiency group mark type i,

r_i = the number of marked or dyed migrants captured from group mark type i, and

m_i = the number of marked or dyed migrants released from group mark type i.

The variance of each trap efficiency test was calculated by the variance of a binomial;

$$V(\hat{e}_i) = \frac{\hat{e}_i(1-\hat{e}_i)}{m_i} \qquad \text{Equation 5}$$

Daily migration was estimated by dividing the estimated catch by the estimated trap efficiency. Since trap efficiency is often a function of stream discharge, regression analysis was used to explore this relationship for each stream. Where mean daily flow failed to show a relationship with individual trap efficiencies, the average trap efficiency was used. The variance of the average trap efficiency was calculated using Equation 2, substituting $\overline{e}$ for $\overline{R}_{fj}$ and $\hat{e}_i$ for $\hat{R}_{fj}$. Daily migration was estimated by summing daytime, nighttime, and combined catch intervals to estimate 24 hour catch and dividing by the estimated efficiency. Total season migration, $\hat{N}$, was estimated by the sum of the daily estimated migrations, and the season migration variance for each species was estimated by the following where the average trap efficiency is used throughout the season;

$$V(\hat{N}) = \hat{N}^2\left(\frac{V(\overline{e})}{\overline{e}^2} + \frac{\sum V(\hat{C}_{uj})}{\left(\sum C_{fj} + \sum \hat{C}_{uj}\right)^2}\right) \qquad \text{Equation 6}$$

In some cases, trap efficiency changed over the season in response to changes in flow or operational changes to the trap. Where this occurred, total migration for each efficiency stratum

was estimated by the sum of the daily migration estimates over the stratum period. The variance of migration estimates for the stratum period was calculated using Equation 6, substituting the stratum period estimates for each of the variables. The variance of the season total migration was estimated by the sum of the variances for the efficiency strata.

Results

Abernathy Creek

The screw trap was installed on April 4 near river mile 0.4, approximately 100 yards upstream of the 2002 position. The trap was checked either once or twice a day, depending on water and debris conditions. The trap fished throughout the season, except on four nights when logs stopped the screw. Lower flows later in the season precluded trap operation in the original position. The trap was moved upstream 12 feet on April 22 in order to increase the speed (rotations/minute) of the screw. As flow continued to decrease, we installed weir panels on May 14 to direct more flow into the screw and increase fish capture rates. The trap was removed on the morning of June 19.

Coho

Catch

On the first night of trapping, the trap screw was jammed by debris (screw stopper) and no coho were caught. Three smolts were captured during the second night of trapping, and daily catch averaged four smolts per night until late April. Catches then began to increase and peaked on May 28 when 124 smolts were caught. By mid-June catches were decreasing and catch averaged only five migrants a day. A total of 2,324 coho smolts were caught throughout the trapping period.

Size

Average coho smolt fork lengths varied little throughout the trapping interval (Table 22, Figure 7). Size ranged from 74 mm to 156 mm, and averaged 114 mm over the season.

Table 22. Mean fork length (mm), standard deviation, range, and sample size of coho and steelhead smolts measured by statistical week, Abernathy Creek 2003.

Statistical Week			COHO SMOLTS						STEELHEAD SMOLTS					
					Range		Number				Range		Number	
#	Begin	End	Avg.	s.d.	Min	Max	Sampled	Caught	Avg.	s.d.	Min	Max	Sampled	Caught
14	03/31	04/06	97.7	9.5	88	107	3	11	215.0	n/a	215	215	1	1
15	04/07	04/13	87.0	n/a	87	87	1	33	164.3	26.5	143	203	4	8
16	04/14	04/20					0	25					0	8
17	04/21	04/27	113.5	12.2	74	127	17	85	173.9	12.4	155	197	17	65
18	04/28	05/04	119.0	12.8	93	147	27	229	161.7	8.0	147	179	25	109
19	05/05	05/11	113.1	9.2	91	127	30	232	167.7	13.1	141	208	26	95
20	05/12	05/18	112.9	14.1	93	156	20	280	162.6	12.7	147	193	16	45
21	05/19	05/25	115.0	8.7	97	146	55	561	161.3	10.8	142	187	51	184
22	05/26	06/01	116.2	8.1	104	135	35	557	155.2	9.0	133	176	20	66
23	06/02	06/08	115.6	9.1	100	133	30	259	159.3	18.7	131	186	10	19
24	06/09	06/15	110.2	6.7	101	122	18	47	147.0	n/a	147	147	1	1
25	06/16	06/22	112.6	6.3	105	119	5	5	151.0	1.4	150	152	2	2
Season Totals			114.4	10.3	74	156	241	2,324	163.0	13.4	131	215	173	603

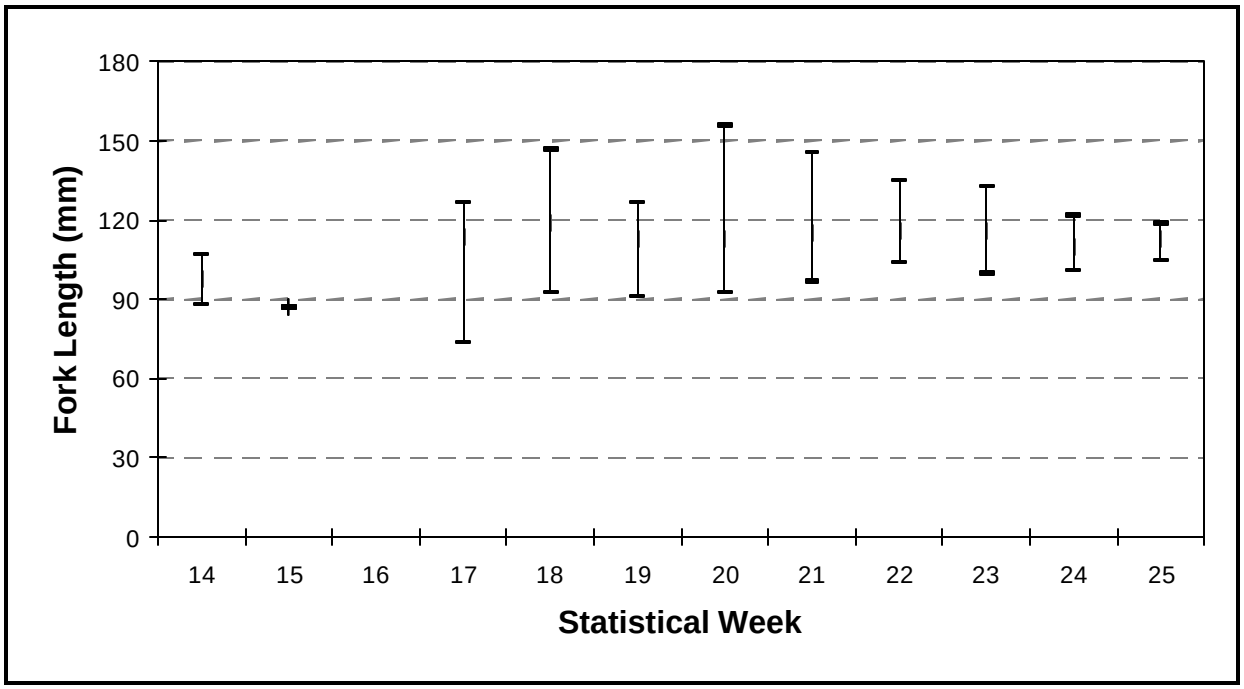

Figure 7. Weekly average, minimum, and maximum coho smolt fork lengths (mm) measured at the Abernathy Creek screw trap, 2003.

Catch Expansion

The trap was operated 1,779 hours out of 1,820 hours over the 76-day trapping period, or 97.7% of the time. Catch was expanded during four trap intervals when trapping was interrupted due to screw stoppers. Trapping was suspended for 15.3 hours on April 4, 11.1 hours on April 9, 6.9 hours on April 11, and 7.9 hours on April 12. We estimated three, one, two, and four additional coho smolts, respectively, would have been caught had we fished continuously through these intervals. The estimated catches represent only a 0.4% increase from the actual catch.

Trap Efficiency

A total of 2,145 coho in 65 groups were marked and released upstream of the trap. An additional two releases of five smolts each were not included due to screw stoppers occurring during the nights of release and recapture. The number of fish released in each group ranged from one to 92 smolts. Recapture rates were not calculated for individual releases due to small release sizes and protracted migration. Efficiency tests were grouped by mark type and trap position. The trap was moved once on April 22, and on May 19 weir panels were installed directly upstream of the trap in order to increase efficiency. Grouped trap efficiency tests conducted during the original trap position (Stratum 1) ranged from 8.6% to 13.6% and averaged 11.1% (Table 23). Capture rates averaged 18.7% during the second trap position (Stratum 2), and 31.7% following the installation of weir panels on May 19 (Stratum 3) (Table 23).

One marked smolt was caught in the trap 22 days after being released. Marked smolts that were marked during one trap stratum and caught in the next were excluded from the analysis in order to cleanly separate trapping strata.

Production Estimate

Total coho production is estimated to be 9,626 smolts with a coefficient of variation of 9.3% and a 95% confidence interval of 7,877 to 11,375 smolts (Figure 8). This estimate is based on our expanded catch estimate of 2,334 migrants and the estimated average trap efficiency for each trap position.

Table 23. Grouped capture efficiency tests for coho smolts by trap position, Abernathy Creek 2003.

Trap Position	Dates		# Marked		Trap Efficiency
	Release	Recapture	Released	Recaptured	
Stratum 1 Original	4/06-4/13	4/09-4/14	22	3	13.6%
	4/14-4/21	04/15	35	3	8.6%
	Sum		57	6	
	Average				11.1%
	Variance				6.4E-04
	n				2
Stratum 2 12 ft. Upstream	4/23-4/27	4/25-5/06	47	10	21.3%
	4/28-5/04	4/29-5/10	221	38	17.2%
	5/05-5/18	5/06-5/19	525	93	17.7%
	Sum		793	141	
	Average				18.7%
	Variance				1.6E-04
	n				3
Stratum 3 Weir Panels	5/19-5/25	5/20-6/09	493	207	42.0%
	5/26-6/08	5/27-6/17	761	237	31.1%
	6/09-6/16	6/11-6/19	41	9	22.0%
	Sum		1,295	453	
	Average				31.7%
	Variance				3.4E-03
	n				3

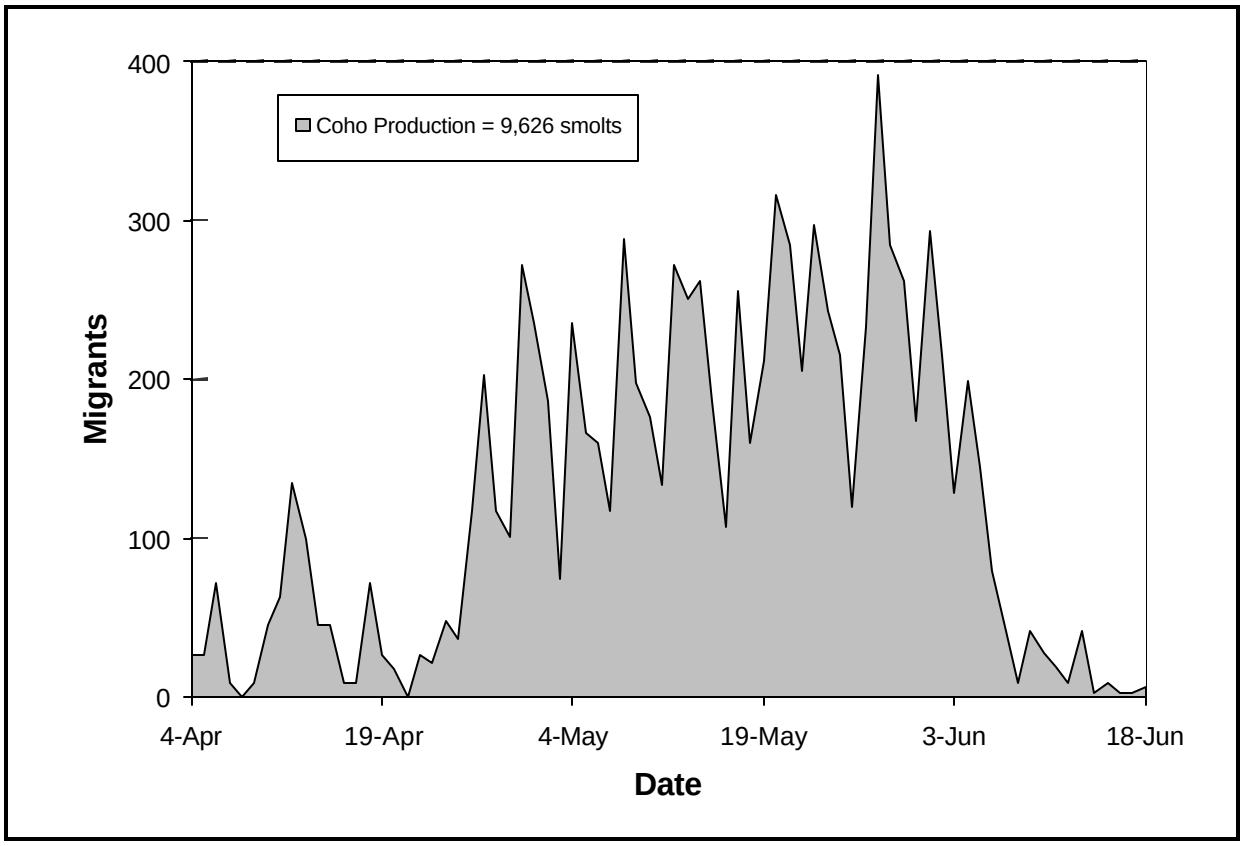

Figure 8. Estimated daily and seasonal coho smolt migration, Abernathy Creek screw trap 2003.

Steelhead and Cutthroat

Catch

We captured no steelhead or cutthroat smolt migrants during first night of trapping, and only one steelhead smolt was caught during the second night. The lack of catches early in the season indicates steelhead and cutthroat outmigrations were in their early stages. Natural origin steelhead catch peaked on May 21 when 57 smolts were caught, and cutthroat catch peaked on April 29 when ten smolts were caught. A total of 603 natural origin steelhead and 139 cutthroat smolts were caught throughout the trapping period.

In addition to natural origin smolts caught, we also captured 3,176 hatchery reared steelhead smolts: 124 were PIT tagged, 237 were unmarked, and 2,815 were coded wire tagged. The number PIT tagged fish captured may be underestimated. The first couple hundred hatchery smolts were not accurately sampled for PIT tags; smolts were only checked for PIT tags if they did not register with the CWT detector. Since both tag types register the CWT detector, the number of CWT tagged and PIT tagged smolts present in the catch may have been over estimated and underestimated, respectively.

Size

Average natural origin steelhead fork lengths increased slightly during the trapping interval (Table 22, Figure 9). Sizes of natural origin steelhead ranged from 131 mm to 215 mm, and averaged 163 mm over the season. Cutthroat fork lengths were not recorded during the trapping season.

Catch Expansion

Catch was expanded during four trap intervals when debris stopped the trap. Estimated catch for those four intervals totaled two natural origin steelhead, zero hatchery steelhead, and zero cutthroat smolts.

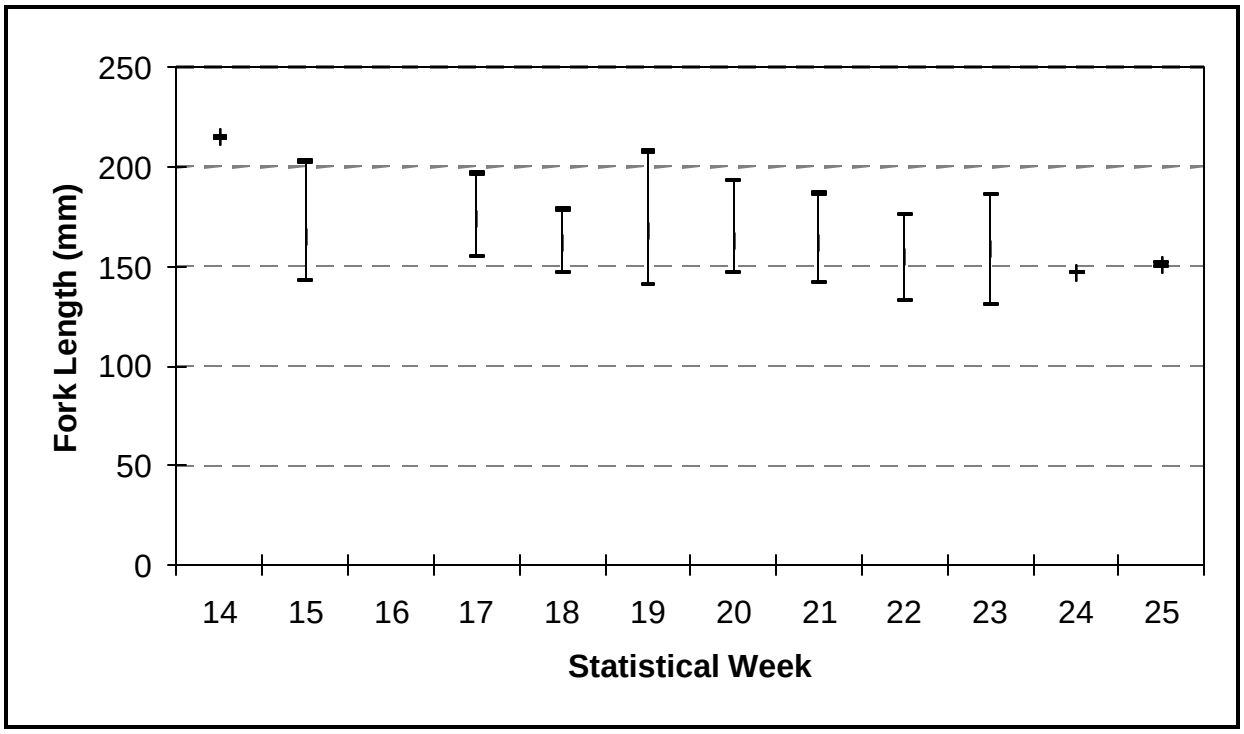

Figure 9. Weekly average, minimum, and maximum natural origin steelhead smolt fork lengths (mm) measured at the Abernathy Creek screw trap, 2003.

Trap Efficiency

A total of 530 natural origin steelhead were marked and released upstream of the trap on 53 days. The number of steelhead released each day ranged from one to 54 smolts. Recapture rates were not calculated for individual releases due to small release groups and protracted migration. Efficiency tests were grouped by mark type and, initially, by trap position. Mean trap efficiency was not significantly different between trap placement treatments (z-test, á=0.05) and these strata were, therefore, not used. The five release groups by mark type ranged from 46 to 165 smolts. Efficiencies ranged from 11.4% to 16.4% and averaged 14.6% (Table 24).

PIT tags were inserted by the US Fish and Wildlife Service Abernathy Fish Technology Center (AFTC) in a total of 110 cutthroat smolts captured in the screw trap and released above their PIT

tag antennae array at river kilometer 2.9. One to eight individuals were released in 43 groups during the trapping season. Cutthroat trap efficiency was 26.4%, estimated from 29 PIT tagged smolts recaptured at the trap. Cutthroat efficiency was not examined by efficiency strata due to the low number of recoveries.

Table 24. Trap efficiency tests using steelhead smolts grouped by mark type, Abernathy Creek 2003.

Dates		# Marked		Trap
Release	Recapture	Released	Recaptured	Efficiency
4/06-4/27	4/25-5/03	46	7	15.2%
4/28-5/04	4/29-5/07	111	18	16.2%
5/05-5/18	5/06-5/19	129	18	14.0%
5/19-5/25	5/21-5/29	165	27	16.4%
5/26-6/08	5/28-6/11	79	9	11.4%
Sum		530	79	
Average				14.6%
Variance				8.4E-05
n				5

Production Estimates

During the period of screw trap operation, we estimated that 4,141 steelhead and 531 cutthroat smolts passed the trap. These estimates were based on expanded catch estimates and the season average trap efficiency for each species. The steelhead migration was not expanded beyond the trapping period as initial and ending catches indicated little migration occurred outside this period. Total steelhead production is estimated at 4,141 smolts with a coefficient of variation of 6.3% and a 95% confidence interval of 3,632 to 4,650 smolts (Figure 10). Total cutthroat production was estimated to be 531 smolts with a coefficient of variation of 15.9% and a 95% confidence interval of 365 to 697 smolts (Figure 10). Cutthroat did not exhibit a migration trend, and although migration may occur outside of the trapping interval, the proportion is unknown and could not be estimated.

Hatchery steelhead migration past the trap was estimated at 21,713 smolts with a coefficient of variation of 6.3% and a 95% confidence interval of 19,046 to 24,380 smolts. This estimate was made using the average natural origin steelhead trap efficiency estimate of 14.6%. This approach estimates 72.1% of the hatchery release migrated past the trap.

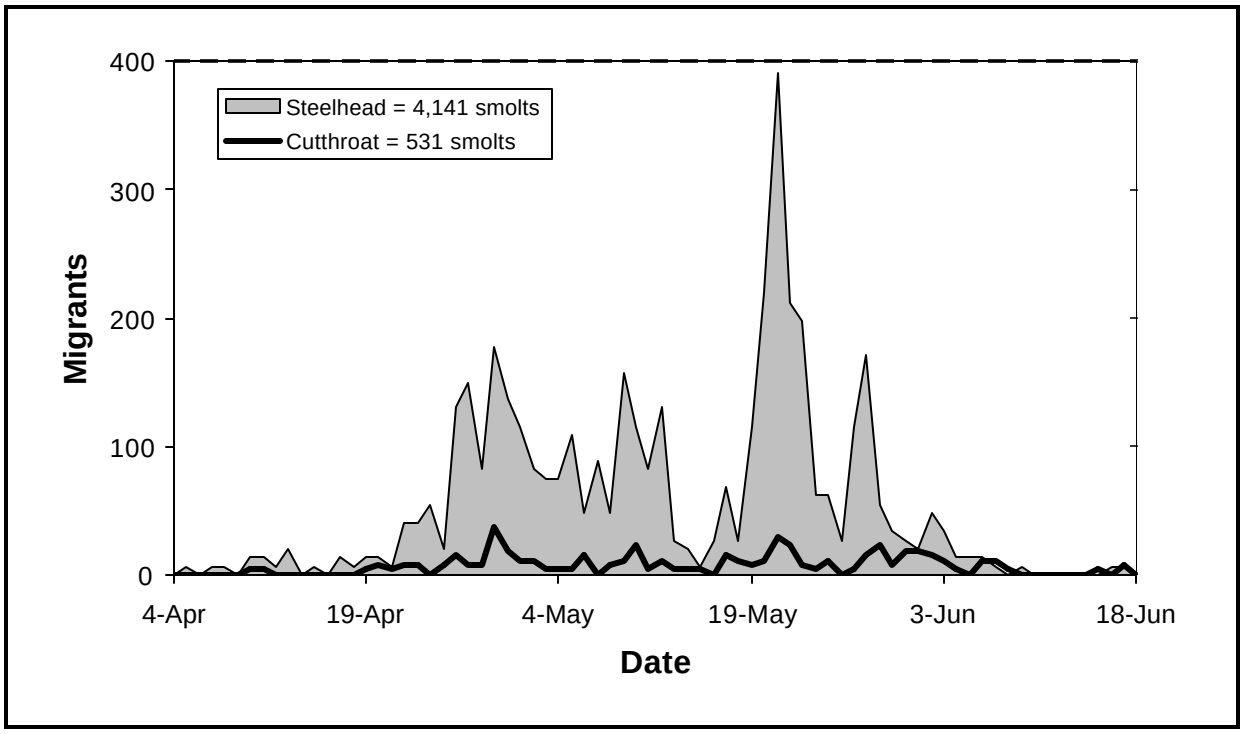

Figure 10. Estimate of daily natural origin steelhead and cutthroat smolt migrations, Abernathy Creek 2003.

Germany Creek

The screw trap was installed on April 4 at RM 0.3 and operated until the morning of June 19. The trap was checked either once or twice a day, depending on water and debris conditions. Due to fluctuating and low flows throughout the season, eight minor adjustments in trap position were made, but did not appreciably alter trap efficiency.

Coho

Catch

We captured 13 coho smolt migrants during the first day of trapping. Catches increased throughout April and peaked on May 30 when 208 smolts were caught. Daily catches then rapidly decreased, and averaged only eight per day by mid June. A total of 2,832 coho smolts were caught throughout the trapping period.

Size

Average coho smolt fork length gradually increased over the trapping interval (Table 25, Figure 11). Size ranged from 83 mm to 164 mm, and averaged 116 mm over the season.

Table 25. Mean fork length (mm), standard deviation, range, and sample size of coho smolts measured by statistical week, Germany Creek 2003.

Statistical Week			Average	s.d.	Range		Number	
#	Begin	End			Min	Max	Sampled	Caught
14	03/31	04/06	108.7	11.1	97	129	9	32
15	04/07	04/13	102.7	14.9	84	157	24	100
16	04/14	04/20	101.8	8.7	83	119	22	88
17	04/21	04/27	113.3	10.2	89	132	22	111
18	04/28	05/04	109.2	8.6	85	123	18	149
19	05/05	05/11	114.1	13.1	94	164	40	221
20	05/12	05/18	118.9	12.6	101	138	10	226
21	05/19	05/25	119.6	9.5	95	141	45	470
22	05/26	06/01	122.2	7.4	101	142	50	894
23	06/02	06/08	120.1	8.8	99	140	45	394
24	06/09	06/15	118.6	8.1	97	133	29	111
25	06/16	06/22	123.2	5.7	114	135	17	36
		Season Totals	115.8	11.8	83	164	331	2,832

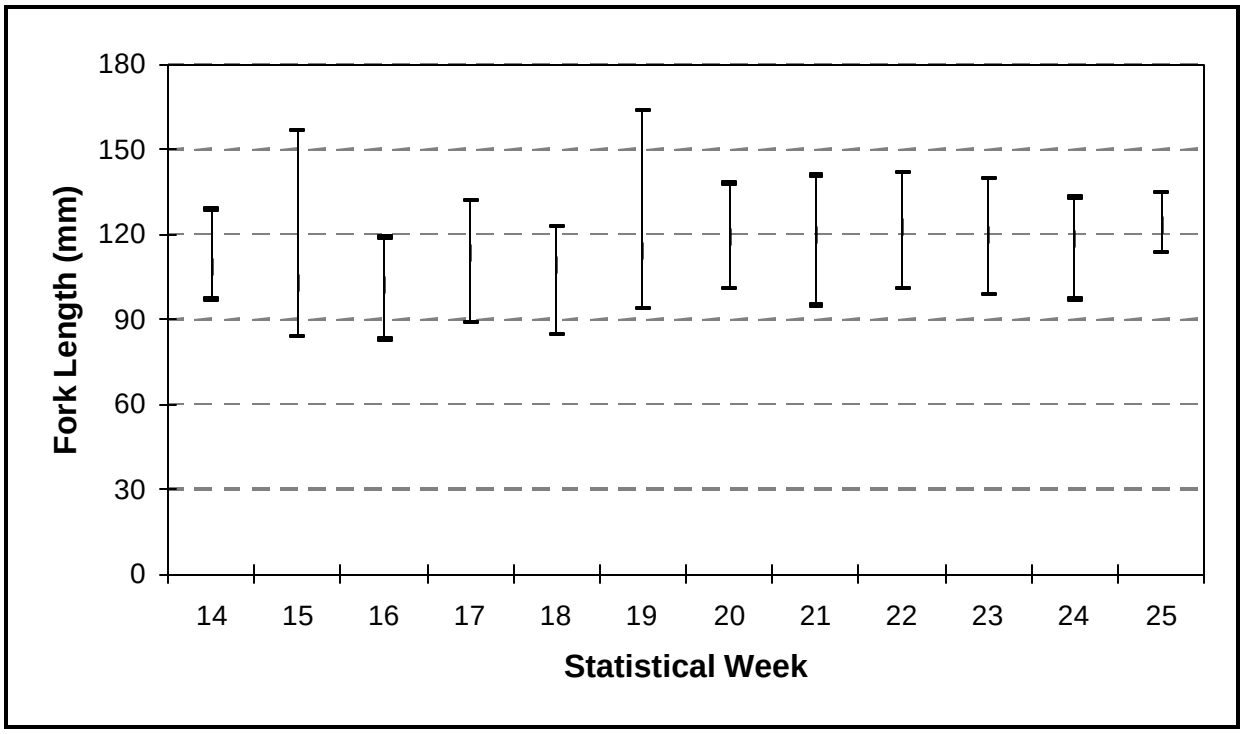

Figure 11. Weekly average, minimum, and maximum coho smolt fork lengths (mm) measured at the Germany Creek screw trap, 2003.

Trap Efficiency

A total of 2,560 coho were marked and released upstream of the trap on 74 days. The number of fish released each day ranged from four to 139 smolts. Recapture rates were not calculated for individual releases due to small release sizes and protracted migration. For example, one smolt was caught 12 days after being released. Efficiency tests were grouped by mark type. Since trap

movements throughout the season were minor, trap efficiency or position strata were not developed. Grouped efficiency tests ranged from 31.4% to 62.5% and averaged 49% (Table 26).

Table 26. Grouped capture efficiency tests for coho smolts by mark type, Germany Creek 2003.

Dates		# Marked		Trap
Release	Recapture	Released	Recaptured	Efficiency
4/05-4/27	4/06-5/09	303	95	31.4%
4/28-5/04	4/29-5/09	142	69	48.6%
5/05-5/18	5/06-5/30	435	272	62.5%
5/19-5/25	5/20-6/02	386	203	52.6%
5/26-6/08	5/27-6/17	1,145	581	50.7%
6/09-6/17	6/10-6/18	149	72	48.3%
Sum		2,560	1,292	
Average				49.0%
Variance				1.7E-03
n				6

Production Estimate

Total coho production is estimated at 5,775 smolts with a coefficient of variation of 8.4% and a 95% confidence interval of 4,822 to 6,728 smolts (Figure 12). This estimate is based on our catch of 2,832 migrants and the estimated average trap efficiency of 49%. As few smolts were migrating at the beginning of trap operation, we estimated no additional smolts outside the period trapped.

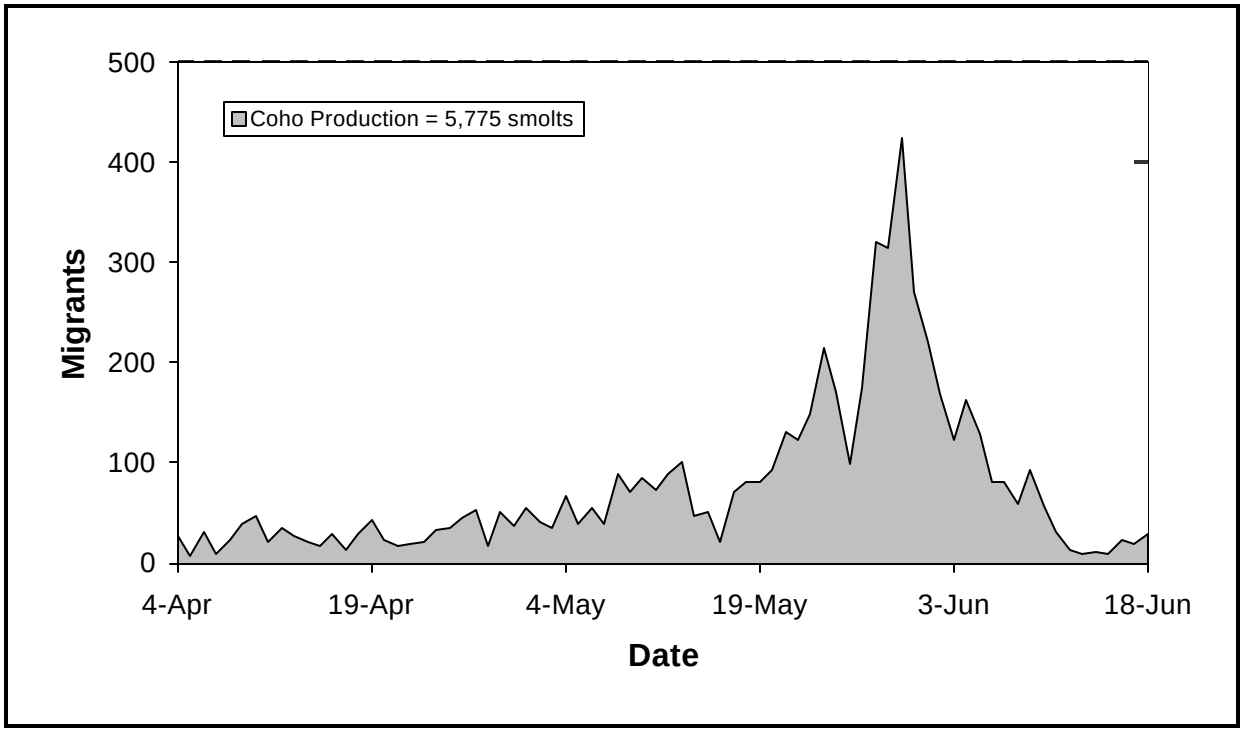

Figure 12. Estimate of daily coho smolt migration, Germany Creek screw trap 2003.

Steelhead and Cutthroat

Catch

On the first day of trapping, we captured six steelhead and zero cutthroat smolts. The steelhead catch increased through April, and peaked on May 13 when 107 smolts were caught. The cutthroat catch peaked on June 1 when 17 smolts were caught. After these peaks, catches of both species declined through the end of the trapping season. A total of 1,859 steelhead and 178 cutthroat smolts were caught over the trapping period.

Size

Weekly average steelhead fork length remained fairly steady over the season (Table 27, Figure 13). Fork length ranged from 131 mm to 229 mm, and averaged 166 mm over the season. Cutthroat fork length ranged from 142 mm to 232 mm, and averaged 184 mm over the season.

Table 27. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of steelhead and cutthroat smolts measured by statistical week, Germany Creek 2003.

Statistical Week			STEELHEAD						CUTTHROAT					
					Range		Number				Range		Number	
#	Begin	End	Avg.	s.d.	Min	Max	Samp.	Caught	Avg.	s.d.	Min	Max	Samp.	Caught
14	03/31	04/06	162.0	n/a	162	162	1	11						0
15	04/07	04/13	171.8	21.0	133	208	17	32	161.0	24.8	142	189	3	3
16	04/14	04/20	175.7	24.8	137	229	16	97	212.0	n/a	212	212	1	1
17	04/21	04/27	168.9	18.0	132	210	30	252	178.2	20.1	161	210	5	5
18	04/28	05/04	167.2	13.1	152	193	21	500	188.8	22.1	153	214	5	7
19	05/05	05/11	173.0	13.6	150	211	40	343	198.8	21.3	164	232	11	17
20	05/12	05/18	162.8	17.5	142	205	10	341	176.5	15.5	145	197	11	14
21	05/19	05/25	161.8	12.6	134	194	47	186	185.6	15.2	158	217	16	26
22	05/26	06/01	161.8	14.3	135	195	37	69	187.8	17.4	169	218	9	46
23	06/02	06/08	159.1	11.1	142	174	10	17	175.4	15.5	153	205	14	50
24	06/09	06/15	136.0	5.6	131	142	3	3					0	6
25	06/16	06/22	152.2	9.6	138	165	6	8	173.0	n/a	173	173	1	3
		Season Total	166.1	16.6	131	229	238	1,859	183.5	19.2	142	232	76	178

Trap Efficiency

A total of 1,757 steelhead were marked and released upstream of the trap on 65 days. The number of fish released each day ranged from one to 82 smolts. Recapture rates were not calculated for individual releases due to the small release sizes and protracted migration. Efficiency tests were grouped by mark type during the trapping season. Grouped efficiency tests ranged from 25.8% to 35.3%, and averaged 31.3% (Table 28).

Trap efficiency tests were not conducted using cutthroat smolts due to small catches throughout the trapping season. Cutthroat production was estimated using the average steelhead capture rate.

Production Estimates

Total steelhead production is estimated at 5,936 smolts with a coefficient of variation of 6% and a 95% confidence interval of 5,236 to 6,636 smolts (Figure 14). Total cutthroat production is estimated at 563 smolts with a coefficient of variation of 6% and a 95% confidence interval of 497 to 629 smolts (Figure 14). These estimates are based on our expanded catch estimates and the estimated average steelhead trap efficiency of 31.3%. Cutthroat did not exhibit as definite a migration trend as steelhead. Although some cutthroat migration may occur outside of the trapping interval, the proportion is unknown and could not be estimated.

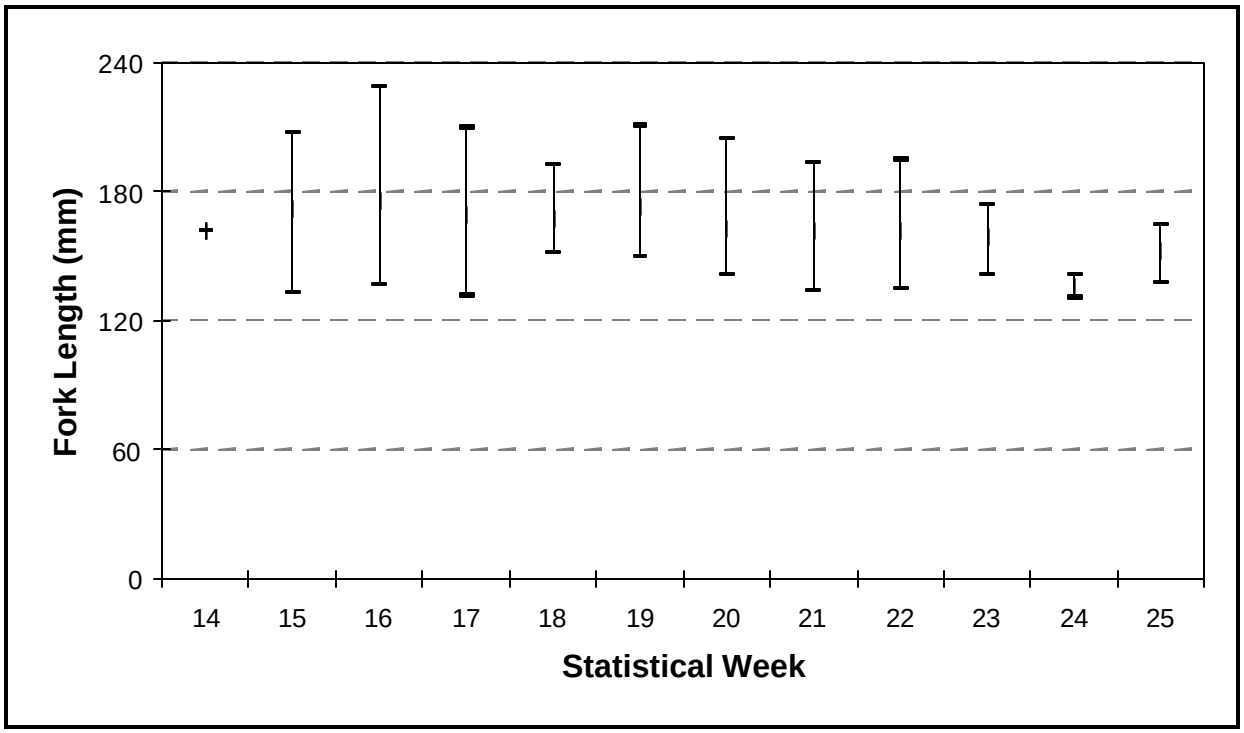

Figure 13. Weekly average, minimum, and maximum steelhead smolt fork lengths (mm) measured at the Germany Creek screw trap, 2003.

Table 28. Trap efficiency tests using steelhead smolts grouped by mark type, Germany Creek 2003.

Dates		# Marked		Trap
Release	Recapture	Released	Recaptured	Efficiency
4/05-4/27	4/11-4/29	326	91	27.9%
4/28-5/04	4/29-5/13	498	171	34.3%
5/05-5/18	5/06-6/05	658	232	35.3%
5/19-5/25	5/20-5/26	194	50	25.8%
5/26-6/12	5/27-6/04	81	27	33.3%
Sum		1,757	571	
Average				31.3%
Variance				3.6E-04
n				5

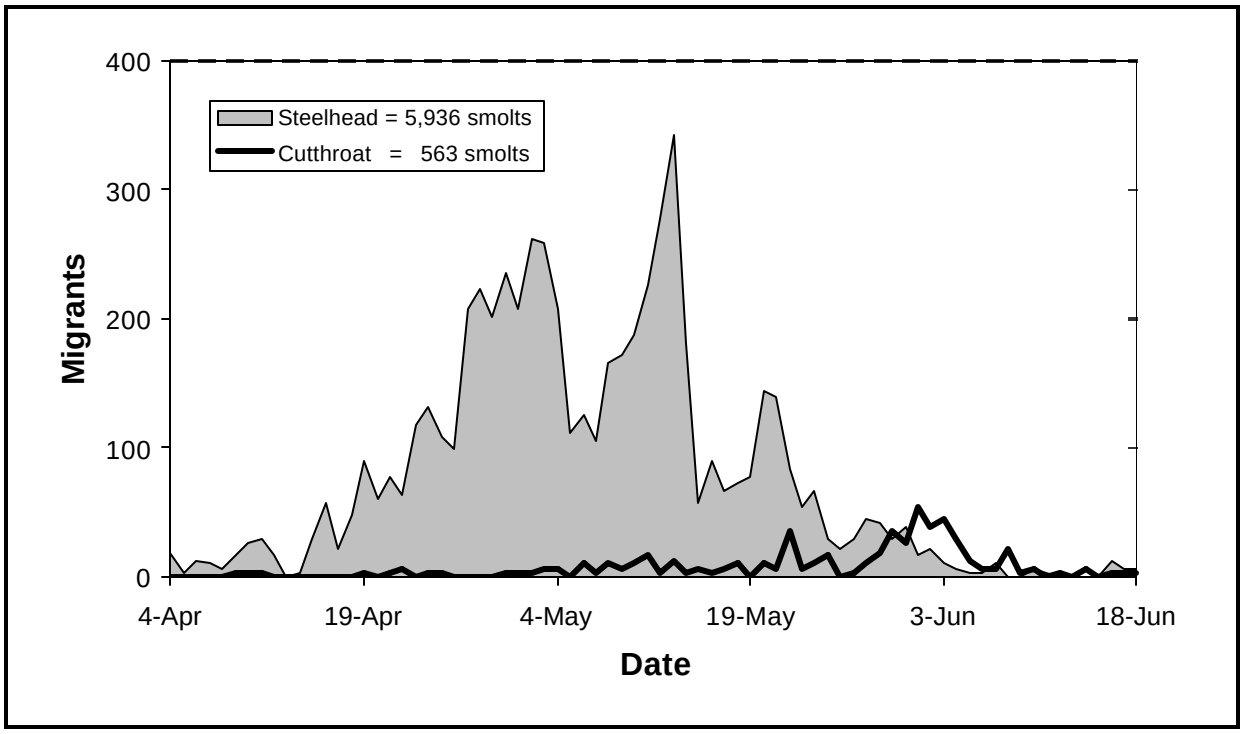

Figure 14. Estimate of daily steelhead and cutthroat smolt migrations, Germany Creek 2003.

Mill Creek

The screw trap was installed on April 4 at approximately rkm 0.5 and was operated continuously until the morning of June 19. Lower flows later in the season precluded trap operation in the original configuration. To direct flow into the trap to increase the speed of the screw, we installed screened weir panels on May 6.

Coho

Catch

On the first day of trapping, we captured three coho smolt migrants. Catches increased to peak on May 21 when 194 smolts were caught. Daily catches then decreased, and averaged less than 13 per day by mid-June. A total of 4,168 coho smolts were caught throughout the trapping season.

Size

Average coho smolt size increased around 100 mm fork length in the beginning of the season to around 110 mm by mid season (Table 29, Figure 15). Fork lengths ranged from 70 mm to 160 mm, and averaged 109 mm over the season.

Table 29. Mean fork length (mm), standard deviation, range, and sample size of coho smolts measured by statistical week, Mill Creek 2003.

Statistical Week			Average	s.d.	Range		Number	
#	Begin	End			Min	Max	Sampled	Caught
14	03/31	04/06	90.0	8.5	84	96	2	10
15	04/07	04/13	98.2	14.9	70	122	11	83
16	04/14	04/20	99.4	13.4	83	117	8	48
17	04/21	04/27	100.3	9.4	77	115	12	66
18	04/28	05/04	108.9	7.6	101	129	15	154
19	05/05	05/11	110.5	12.6	83	160	32	586
20	05/12	05/18	111.6	7.3	99	128	30	723
21	05/19	05/25	110.0	7.3	93	128	70	981
22	05/26	06/01	111.5	7.5	94	128	45	790
23	06/02	06/08	108.6	8.6	90	128	45	508
24	06/09	06/15	107.8	7.3	94	127	25	186
25	06/16	06/22	108.6	7.8	96	119	15	33
		Season Totals	108.7	9.5	70	160	310	4,168

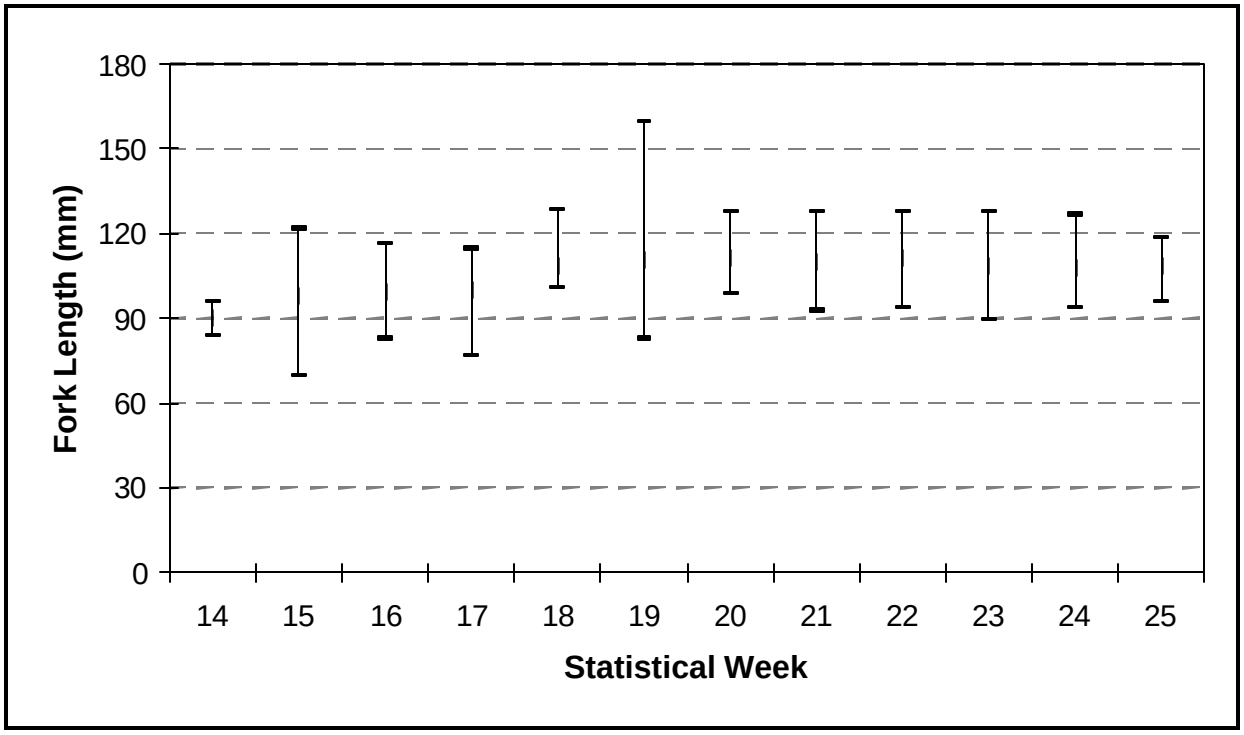

Figure 15. Weekly average, minimum, and maximum coho smolt fork lengths (mm) measured at the Mill Creek screw trap, 2003.

Trap Efficiency

A total of 3,363 coho were marked and released upstream of the trap on 74 days over the season. The number of fish released each day ranged from two to 133 smolts. Recapture rates were not calculated for individual releases due to small numbers and protracted migration. Efficiency tests were grouped by mark type and efficiency stratum. Screen panels were installed upstream of the trap on May 6 in order to increase flow and direct migrants into the trap. This formed two

efficiency strata (before and after panel installation). Prior to installing the panels (Stratum 1), grouped efficiency tests ranged from 15.1% to 19.3%, and averaged 17.2% (Table 30). Following the installation of the screen panels (Stratum 2), grouped efficiency tests ranged from 30.2% to 60.9%, and averaged 45.6% (Table 30).

Marked smolts released in one efficiency stratum and recaptured in another stratum were excluded in order to simplify the analysis.

Production Estimate

Total coho production is estimated at 10,514 smolts with a coefficient of variation of 11.8% and a 95% confidence interval of 8,074 to 12,954 smolts (Figure 16). This estimate is based on our catch of 4,168 migrants and the estimated average trap efficiency for each stratum.

Table 30. Grouped capture efficiency tests for coho smolts by efficiency strata, Mill Creek 2003.

Efficiency Stratum	Dates		# Marked		Trap
	Release	Recapture	Released	Recaptured	Efficiency
Stratum 1	4/05-4/14	4/08-4/14	93	14	15.1%
	4/15-4/27	4/17-4/28	99	17	17.2%
	4/28-5/05	4/30-5/05	161	31	19.3%
	Sum		353	62	
	Average				17.2%
	Variance				1.5E-04
	n				3
Stratum 2	5/06-5/18	5/07-6/10	992	604	60.9%
	5/19-5/25	5/20-6/09	592	307	51.9%
	5/26-6/08	5/27-6/19	1,178	463	39.3%
	6/09-6/17	6/10-6/19	248	75	30.2%
	Sum		3,010	1,449	
	Average				45.6%
	Variance				4.6E-03
	n				4

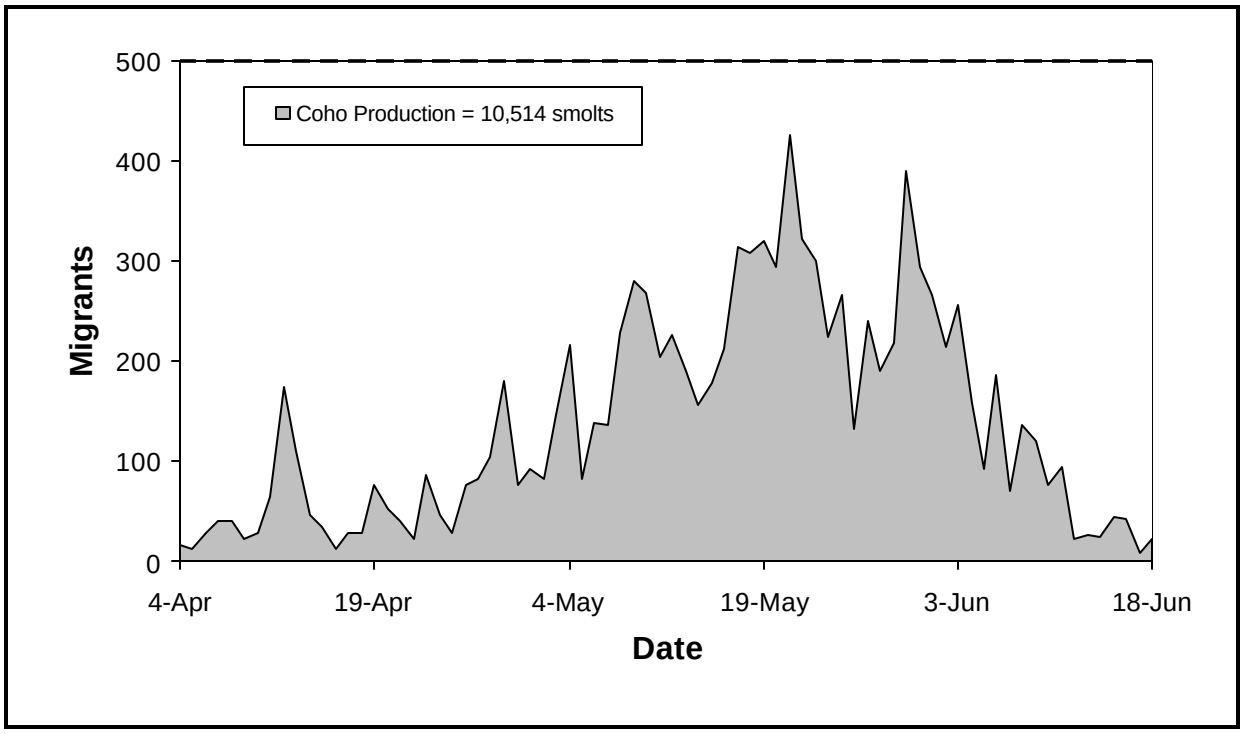

Figure 16. Estimate of daily natural origin coho smolt migration, Mill Creek screw trap 2003.

Steelhead and Cutthroat

Catch

We captured one steelhead and zero cutthroat smolt migrants during the first day of trapping. Steelhead catches remained low throughout April, and began increasing in early May. Catch peaked on May 12 when 20 smolts were caught, and cutthroat catch peaked on June 2 when nine smolts were caught. A total of 253 steelhead and 115 cutthroat smolts were caught over the trapping season.

Size

Weekly average steelhead fork lengths varied slightly over the trapping season (Table 31, Figure 17). Sizes of steelhead ranged from 123 mm to 205 mm, and averaged 160 mm fork length over the season. Sizes of cutthroat ranged from 124 mm to 232 mm, and averaged 167 mm fork length over the season (Table 31).

Trap Efficiency

A total of 229 steelhead smolts were marked and released upstream of the trap on 54 days. The number of fish released each day ranged from one to 20 smolts. Recapture rates were not calculated for individual releases due to small release sizes and protracted migration. Efficiency tests were grouped by mark type and efficiency stratum. As with coho efficiency, strata were developed for before and after installation of screened weir panels upstream of the trap. Prior to installing the panels (Stratum 1), grouped efficiency tests ranged from 0% to 9.1%, and averaged 3.0% (Table 32). No marked steelhead from the first two grouped mark types were recovered in

early April. These groups were dropped from the efficiency estimate, since they were small and we believed the fish were not actively migrating that early in the season. The efficiency during Stratum 1 was therefore estimated by the 9.1% capture rate measured from the third mark type group. Following the installation of the screen panels (Stratum 2), grouped efficiency tests ranged from 14.7% to 33.3%, and averaged 24.0% (Table 32).

Two marked smolts that were released before the panels were installed, but migrated after the installation were excluded from the recapture data in order to simplify the analysis.

Due to low cutthroat catches, we used steelhead trap efficiency to estimate cutthroat migration.

Table 31. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of steelhead and cutthroat smolts measured by statistical week, Mill Creek 2003.

Statistical Week			STEELHEAD						CUTTHROAT					
#	Begin	End	Avg.	s.d.	Range Min	Range Max	Number Samp.	Number Caught	Avg.	s.d.	Range Min	Range Max	Number Samp.	Number Caught
14	03/31	04/06	142.0	n/a	142	142	1	3					0	1
15	04/07	04/13	149.8	15.7	131	165	6	10	148.7	14.3	131	170	6	8
16	04/14	04/20	163.0	31.2	144	199	3	7	135.5	8.6	124	143	4	2
17	04/21	04/27	152.0	21.2	137	167	2	6	161.0	21.2	146	176	2	2
18	04/28	05/04	155.9	14.2	129	180	18	20	232.0	n/a	232	232	1	1
19	05/05	05/11	161.2	15.7	137	198	37	61	184.2	24.5	144	230	12	14
20	05/12	05/18	163.0	11.8	130	184	25	55	173.0	14.9	153	204	9	13
21	05/19	05/25	164.7	15.1	132	205	32	47	161.8	10.3	150	183	18	22
22	05/26	06/01	155.8	18.9	123	190	16	31	179.7	27.9	155	210	3	18
23	06/02	06/08	160.0	19.2	142	187	7	11					0	20
24	06/09	06/15	177.0	n/a	177	177	1	2	158.0	n/a	158	158	1	12
25	06/16	06/22						0	162.0	n/a	162	162	1	2
Season Total			160.4	15.8	123	205	148	253	167.1	22.6	124	232	57	115

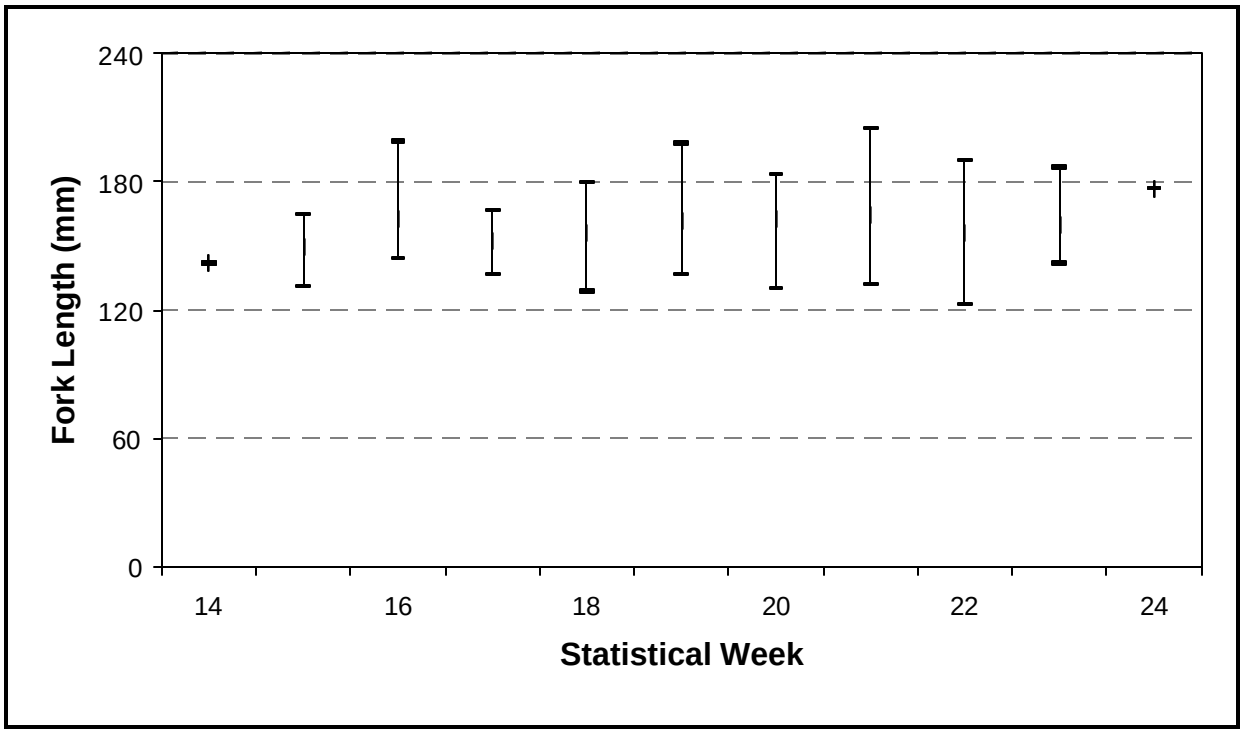

Figure 17. Weekly average, minimum, and maximum steelhead smolt fork lengths (mm) measured at the Mill Creek screw trap, 2003.

Table 32. Trap efficiency tests using steelhead smolts grouped by mark type and efficiency stratum, Mill Creek 2003.

Efficiency Stratum	Dates		# Marked		Trap
	Release	Recapture	Released	Recaptured	Efficiency
Stratum 1	4/05-4/13		12	0	0.0%
	4/15-4/26		10	0	0.0%
	4/28-5/05	4/30-5/05	22	2	9.1%
	Sum		44	2	
	Average				3.0%
	Variance				9.2E-04
	n				3
Stratum 2	5/06-5/18	5/07-5/30	105	35	33.3%
	5/19-5/25	5/20-6/07	46	11	23.9%
	5/26-6/14	5/28-6/03	34	5	14.7%
	Sum		185	51	
	Average				24.0%
	Variance				1.4E-03
	n				3

Production Estimates

Total steelhead production is estimated to be 1,383 smolts with a coefficient of variation of 27.5% and a 95% confidence interval of 636 to 2,130 smolts (Figure 18). Total cutthroat production is estimated to be 574 smolts with a coefficient of variation of 21.5% and a 95% confidence interval of 332 to 816 smolts (Figure 18). These estimates are based on our daily catches and the estimated average steelhead trap efficiency for each efficiency stratum. Cutthroat did not exhibit a migration trend, and although migration may have occured outside of the trapping interval, the proportion is unknown and could not be estimated.

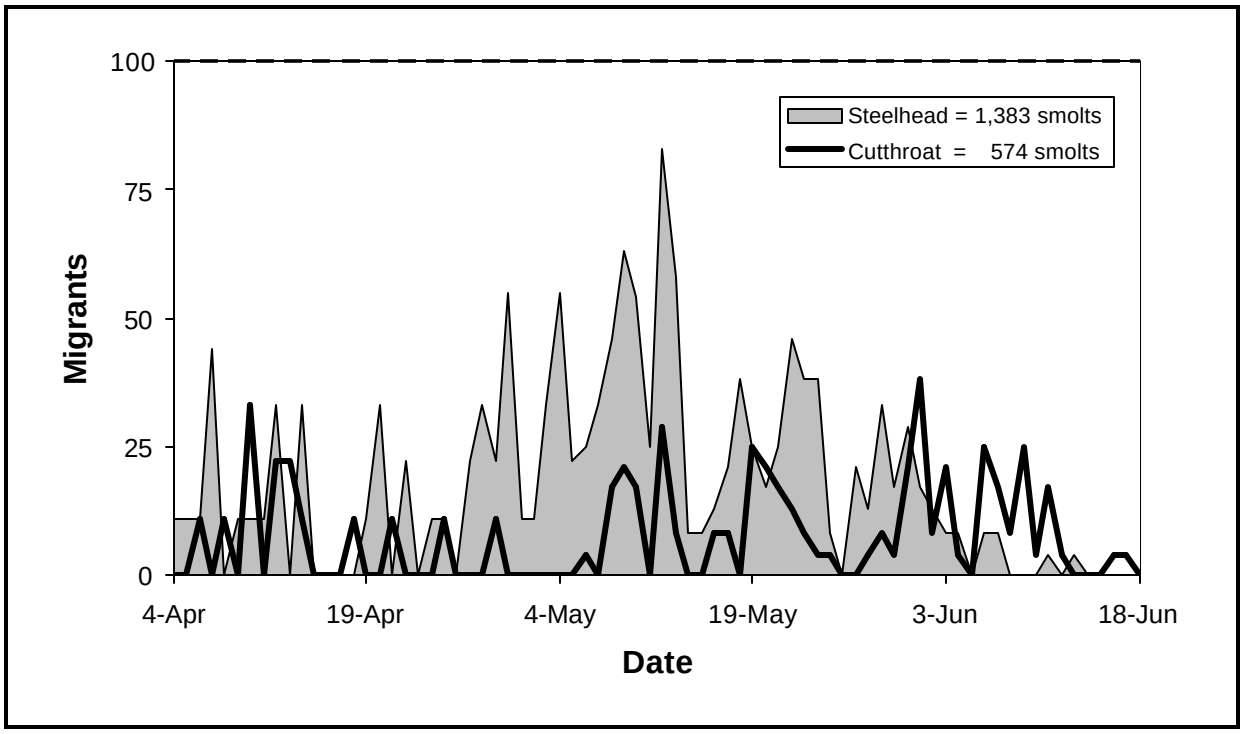

Figure 18. Estimate of daily steelhead and cutthroat smolt migrations, Mill Creek 2003.

Discussion

Hood Canal IMW Streams

Downstream Migrant Trapping

Smolt production from the Hood Canal IMW streams is measured by catching 100% of the migrants during the trapping period. Only a very small percentage of the total outmigration occurs before and after the trapping period, therefore variance is negligible.

Coho and steelhead smolt production in Big Beef Creek was substantially higher than in Little Anderson, Seabeck, and Stavis Creeks. This difference results from Big Beef being a larger watershed and from the large wetland complex available for salmonid rearing. Conversely, cutthroat smolt production is much more similar in all four streams. The ratio of coho to cutthroat production decreases with increasing development in the basin (Horner et al. 1996). Although only low levels of development are found in all four of these watersheds, degraded conditions similar to those found in urbanizing watersheds such as a lack of pools, high sediment loads, and altered hydrology exist in these streams. We observed relatively low coho to cutthroat ratios for Stavis (5:1), Seabeck (4:1), and Little Anderson (0.3:1) creeks, whereas the ratio for Big Beef Creek (29:1) was substantially higher. The low ratios at Stavis, Seabeck, and Little Anderson creeks could indicate lower habitat quality for juvenile coho rearing in these streams, and/or it could reflect low coho escapements due to impacts from harvest in fisheries.

Upstream Migrant Trapping

Total escapements of coho and chum salmon into Big Beef Creek are also counts. All adult salmon must enter the weir trap and be counted prior to continuing their upstream migration. Variance of the escapement estimate is zero for Big Beef Creek.

Big Beef Creek natural origin coho escapement estimates require accurately determining the stray hatchery coho from the wild return. This has been made simpler in recent years by the mass adipose marking of hatchery fish. Of the unmarked fish returning, hatchery fish make up a very small percentage. Based on scale analysis, we estimated 1.4% of the unmarked fish released upstream to spawn in Big Beef Creek in 2003 were of hatchery origin.

Comparison of Scale Analysis and CWT-based Estimates

The CWT-based estimate of the stock composition of the adult return relies on assumptions regarding the origin of the hatchery fish that stray to Big Beef Creek. In 2003, we recovered only 52 hatchery origin tags (three unmarked and 49 ad-marked) from ten hatchery sources (Table 13). Although tag recoveries remain the only means of determining specific origin, due to the small sample sizes, tags are less reliable than scale analysis for estimating total hatchery strays to Big Beef Creek. It should be noted, however, that these results could be an artifact of the existence of our weir. Capturing a hatchery coho in our upstream trap is not necessarily evidence of straying, but rather of entry into the stream; had they not been captured in our trap, some of these hatchery fish may have left the stream before spawning.

We could not expand tag recoveries to estimate the total unmarked hatchery return due to discrepancies in reported mark rates, tag loss, and releases of unmarked/untagged fish from hatchery facilities in Hood Canal. We believe the scale-based estimate of 4,682 natural origin and 66 hatchery coho in the unmarked return is the most accurate, as it is derived from the largest sample and is not based on assumptions regarding origin.

Comparison of scale-based determination of origin with that from CWT recoveries indicate high classification accuracy using scale analysis. In 2003, out of a tag sample of 99 unmarked adults (97 natural origin and two hatchery coho), WDFW scale analyst John Sneva made no classification errors. In the tag sample of 71 unmarked jacks (70 natural origin and one hatchery), only two scale reading errors were made (one natural origin jack classified as hatchery, and one hatchery jack classified as natural origin). These results confirm the accuracy of the scale-based stock identification method. Because the error rate was negligible, we made no adjustments to the scale-based estimates.

Coho Escapements into Little Anderson, Seabeck, and Stavis Creeks

The coho escapement estimates for Little Anderson, Seabeck, and Stavis Creeks assume the proportions of the outmigrating smolts that return as adults to these streams is the same as for Big Beef Creek. It further assumes that the hatchery stray rates are the same. The principal source of error is in the first assumption. Because of reduced effort in pre-terminal commercial fisheries and adoption of selective sport fisheries in recent years, the terminal net fisheries have the largest harvest impact on natural origin Hood Canal coho. The Area 12 Terminal Net Fishery consists of treaty fishers beach seining along the shoreline near the mouths of the IMW streams. Depending on where the fishing effort is concentrated, differences in harvest rates between the four stocks could be substantial. Often, fishing is centered in the Lone Rock area, between the mouths of Big Beef and Little Anderson Creeks. In years when effort is high, impacts on Little Anderson and Big Beef coho may be greater than on Seabeck and Stavis coho due to their proximity to the fishery. In 2003, the fishing effort was low and likely resulted in little if any harvest rate differences between the four streams.

As discussed in the previous section, hatchery stray rates estimated for Big Beef Creek may be artificially high due to the presence of the trap at the head of the estuary. Hatchery fish that enter non-natal streams and subsequently leave ("dip-ins") are counted as strays at Big Beef Creek once they are captured in the trap. Furthermore, the presence of the FRI hatchery facility may provide an attraction for hatchery fish that is not present in the other streams. Nevertheless, the consequences of violating our assumption regarding equal hatchery stray rates between Big Beef Creek and the other three streams would likely have only a minor effect on the escapement estimates for Little Anderson, Seabeck, and Stavis Creeks. Hatchery strays made up about 8% of the total Big Beef return. Even if this estimated rate is biased high for the other streams, the impact of this error on the escapement estimates for Little Anderson, Seabeck, and Stavis Creeks would likely be minor, resulting is a slight over-estimation, given that these fish make up only a small proportion of the total escapement.

Lower Columbia IMW Streams

The certainty of our smolt production estimates is largely dependant on the veracity of our trap efficiency estimates. Trapping was continuous at all traps except Abernathy Creek, and trapping was only interrupted there on four dates early in the season when catches were still low.

Production estimates for Abernathy have the highest precision of the three streams evaluated. Catching large numbers of smolts, and releasing many marked groups upstream to estimate efficiency accomplished this. We were able to best represent coho daily migrations throughout the season based on adequate mark groups released during each of the trap efficiency strata.

Steelhead daily migration estimates are less precise due to the low numbers of marked individuals released to estimate efficiency. Marked natural origin steelhead released early in the season were grouped with the second efficiency stratum. If the migration were not yet underway, combining the first two strata would underestimate steelhead trap efficiency and overestimate migration early in the season. The lack of significance between the second and third efficiency strata resulted in the combining of all strata. We believe the resulting seasonal efficiency estimate of 14.6% results in a reasonably accurate total production estimate. Potential overestimation early in the season occurs when migration rates are low. This potential error is likely minor in the context of the total production estimate.

Our estimate of steelhead trap efficiency (14.6%) is validated by the work done by Zydlewski *et al.* (*In Press*). PIT tagged natural origin steelhead passing the two arrays were subsequently recaptured in the screw trap at a rate of 12.1% (Zydlewski pers. comm.). The PIT tagged steelhead were marked in the previous fall and had no recognition of the rotary screw trap. Furthermore, since the PIT tag arrays are located several kilometers above the trap, whereas the marked natural origin steelhead were released only 100 meters above the trap, we would expect the PIT tags to provide a somewhat lower trap efficiency estimate since higher opportunity existed for those fish to be preyed upon or to residualize before reaching the trap. Due to the similarities between the independent capture rate estimates, we have high confidence in our production estimate.

Germany Creek also produced ample numbers of coho and steelhead for marking, which enabled development of precise production estimates. Trapping operations at Germany Creek were not altered throughout the 2003 season, and average trap efficiency was used for each species at this site.

Too few cutthroat smolts were captured in Germany Creek to measure trap efficiency. Therefore, we assumed cutthroat trap efficiency was equal that of steelhead smolts since they are similarly sized. Because cutthroat are generally are less abundant, it is rare that efficiency is measured. The best data sets are Abernathy Creek in 2003 and Issaquah Creek in 2000. In Abernathy Creek, PIT tag recoveries estimated cutthroat capture efficiency at 26.4%. In comparison, season average steelhead efficiency measured only slightly more than half this rate (14.6%) and coho efficiency is in-between (21.7%). In Issaquah Creek, cutthroat efficiency was measured from a low sample size at 7% compared to 15% for coho (Seiler et al. 2003). The Issaquah example illustrates the outcomes we believe occurs in most situations; that the larger

steelhead and cutthroat smolts are captured at a lower efficiency rate than coho smolts. The high rate measured for the PIT tagged cutthroat in Abernathy Creek may have resulted from their recently having been tagged. The handling and surgical insertion of a PIT tag may have caused the fish to become less able to avoid the trap compared to the Issaquah fish that were simply fin marked. We don't believe this was the case for the Abernathy steelhead that were PIT tagged the previous year since these fish had at least 6 months to recover from the surgery. Nevertheless, if the true trap efficiency for cutthroat was higher in the Germany Creek trap than for steelhead, then the cutthroat production estimate is biased high. Conversely, if the cutthroat PIT tagging made the Abernathy cutthroat more susceptible to capture than untagged fish, the Abernathy cutthroat production estimate is biased low.

Mill Creek produced fewer steelhead smolts than Abernathy and Germany Creeks. Due to low catches during the trapping season at Mill Creek, especially in April, capture rate estimates were highly variable. Early in the season, prior to screens being installed to increase efficiency on May 6, capture rates averaged only 3%. Following the screen installation, capture rates averaged 24%. Estimating April migration using the 3% capture rate overestimated production, as exhibited by migration timing from previous years' estimates (Seiler et al. in prep) and compared to Abernathy and Germany Creeks. The first two release groups of the trapping season only contained ten and twelve marked steelhead. Efficiency, therefore, would have to be greater than 10% in order to recapture one fish out of either of those groups. The third grouped release resulted in an estimated trap efficiency of 9.1%. We used this test to estimate migration prior to trap alterations on May 6. We believe this best represents the true migration during that interval.

In order to validate the 9.1% efficiency used for Mill Creek steelhead in Stratum 1, we compared steelhead and coho trap efficiency estimates during Stratum 2. Coho smolts, being smaller than steelhead smolts, are usually caught at a higher rate. The ratio of the Stratum 2 steelhead capture rate (24.0%) to the Stratum 2 coho capture rate (45.6%) was 0.53. Assuming the same relationship existed during Stratum 1, applying this ratio to the Stratum 1 coho efficiency (17.2%) estimates Stratum 1 steelhead efficiency at 9.05%. This estimated efficiency is nearly identical to the 9.1% steelhead capture rate estimated by the largest single mark type group released during Stratum 1.

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