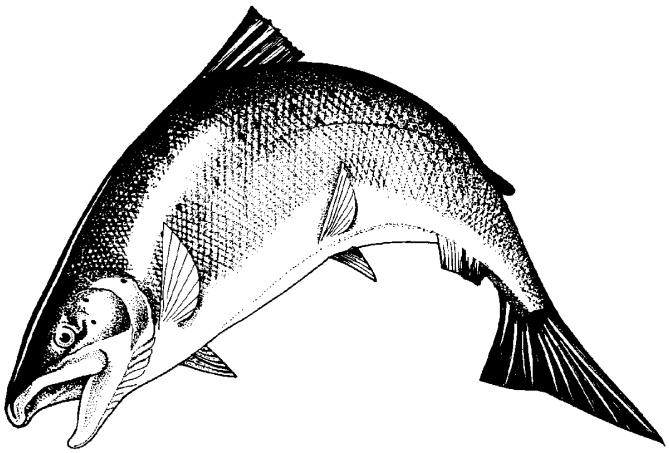
Appendix A

2004 Juvenile Salmonid Production Evaluation and Adult Escapement



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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 appendix presents the 2004 freshwater smolt production estimates for the Hood Canal (Figure 1) and Lower Columbia (Figure 2) IMWs and the 2004 escapement estimates for the Hood Canal IMWs. It also details the field work and analytical steps taken to produce these estimates.

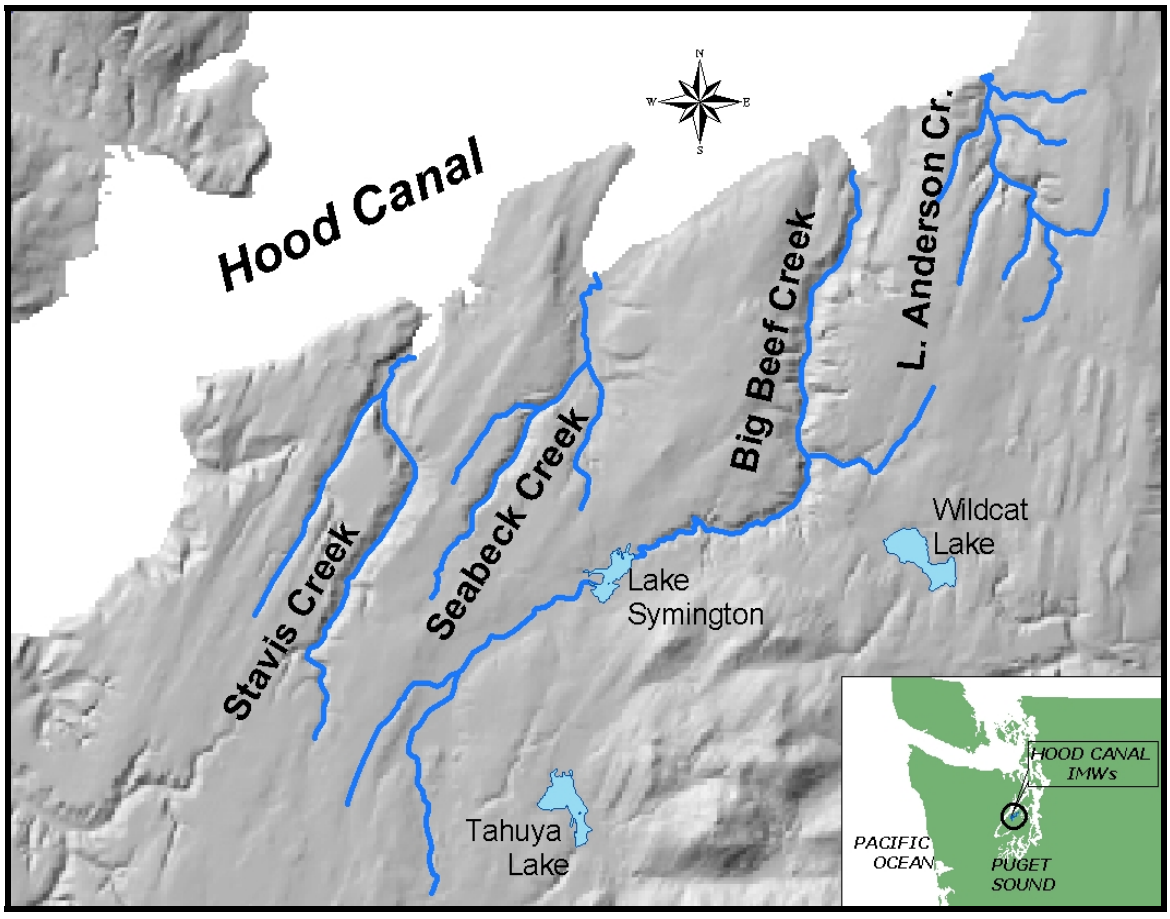

Figure 1. Map showing the location of the four Hood Canal IMWs: Little Anderson, Big Beef, Seabeck, and Stavis Creeks.

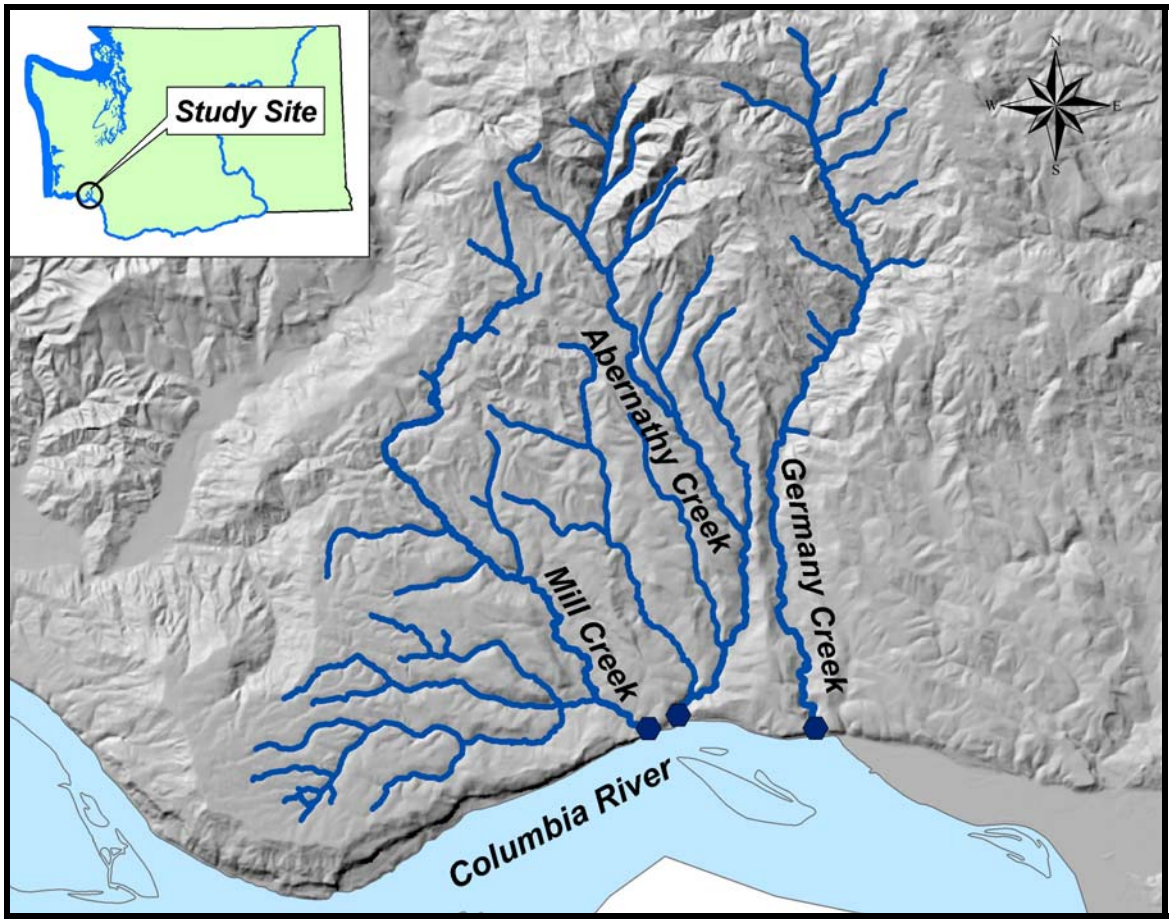

Figure 2. Map showing the location of the three Lower Columbia IMWs: Mill, Abernathy, and Germany Creeks. Circles at the mouth of each stream represents the downstream migrant trapping location.

Hood Canal IMW Downstream 2004

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. In addition to trapping the Big Beef Creek mainstem, we rebuilt the fish trap at the outlet of the University of Washington Fisheries Research Institute's (FRI) spawning channel and ponds during the summer of 2003. The refit allowed installation of a downstream trap at the outlet of the complex. The trap was screened with one half inch coated wire mesh capturing all yearling smolts emigrating from this area.

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. It also includes yearly smolt counts from the University of Washington Fisheries Research Institute's (FRI) spawning channel and ponds. Trapping at the outlet of the channel and ponds beginning in 2004 will provide an opportunity to update this model with new data as well as provide direct counts of smolts migrating from the site.

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 29. 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 15 at 0830 hours, when we dismantled the weir.

We installed the pond and channel trap on April 15 and began operation that day. The trap operated continuously through June 7 at 0830 hours

Seabeck Creek

We installed the trap just above tidewater on March 30 at 1330 hours. We operated the trap without any outages through June 7 at 0900 hours, capturing all downstream migrants.

Little Anderson Creek

We installed the trap 30-meters above tidewater. Trap operation began on March 29 at 1330 hours. We continued operating the trap without any outages through June 7 at 0830 hours, capturing all downstream migrants.

Stavis Creek

We installed the trap in the same location as in past years (approximately 500-meters upstream of the Stavis Bay Road bridge). Trap operation began on April 1 at 1330 hours. We operated the trap without any outages through June 9 at 0930 hours, capturing all downstream migrants.

Fish Counts and Estimated Production

Big Beef Creek

Coho Smolts

Over the season, we caught a total of 23,827 coho smolts at Big Beef Creek (Table 1). The coho smolt migration increased steadily during April to an initial daily high of 1,690 on May 1, followed by lesser peaks of smolts on May 3 and 4 (Figure 3). Thereafter, the migration decreased gradually through the end of the season. Over the season at the pond and channel trap we captured a total of 711 coho smolts. Coho migration from the complex increased from one to two fish per day to a peak of 48 on May 4 and declined steadily after this date.

We estimated 458 smolts emigrated before and 66 after trapping from Big Beef Creek (Table 2). Adding these estimates to the number of smolts caught during the trapping period, 23,827 from the stream and the 711 smolts from the FRI channels and ponds, yields a total production

estimate of 25,062 coho smolts. This smolt production resulted from a spawning escapement of 803 males and 986 females released upstream in Fall 2002. Average production was estimated at 25.4 smolts per female.

Other Salmonids

Other downstream migrant salmonids captured at Big Beef Creek included 1,897 steelhead smolts, 1,464 cutthroat smolts, 411 trout parr, 89,354 chum fry, 207 chinook fry, and 12,741 coho fry (Table 1). In addition, we caught seven steelhead adults (five males and two females) and 58 cutthroat adults (41 males and 17 females).

Table 1. Downstream migrant salmonids captured at Big Beef, Stavis, Seabeck, and Little Anderson Creeks, Spring 2004.

Species/Age	TOTAL CATCH			
	Big Beef Creek	Little Anderson Creek	Seabeck Creek	Stavis Creek
Coho smolts	23,827	367	1,937	7,902
Coho fry	12,741	0	3	0
Chum fry	89,354	0	0	0
Chinook fry	207	0	0	0
Trout parr	[a] 411	[d] 339	[f] 59	[h] 105
Steelhead adults	[b] 7	0	0	0
Steelhead smolts	1,897	8	27	51
Cutthroat adults	[c] 58	[e] 14	[g] 12	[i] 31
Cutthroat smolts	1,464	1,035	272	1,354

[a] Includes 222 steelhead parr and 189 cutthroat parr.
[b] Includes 5 males and 2 females.
[c] Includes 41 males and 17 females.
[d] Includes 1 steelhead parr and 338 cutthroat parr.
[e] Includes 5 males and 9 females.
[f] Includes 59 cutthroat parr.
[g] Includes 8 males and 4 females.
[h] Includes 105 cutthroat parr.
[i] Includes 19 males and 12 females.

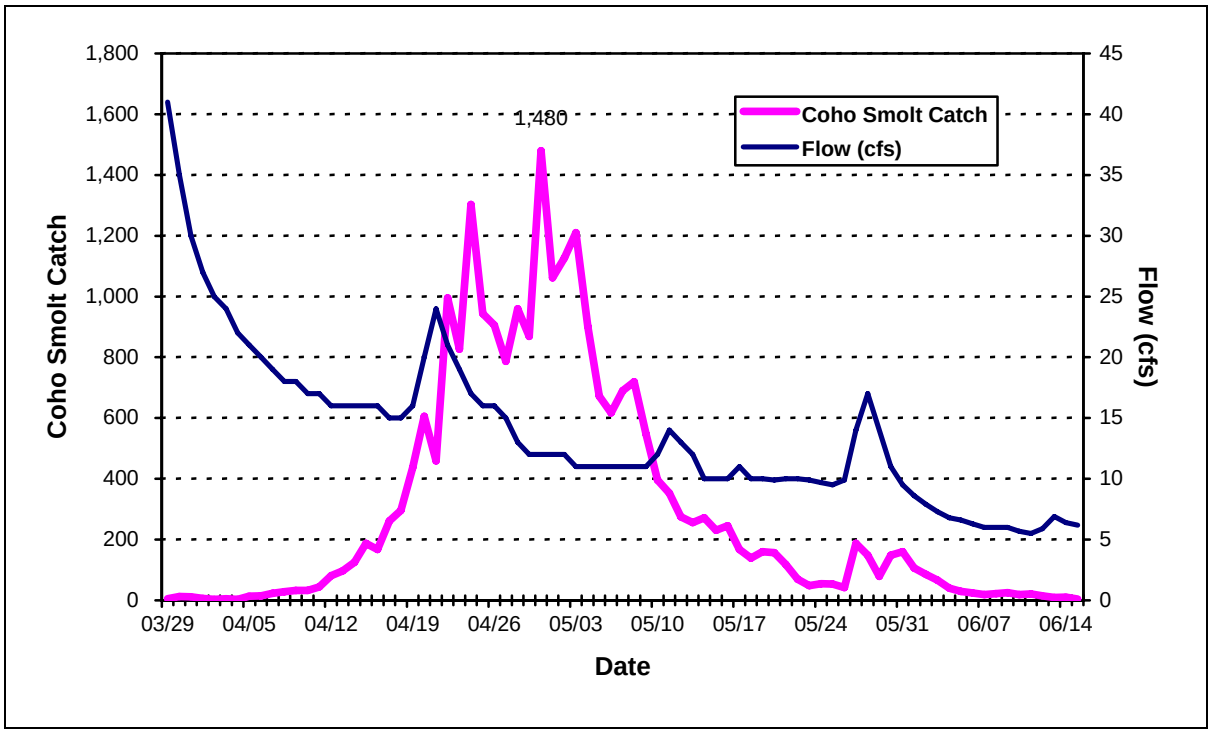

Figure 3. Daily coho smolt catch and daily mean flow (cfs), Big Beef Creek 2004.

Table 2. Total estimated coho smolt migration from Big Beef, Stavis, Seabeck, and Little Anderson Creeks, Spring 2004.

Trap Site	BEFORE TRAPPING [a]		AFTER TRAPPING [a]		Total Catch During Trapping	Total Estimated Production
	Dates	Number Estimated	Dates	Number Estimated		
Big Beef Creek	3/1-3/29	458	6/9-6/30	66	23,827	[b] 25,062
Stavis Creek	3/1-4/8	276	6/10-6/30	44	7,902	8,222
Seabeck Creek	3/1-4/3	39	6/10-6/30	15	1,937	1,991
Little Anderson Creek	3/1-3/29	7	6/8-6/30	3	367	377

[a] Before and after trapping estimates based on four model years.

[b] Includes 711 smolts captured in the FRI spawning channel and pond trap.

Little Anderson, Seabeck, and Stavis Creeks

Over the season we caught a total of 7,902, 1,937, and 367 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 8,222, 1,991, and 377 (Table 2). These streams produced relatively few steelhead smolts -- only 51, 27 and 8 were captured at Stavis, Seabeck, and Little Anderson creeks, respectively. In contrast, we captured 2,661 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).

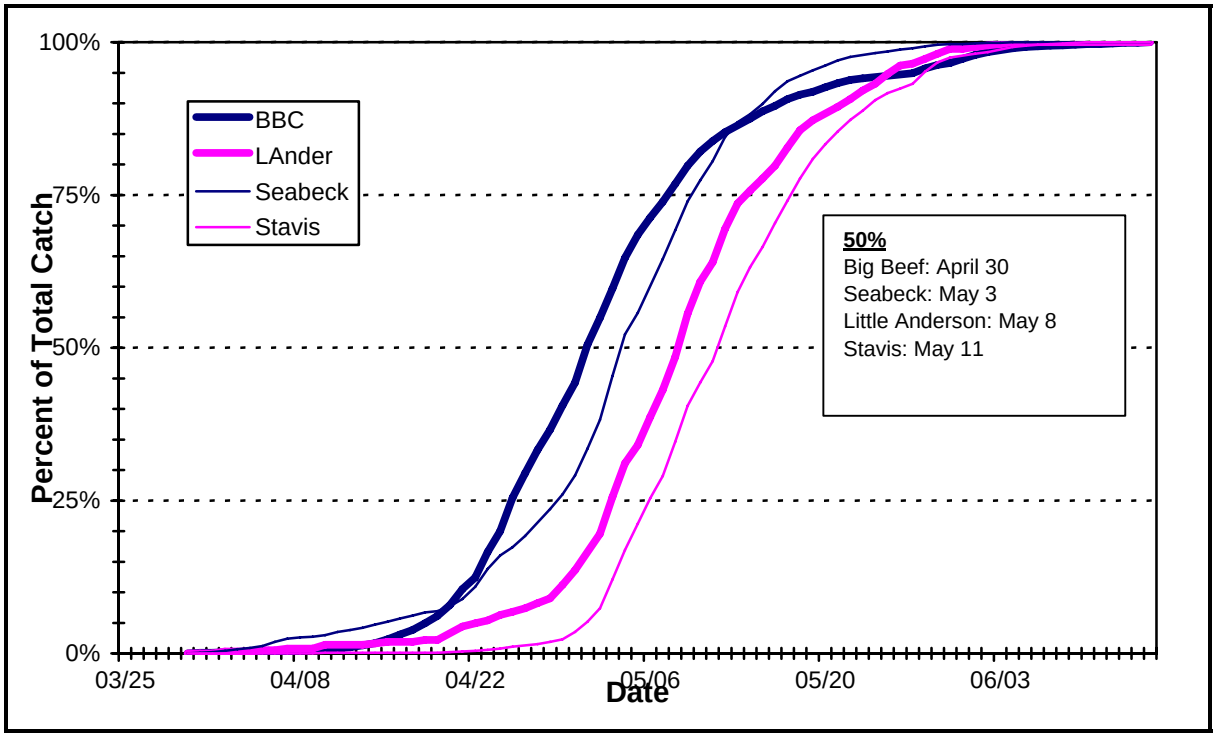

Figure 4. Percent cummulative coho smolt migration at Big Beef, Little Anderson, Seabeck, and Stavis Creeks, Spring 2004.

Coded-wire Tagging

We coded-wire tagged (CWT) 22,086 coho smolts (tag code 63-21/71) at Big Beef Creek (Table 3). The remaining coho smolt catch (1,741) was released untagged. Only 0.16% 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 88.1% (total number tagged applied to total estimated production of 25,062.

Table 3. Disposition of the coho smolt catch, Big Beef Creek 2004.

Disposition	Number	Percent
Released untagged		
Before/after tagging	608	2.55%
Poor condition	792	3.32%
Escaped during transfer	171	0.72%
Too small/large	71	0.30%
Donated to U.W.	0	0.00%
Other	61	0.26%
Total	1,703	7.15%
Mortality		
Trap mortality	32	0.13%
Sacrificed for tag placement	6	0.03%
Total	38	0.16%
Tagged and Released	[a] 22,086	92.69%
TOTAL CATCH	23,827	100.00%

[a] Tag code 63-21/71

Size

Over the season at Big Beef Creek, we randomly selected 961 coho smolts for fork length measurement. Weekly mean fork lengths ranged from a low of 95.2 mm to a high of 128.7 mm (Table 4). The season average fork length, weighted by catch, was 105.5 mm and the standard deviation was 10.00 mm.

Mean fork length (weighted by catch) was 100.9 mm, 109.5 mm, and 97.9 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 2004.

STATISTICAL WEEK			Mean	s.d.	RANGE		Number	Total	Sample
No.	Begin	End			Min	Max	Sampled	Catch	Rate
14	03/29/04	04/04/04	112.3	18.34	84	138	12	46	26.1%
15	04/08/04	04/14/04	128.7	17.31	90	179	32	157	20.4%
16	04/18/04	04/24/04	113.4	11.85	87	147	77	1,098	7.0%
17	04/28/04	05/04/04	109.7	11.02	87	140	120	5,590	2.1%
18	05/08/04	05/14/04	106.2	9.49	81	134	167	6,446	2.6%
19	05/18/04	05/24/04	102.9	10.06	77	130	191	5,957	3.2%
20	05/28/04	06/03/04	98.8	8.24	81	122	206	2,149	9.6%
21	06/07/04	06/13/04	100.3	7.02	87	112	44	994	4.4%
22	06/17/04	06/23/04	95.2	11.40	76	124	49	608	8.1%
23	06/27/04	07/03/04	105.5	9.74	85	126	42	622	6.8%
24	07/07/04	07/13/04	111.2	8.35	98	126	21	140	15.0%
25	07/17/04	07/23/04					0	20	0.0%
SEASON TOTAL			105.5	10.00	76	179	961	23,827	

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 2004.

STATISTICAL WEEK			Mean	s.d.	RANGE		Number	Total	Sample
No.	Begin	End			Min	Max	Sampled	Catch	Rate
14	03/29/04	04/04/04					0	2	0.0%
15	04/05/04	04/11/04	109.0	---	109	109	1	3	33.3%
16	04/12/04	04/18/04	---	---	---	---	0	3	0.0%
17	04/19/04	04/25/04	101.7	8.87	91	114	6	17	35.3%
18	04/26/04	05/02/04	101.0	4.24	98	104	2	52	3.8%
19	05/03/04	05/09/04	102.7	9.60	80	115	21	139	15.1%
20	05/10/04	05/16/04	99.6	9.05	87	116	12	79	15.2%
21	05/17/04	05/23/04	95.5	9.74	84	110	8	45	17.8%
22	05/24/04	05/30/04	103.7	13.88	85	121	11	23	47.8%
23	05/31/04	06/06/04					0	4	0.0%
SEASON TOTAL			100.9	8.9	80	121	61	367	

Notes: Season mean and standard deviation are weighted by catch.

Table 6. Mean for length (mm), standard deviation, range, number of coho smolts sampled for fork length, and total catch, by statistical week, Seabeck Creek 2004.

STATISTICAL WEEK			Mean	s.d.	RANGE		Number	Total	Sample
No.	Begin	End			Min	Max	Sampled	Catch	Rate
14	03/29/05	04/04/05					0	19	0.0%
15	04/05/05	04/11/05	117.4	11.55	100	139	15	53	28.3%
16	04/12/05	04/18/05	111.7	10.96	93	131	11	59	18.6%
17	04/19/05	04/25/05	113.7	9.89	95	131	19	219	8.7%
18	04/26/05	05/02/05	109.8	9.42	89	131	48	430	11.2%
19	05/03/05	05/09/05	110.7	8.79	90	137	43	691	6.2%
20	05/10/05	05/16/05	105.8	9.10	84	125	55	325	16.9%
21	05/17/05	05/23/05	100.8	6.39	95	114	13	104	12.5%
22	05/24/05	05/30/05	98.4	5.77	90	106	5	32	15.6%
23	05/31/05	06/06/05					0	5	0.0%
SEASON TOTAL			109.5	9.07	84	139	209	1,937	

Note: Season mean and standard deviations are weighted by catch.

Table 7. Mean for length (mm), standard deviation, range, number of coho smolts sampled for fork length, and total catch, by statistical week, Stavis Creek 2004.

STATISTICAL WEEK			Mean	s.d.	RANGE		Number	Total	Sample
No.	Begin	End			Min	Max	Sampled	Catch	Rate
14	03/29/05	04/04/05					0	1	0.0%
15	04/05/05	04/11/05					0	3	0.0%
16	04/12/05	04/18/05					0	6	0.0%
17	04/19/05	04/25/05	86.0	6.24	81	93	3	90	3.3%
18	04/26/05	05/02/05	101.8	13.02	82	129	25	600	4.2%
19	05/03/05	05/09/05	103.2	14.37	79	135	61	2,680	2.3%
20	05/10/05	05/16/05	96.3	9.88	79	116	79	2,279	3.5%
21	05/17/05	05/23/05	92.9	9.11	77	120	73	1,426	5.1%
22	05/24/05	05/30/05	90.1	8.22	79	110	40	631	6.3%
23	05/31/05	06/06/05					0	158	0.0%
24	06/07/05	06/13/05					0	28	0.0%
SEASON TOTAL			97.9	11.37	77	135	281	7,902	

Note: Season mean and standard deviations are weighted by catch.

Hood Canal IMW 2004 Escapement and Spawner Distribution

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 2004 season, the upstream trap and weir were installed in mid-August. We operated the trap continuously through January 3, 2005. 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 CWTs 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 1% of the adults (35 males and 8 females) and 26% of the jacks for tag recovery. 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 2001) that we tagged and released as smolts in Spring 2003 (31,553 total released with tag code 63-16/70), 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 2002) that we tagged and released as smolts in Spring 2004 (22,086 total released with tag code 63-21/71), plus a minimal number of strays from hatchery DIT groups.

Size and Age

We measured fork length on every tenth 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 9% 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 2001 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 13% of the unmarked coho captured in the trap.

Spawning Ground Surveys

Weekly surveys were conducted during the fall coho upstream migration and spawning period to count live coho and chum salmon, salmon carcasses, and redds (salmon nests). To spatially orientate the survey data collected, as well as that of other IMW field studies, we utilized a segmentation approach developed by the joint WDFW and Northwest Indian Fisheries Commission (NWIFC) Salmonid Habitat Inventory and Assessment Project (SHIAP). This approach breaks the watershed into stream segments of similar stream size, channel gradient, and valley confinement conditions. We determined the location of these segments and marked their end-points in the field with flagging and aluminum tree tags. The SHIAP segments were established on all of the coho spawning habitats known prior to the start of the surveys. In addition, within each segment, reference points were established at 100-meter intervals, beginning at the downstream end of each segment, to define smaller stream reaches. The location of segment breaks and reference points were determined using a handheld GPS receiver where reception was adequate.

We attempted to survey all spawning habitat in each IMW watershed each week. The amount of habitat surveyed depended on accessible habitat and water clarity. Small tributaries were not surveyed early in the season when streams were dry or flow was too low to permit entry. When flows increased, surveying began in these tributaries and continued until at least one week after flows would no longer support entry. Surveys were not conducted during weeks when turbidity or high stream flows resulted in unsuitable conditions.

Counts of live salmon, carcasses, and redds were identified by species and referenced to the segments and reference points the observations fell between. Sampled carcasses were categorized as male, female, or jack. The snout was removed from all sampled coho carcasses to check for coded wire tags and to mark the carcasses as having been sampled.

Estimating Escapements into Little Anderson, Seabeck, and Stavis Creeks

Two approaches were used to estimate coho escapement into Little Anderson, Seabeck, and Stavis Creeks. As in 2003, we estimated escapements using the smolt-to-returning adult survival rate (SRR) calculated for Big Beef Creek. This rate was applied to the 2003 smolt production values from Little Anderson, Seabeck, and Stavis Creeks to estimate the 2004 escapements into these streams. The second approach estimated coho escapements through analysis of the redd count data collected during spawning ground surveys.

Survival-to-Return Rate Based Estimates

The SRR was estimated for Big Beef Creek coho by the estimated escapement of 2001-brood coded wire tagged natural origin Big Beef coho divided by the number of 2001 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 SRR 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 2001 brood coho smolt productions by the Big Beef Creek SRR; and 2) dividing the product by the estimated proportion of the total Big Beef Creek escapement comprised of natural origin coho.

Redd Based Estimates

We attempted to count coho redds over the entire accessible Little Anderson, Big Beef, Seabeck, and Stavis watersheds on a weekly basis. Total counts of redds were made each week. To avoid double counting redds that were visible for more than a week, we estimated the redd life (i.e. period of redd visibility) as a function of Big Beef Creek flow. Occasionally, a survey was missed in a stream segment due to high water or other factors. When this occurred, redd density (redds/meter) was estimated by the following:

$$\hat{D}_{ij} = \frac{D_{ik}}{D_{i+/-1k}} D_{i+/-1j}$$

Equation 1

Where:

$\hat{D}_{ij}$ = Estimated coho redd density in week i at site j,

D_{ik} = Coho redd density in week i at adjacent site k,

$D_{i+/-1k}$ = Coho redd density in either the previous or following week i + / - 1 at site k, and

$D_{i+/-1j}$ = Coho redd density in either the previous or following week i + / - 1 at site j.

Estimated coho redd density was multiplied by the length of the survey segment to estimate the visible coho redds during that week.

New coho redds found each week were summed over the season to estimate total redd production. The 2004 spawning escapement was estimated assuming each female coho produced one redd and the male: female sex ratio was 1:1.

Results

Coho Catch and Migration Timing

Coho were first observed moving into the upper estuary in mid-September. We trapped and sacrificed the first hatchery ad-marked adult coho above the weir on September 5 and the first wild unmarked coho on September 13. The coho migration began increasing gradually in early October, as flows began to rise (Figure 5). The migration first peaked on October 17, with 1,293 adults and 100 jacks captured, followed by a second, lower peak on November 2, with 773 adults and 33 jacks trapped. The peak migration coincided with the first significant freshet (Figure 5). By the evening of November 2, over 70% of the natural origin adult coho and 96% of the adult hatchery coho run had returned. On December 27 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 28 through the end of the trapping period (January 3, 2005).

Over the season, we trapped a total of 4,115 adult coho (2,013 males and 2,102 females) and 460 jacks (Table 8). The adult return consisted of 4,019 (98%) unmarked and 96 (2%) ad-marked coho. The jack return included 318 (69%) unmarked and 142 (31%) ad-marked jacks (Table 8).

Of the 4,019 unmarked adults trapped, 3,237 (81%) detected positive for a CWT. From these, we sacrificed 35 males and 8 females for CWT recovery (Table 8). We also sacrificed 67 unmarked/tagged jacks, 26% of the 262 that returned. We killed all 96 ad-marked adults that returned, of which 4 males and 6 females detected positive for a CWT. Also we killed all 142 ad-marked jacks, of which 15 that detected positive for a CWT (Table 8).

A total of 3,973 unmarked adults were released upstream (Table 8). Of these, 1,932 (49%) were males and 2,041 (51%) were females. We also released 251 jacks upstream.

We observed three dead adult coho below the weir trap (one tagged male, one untagged male and one tagged female). No coho died in the trap (Table 8).

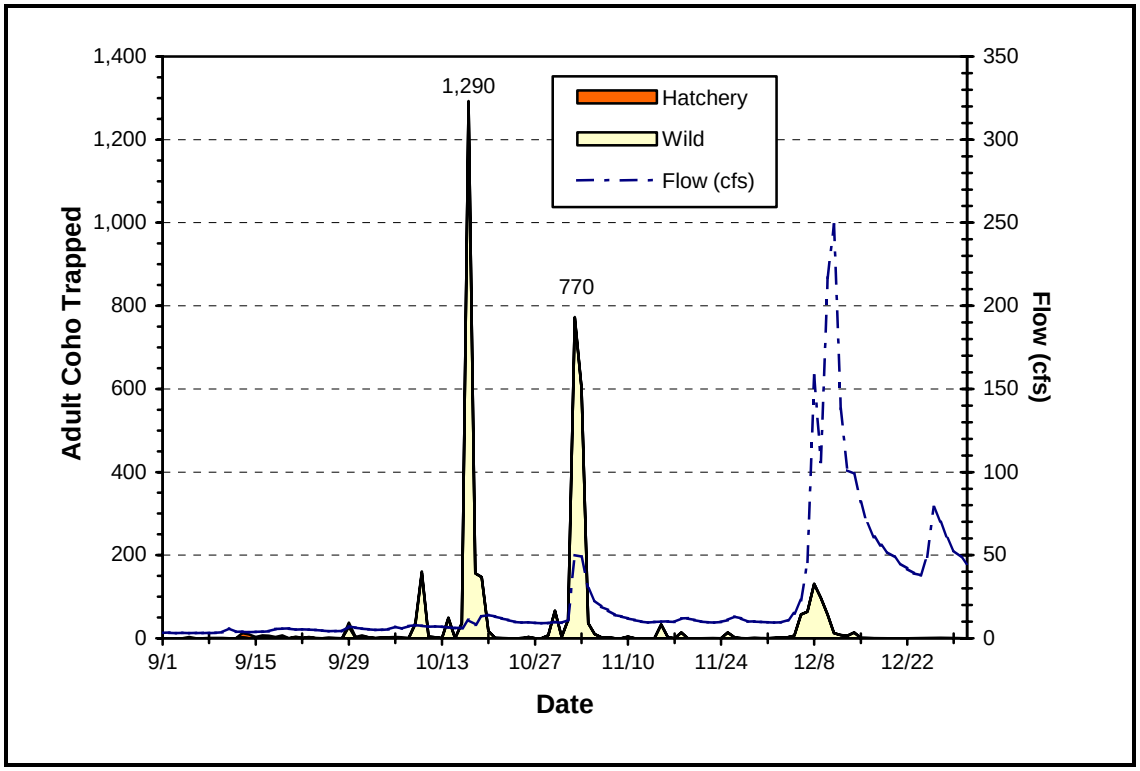

Figure 5. Natural and hatchery origin adult coho trapped at Big Beef Creek by day, and mean daily flow (cfs), September 1 through December 31, 2004.

Table 8. Disposition of coho returning to Big Beef Creek, Fall 2004.

Disposition	Un-marked										Ad-marked										Total Coho			
	Adults						Total	Jacks			Adults						Total	Jacks			Adults			Jacks
	Male			Female							Male			Female							Male	Female	Total	
	+	-	Tot	+	-	Tot		+	-	Tot	+	-	Tot	+	-	Tot		+	-	Tot				
Total Return	1,580	389	1,969	1,657	393	2,050	4,019	262	56	318	4	40	44	6	46	52	96	15	127	142	2,013	2,102	4,115	460
Trap Mortalities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dead Below Weir	1	1	2	1	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	0
Sacrificed	35	0	35	8	0	8	43	67	0	67	4	40	44	6	46	52	96	15	127	142	79	60	139	209
Total Upstream	1,544	388	1,932	1,648	393	2,041	3,973	195	56	251	0	0	0	0	0	0	0	0	0	0	1,932	2,041	3,973	251

Note: The plus sign (+) indicates a positive detection for a CWT. The minus sign (-) indicates that no CWT was detected.

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 2004 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 2001-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 18% of all 2001 brood hatchery coho smolts were released unmarked.

The 2001-brood hatchery fish that returned as adults in Fall 2004 included coho released as smolts in Spring 2003 from the Quilcene National Fish Hatchery, George Adams Hatchery, Quilcene Bay Sea Pens, and Port Gamble Sea Pens. These hatchery and net pen releases totaled approximately 1.2 million smolts (Table 9).

Scale Analysis

We collected scale samples from 467 unmarked adults, 11.6% of the total unmarked return (Table 10). Nineteen of these samples were unreadable due to regeneration, leaving 448 for analysis. Projecting the sample results to estimate the naturally produced and hatchery components of the unmarked adult return estimated a total of 3,994 (99.4%) natural origin and 25 (0.6%) hatchery origin fish.

In total we collected scales from 80 unmarked jacks, 25.2% of the unmarked jack return. This sampling resulted in 80 readable samples, of which 74 were natural origin and six were hatchery origin (Table 10). Projecting these sample results to the total jack return estimated 294(92.5%) natural origin and 24(7.5%) hatchery origin jacks in the unmarked jack return (Table 10).

Table 9. Numbers of 2001-brood hatchery and sea pen-reared coho smolts released into Hood Canal in 2003.

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	05-10-80	072003UILB80440	12,148		75,604		87,752
			05-10-81			12,158		1,292	13,450
			05-10-78	072003UILB60440	11,640		73,989		85,629
			05-10-79			12,017		1,413	13,430
			05-10-76	072003UILB40440	11,449		73,123		84,572
			05-10-77			12,790		1,503	14,293
			05-10-82	072003UILD60440		11,366		1,285	12,651
			05-10-83		10,454		65,981		76,435
			Total		45,691	48,331	288,697	5,493	388,212
	George Adams Hatchery	Purdy Creek	63-15-17	420021014	22,740	53			22,793
			63-15-18		12,913		9,198		22,111
			63-14-73			22,374			22,374
			63-14-74			23,064			23,064
			NA	NA			241,526		241,526
			Total		35,653	45,491	250,724		331,868
Sea Pen Releases	Quilcene Bay Sea Pens	Quilcene NFH	05-10-64	142003DI04		20,000		47,000	67,000
			05-99-99[b]						
			Total			20,000		47,000	67,000
	Port Gamble Sea Pens	Big Quilcene	21-03-98	142003DI05	44,779		319,103		363,882
			21-03-99			45,159		90	45,249
			Total		44,779	45,159	319,103	90	409,131
				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.
[b] High mortality associated with tag codes 05-10-64 and 05-99-99. No release numbers reported.

Table 10. Results of coho scale sample analysis for stock identification, Big Beef Creek 2004.

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	1,963	255	13.0%	10	243	2	1,948	15
	Males 35-45 cm	6	6	100.0%	0	6	0	6	0
	Females	2,050	206	10.1%	9	196	1	2,040	10
	Total Adults	**4,019**	**467**	**11.6%**	**19**	**445**	**3**	**3,994**	**25**
Jacks	***Unmarked***								
	Total Jacks	**318**	**80**	**25.2%**	**0**	**74**	**6**	**294**	**24**

[a] Regenerated scales were assumed natural origin.

CWT Recovery

Adults

Unmarked/tagged coho comprised 80.5% of the total unmarked adult return. 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 43 unmarked adult coho (35 males and 8 females) for CWT recovery at the trap, and all but one of these contained tags. In addition, we recovered one tag from an unmarked spawned female that was dead below the weir, and another from an unmarked male that was dead below the weir. In total, these recoveries consisted of 40 Big Beef Creek natural origin fish (code 63-16/70), four hatchery coho, 2 Big Quilcene stock released from the Port Gamble Sea Pens (code 21-03/99), one hatchery coho from the Quilcene Bay Sea Pens (code 05-10/64), one hatchery coho released at the Goldstream River by the Canadian Department of Fish and Oceans (code 18-23/37) and one fish did not contain a tag (Table 13).

In addition, we killed a total of 96 ad-marked adults (44 males and 52 females) at the trap, of which 4 males and 6 females detected positive for a CWT. Eight of these fish contained tags; all were hatchery origin released from the Port Gamble Sea Pens. Two snouts from ad-marked adults that had detected positive for a tag contained none (Table 13).

We also collected snouts from 711 unmarked carcasses during stream surveys (686) and from the weir (25), of these 703 contained tags (Table 13).

Tag recoveries consisted of 701 Big Beef Creek natural origin adults (code 63-16/70), and two unmarked hatchery fish, one from the Goldstream River (CDFO) (code 18-23/38), and one from the Minter Creek Hatchery (code 63-14/96). We did not recover CWT's from the remaining 8

coho snouts obtained during stream surveys because, one tag was lost in the lab, and seven snouts did not contain tags.

In addition, during stream surveys we collected snouts from the carcasses of 4 additional unmarked/tagged jacks. All four jacks had Big Beef Creek natural origin tags (code 63-21/71) (Table 12).

Jack

Unmarked/tagged jacks comprised 82.4% of the unmarked jack return. 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 82 jacks (67 unmarked and 15 ad-marked) for CWT recovery at the trap (Table 12). Tag recoveries from unmarked jacks included 58 Big Beef Creek natural origin tags (code 63-21/71) and seven tags from the Port Gamble Sea Pens (code 21-03/45). All tags recovered from the ad-marked/tagged jacks (15 total with one lost head) were also from the Port Gamble Sea Pens (code 21-04/27).

Table 11. Coded-wire tag recoveries from unmarked and ad-marked adult coho (2001 brood), Big Beef Creek 2004.

Group	Tag Code	Origin	CWT RECOVERIES				
			Sacrificed at Trap	Stream Surveys/Weir Rec	Trap Mortality	Dead Below Weir	Total
Unmarked	63-16/70	Big Beef Creek	40	701 [a]			**741**
	21-03/99	Port Gamble Sea Pens Pens/Hatchery	1			1	**2**
	05-10/64	Quilcene Bay Sea Pens				1	**1**
	18-23/37	CDFO Goldstream River	1				**1**
	18-23/38	CDFO Goldstream River		1			**1**
	63-14/96	Minter Creek		1			**1**
	Lost Tags			1			**1**
	No Tags		1	7			**8**
TOTAL UNMARKED ADULTS			**43**	**711**	**0**	**2**	**756**
Ad-marked	21-03/98	Port Gamble Sea Pens	8				**8**
	Lost heads		2				**2**
TOTAL AD-MARKED ADULTS			**10**		**0**		**10**

[a] Includes 6 Big Beef Creek wild tags recovered from Stavis (2), Seabeck (3), and Little Anderson Creeks (1).

Table 12. Coded-wire tag recoveries from unmarked and ad-marked jack coho (2002 brood), Big Beef Creek 2004.

Group	Tag Code	Origin	CWT RECOVERIES		
			Sacrificed at Trap	Stream Surveys	Total
Unmarked	63-21/71	Big Beef Creek	58	4	**62**
	63-15/27	Port Gamble Sea Pens	7		**7**
	Lost head		1		
	No Tag		1		
TOTAL UNMARKED ADULTS			**72**	**9**	**81**
Admarked	21-04/27	Port Gamble Sea Pens	14		**14**
	Lost head		1		**1**
TOTAL AD-MARKED ADULTS			**82**	**4**	**86**

Estimation of Tag Loss

Tag loss of the 2001-brood adults and 2002-brood jacks returning in 2004 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 756 snouts from unmarked/tagged adults, 741 contained Big Beef Creek tags, six contained hatchery tags, eight heads did not contain tags, and one tag was lost (Table 14). Expansion of these tag recovery results to the total unmarked/tagged return of 3,237 estimates 3,211 Big Beef Creek tags and 26 hatchery tags in the total unmarked/tagged return (Table 14). Adding the 10 ad-marked/tagged coho counted at the trap to the 26 unmarked/tagged hatchery coho estimated via CWT expansion estimates that a total of 36 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.

Jack

We collected 71 snouts from unmarked/tagged jacks, of which 62 contained Big Beef Creek tags (Table 13). Expansion of these tag recovery results to the total unmarked/tagged jack return of 262 estimates a total of 235 Big Beef Creek tags and 27 hatchery tags in the unmarked jack return (Table 13).

Table 13. Coded-wire tags recovered from natural origin and hatchery adults (2001 brood) and estimated total tagged adults returning, Big Beef Creek 2004.

Group	Tag Code	Origin	Observed Tag Recoveries	Estimated Total Tags
Unmarked	63-16/70	Big Beef Creek	741	[a/] 3,211
	21-03/99	Port Gamble Sea Pens	2	
	05-10/64	Quilcene Nat'l Fish Hatchery	1	
	18-23/37	CDFO Goldstream River	1	
	18-23/38	CDFO Goldstream River	1	
	63-14/96	Minter Creek Hatchery	1	
		Total	**747**	**3,211**
Ad-Marked	21-03/98	Port Gamble Sea Pens	8	
	Lost Heads		2	
		Total	**10**	**10**

[a] Big Beef Creek (BBC) tagged adult sample expansion is: 3,237 total unmarked/tagged adults returning and 747 snouts contained tags, of which 741 contained BBC tags (741/747 = .9920 x 3,237 = 3,211 estimated BBC tags in the total return).

Table 14. Coded-wire tags recovered from natural origin and hatchery jacks (2002 brood) and estimated total tagged jacks returning, Big Beef Creek 2004.

Group	Tag Code	Origin	Observed Tag Recoveries	Estimated Total Tags
Unmarked	63-21/71	Big Beef Creek	62	[a]235
	63-15/27	Port Gamble Bay Sea Pens	7	
	Lost head		1	
	No tags		1	
Total			71	235
Ad-marked	21-03/98	Port Gamble Sea Pens	1	1

[a] Big Beef Creek (BBC) tagged jack sample expansion is: 262 total unmarked/tagged jacks returning and 71 snouts dissected, 69 contained tags, of which 62 were BBC origin (62/69 = .8986 x 262 = 235 estimated BBC tags in the total return).

Tag Rate Estimates

Scale analysis indicated there were 464 tagged natural origin adults and 3 tagged hatchery strays in the scale sample of 467 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 3,237 adults estimates that 3,216 tagged adults were of natural origin. Dividing this number by the estimated 3,993 total unmarked naturally produced adults returning (Table 10) yields a natural origin tag rate of 80.5% (3,216/3,993).

In comparison, we estimated the tag rate upon smolt out-migration at 87.5% (31,553/36,060) 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 70.9% (25,577/36,060), lower than the rate of 80.5% estimated at adult return.

The tag rate for naturally produced jacks that returned in 2004 was estimated at 80% (235/294), 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 2004 we estimated the tag rate upon smolt out-migration at 88.0% (22,066/25,062)(see Hood Canal IMW Downstream beginning on page 9), 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 71.4% (17,887/25,062), also lower than the rate estimated from the jack return to the trap.

Survival to Adult Return

Adults

Survival of the 2001-brood Big Beef Creek coho tag group from smolt emigration in Spring 2003 to return as adults in Fall 2004 was estimated via two methods, CWT analysis and scale results. Based on CWT results, we estimated that 3,211 tagged naturally produced adults returned (Table 13). Dividing these by the estimated 25,577 natural origin smolts tagged in Spring 2003 (adjusted for tag loss [3.5%] and delayed tagging mortality [16%])(Table 10) yields a survival-to-return rate of 12.6%. In comparison, dividing the scale-based estimate of 3,216 Big Beef Creek natural origin tags returning by the adjusted estimate of 25,577 natural origin smolts tagged in Spring 2003 yields a survival-to-return rate of 12.6%, 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 (2002-brood). We estimated that 235 tagged natural origin jacks returned via expanding in-sample CWT results (Table 14). Dividing these 235 tags by an adjusted estimate of 17,903 natural origin smolts tagged in Spring 2004 (adjusted for tag loss and delayed mortality from a total tagged release of 22,086) yields a survival-to-return estimate of 1.3%.

We sampled scales from a total of 80 unmarked jacks (Table 10). Scale results revealed there were 74 tagged natural origin jacks and 6 tagged hatchery strays in this sample, yielding a natural origin tag rate of 92.5%. Applying this rate to the total unmarked/tagged jack return of 262 estimates that 242 tagged natural origin jacks returned. Dividing this estimate by the 17,903 (adjusted) smolts tagged in Spring 2004 yields a survival-to-return rate of 1.4%, 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 2,187 Big Beef Creek tags (2001 brood) were caught in 2004 fisheries (preliminary estimate): 2,024 in terminal mixed net/seine fisheries, 53 in Puget Sound and ocean sport (combined), and 110 from the treaty and non-treaty troll fishery in the ocean (Table 15). Adding the estimated escapement of 3,216 (scale analysis) tagged natural origin coho to this harvest, and dividing this sum by the adjusted number of smolts tagged in Spring 2003, yields a preliminary estimated marine survival rate of 21.1% ([2,187 + 3,216]/25,577) (Table 15). We will compute a final estimate of marine survival for natural origin 2001-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 (2001 brood), based on the estimated catch and escapement of tagged natural origin adults during 2004 (Preliminary).

	Area	Fishery Type	Total Estimated BBC Tags in the Adult Coho Return (2001 Brood) Tag Code: 63-16/70
HARVEST	***Ocean (WA)***	Troll (Treaty + Non-treaty)	110
	Puget Sound	Sport + Mixed Net/Seine (combined) [a]	2,077
	ESTIMATED HARVEST OF BBC TAGS (Preliminary) [b]:		**2,187**
ESCAPE-MENT	**Big Beef Creek Trap**	Return of natural origin tags to trap [c]	**3,216**
	ESTIMATED ESCAPEMENT OF BBC TAGS:		**3,216**
SUMMARY		**TOTAL RUN (Harvest + Escapement)**	**5,403**
	Total Smolts Tagged (tag code 63-12/89)		31,553
	Total Adjusted Smolts Tagged [d]		25,577
	Harvest Rate (Total Harvest/Total Run)		[b e] 8.6%
	Escapement Rate (Total Escapement/Total Run)		91.4%
	MARINE SURVIVAL (Total Run/Total Adjusted Smolts Tagged)		**21.1%**

[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 63-16/70 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 2002 and 2003, we conducted daily on-the-water monitoring of the treaty coho fishery in Hood Canal enumerating total catches and determining the CWT incidence and disposition. This monitoring was continued in Fall 2004.

As in the previous year we focused our sampling effort in catch 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. When large catches prevented 100% sampling sub-samples were obtained and catch data expanded. Snouts were removed from tagged fish and then labeled for subsequent processing at the WDFW

coded-wire tag lab. We 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 26 through November 20 (Table 16). During this period, the tribal beach seine fishery was active in the near-shore areas on several days. On these days, we electronically sampled catches to determine tag incidence and recover coded-wire tags (Table 17).

An estimate of the total tags captured in the Hood Canal treaty coho fishery will not be possible until Fall 2006, when we expect tag expansion estimates to be finalized in the RMIS database. Our preliminary estimate of 2,187 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 chum and coho fisheries (set net and beach seine) in Hood Canal, Fall 2004.

Area	Dates Open	Total Days
12	9/26-9/30, 10/3-10/7, 10/10-10/14, 10/17-10/23, 10/24-11/20	50
12B	9/26-9/30, 10/3-10/7, 10/10-10/14, 10/17-10/23, 10/24-11/20	50
12C	9/26-9/30, 10/3-10/7, 10/10-10/14, 10/17-10/23, 10/24-11/20	50

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	Total Fish	% Tagged
63-16/70	Big Beef Creek (adults)	1,142	Data not yet available	Data not yet available
63-21/71	Big Beef Creek (jacks)	7		
63-14/89	Marblemount Hatchery	1		
63-15/17	George Adams Hatchery	3		
63-15/18	George Adams Hatchery	1		
63-15/38	South Sound Sea Pens	1		
63-15/39	South Sound Sea Pens	5		
63-15/40	South Sound Sea Pens	3		
21-02/22	Lower Elwha Hatchery	1		
21-03/45	Lower Elwha Hatchery	1		
21-03/98	Port Gamble Bay Sea Pens	2		
21-03/99	Port Gamble Bay Sea Pens	1		
63-10/64	Unknown - Not in RMIS	1		
63-14/73	George Adams Hatchery	6		
63-14/74	George Adams Hatchery	1		
TOTAL		**1,176**		

Coho Spawner Distribution

Coho spawning ground surveys began on October 25 and ended December 30. Over the season, surveyors counted 3,076 live coho, 986 carcasses, and 1,532 redds, most of which occurred in

Big Beef Creek (Table 18). Weekly spawning ground surveys were conducted over as much as 6.5km of Little Anderson Creek, 17.5km of Big Beef Creek, 9.1km of Seabeck Creek, and 13.8km of Stavis Creek.

Stream discharge was well below average until the second week in December (Figure 6). Low flows reduced the utilization of headwater spawning areas (Figure 7, Figure 8, Figure 9, and Figure 10). A freshet that peaked on December 11 enabled spawning salmon to finally penetrate into these upstream reaches that previously had insufficient stream flow. The distribution of coho redds greatly expanded following the December 11 peak flow (Figure 11, Figure 12, Figure 13, and Figure 14). This change in distribution was difficult to discern in Big Beef Creek, due to the high spawning densities recorded in that watershed (Figure 8 and Figure 12). Yet, penetration into the upper ends of tributaries was greatly increased after the December 11 flow event (Figure 15 and Figure 16, for example).

Table 18. Counts of live and dead coho and coho redds observed during spawning ground surveys in the Hood Canal IMWs, 2004.

Watershed	Dates	Live Coho	Carcasses				Redds
			Males	Females	Jacks	Not Determined	
L. Anderson	10/28 – 12/22	22	1	4	0	1	31
Big Beef	10/25 – 12/30	2,632	411	402	10	43	1,085
Seabeck	10/28 – 12/30	143	18	35	5	0	167
Stavis	10/27 – 12/28	279	26	27	2	1	249

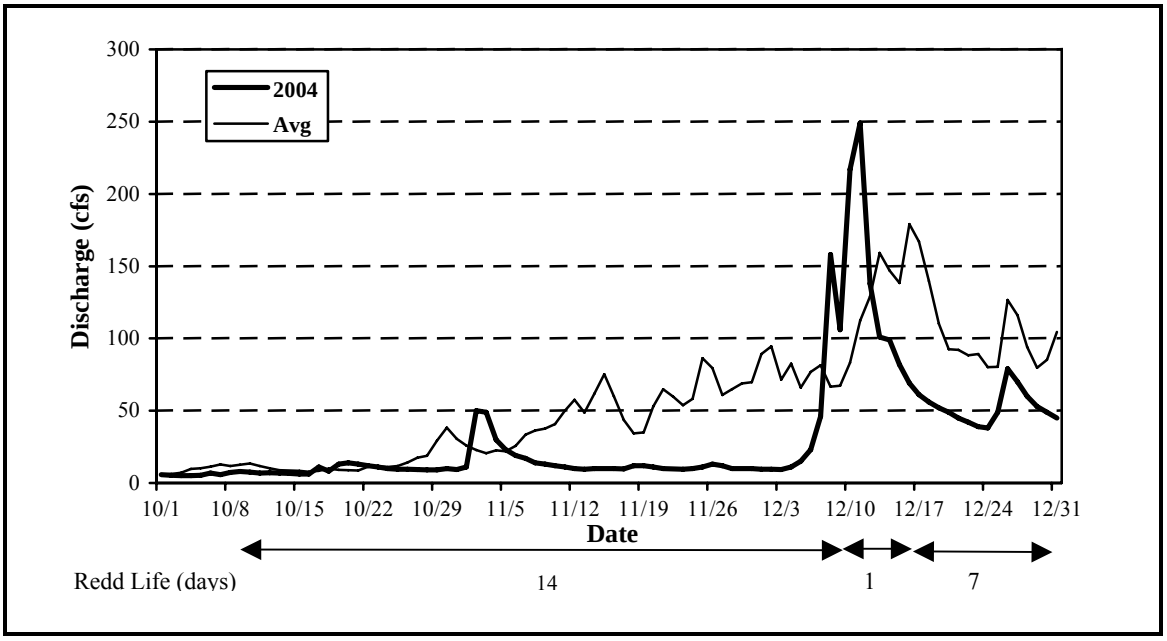

Figure 6. 2004 Big Beef Creek discharge and estimated redd life relative to average stream discharge, USGS gage data.

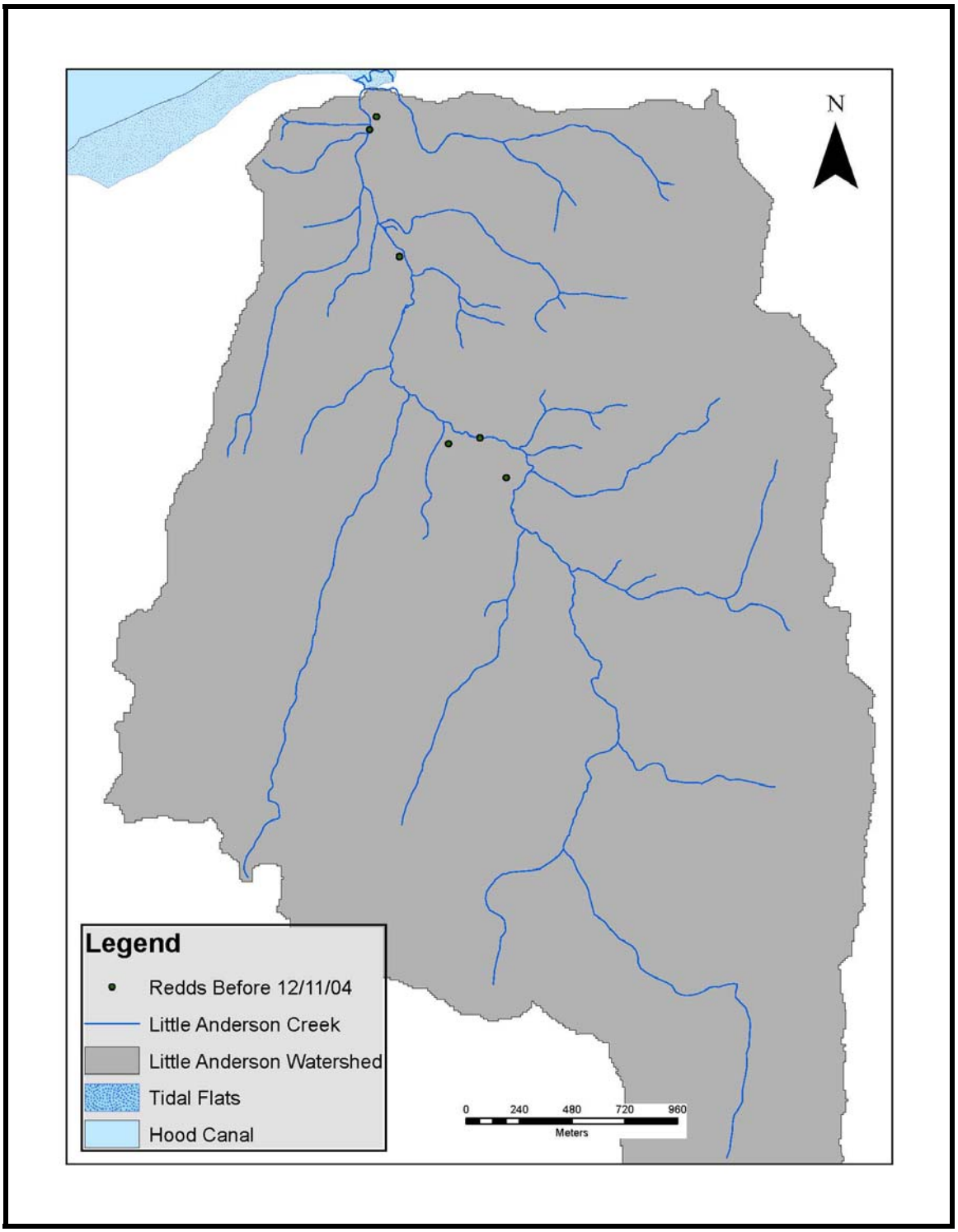

Figure 7. 2004 distribution of coho redds in Little Anderson Creek prior to the December 11, 2004 flow event.

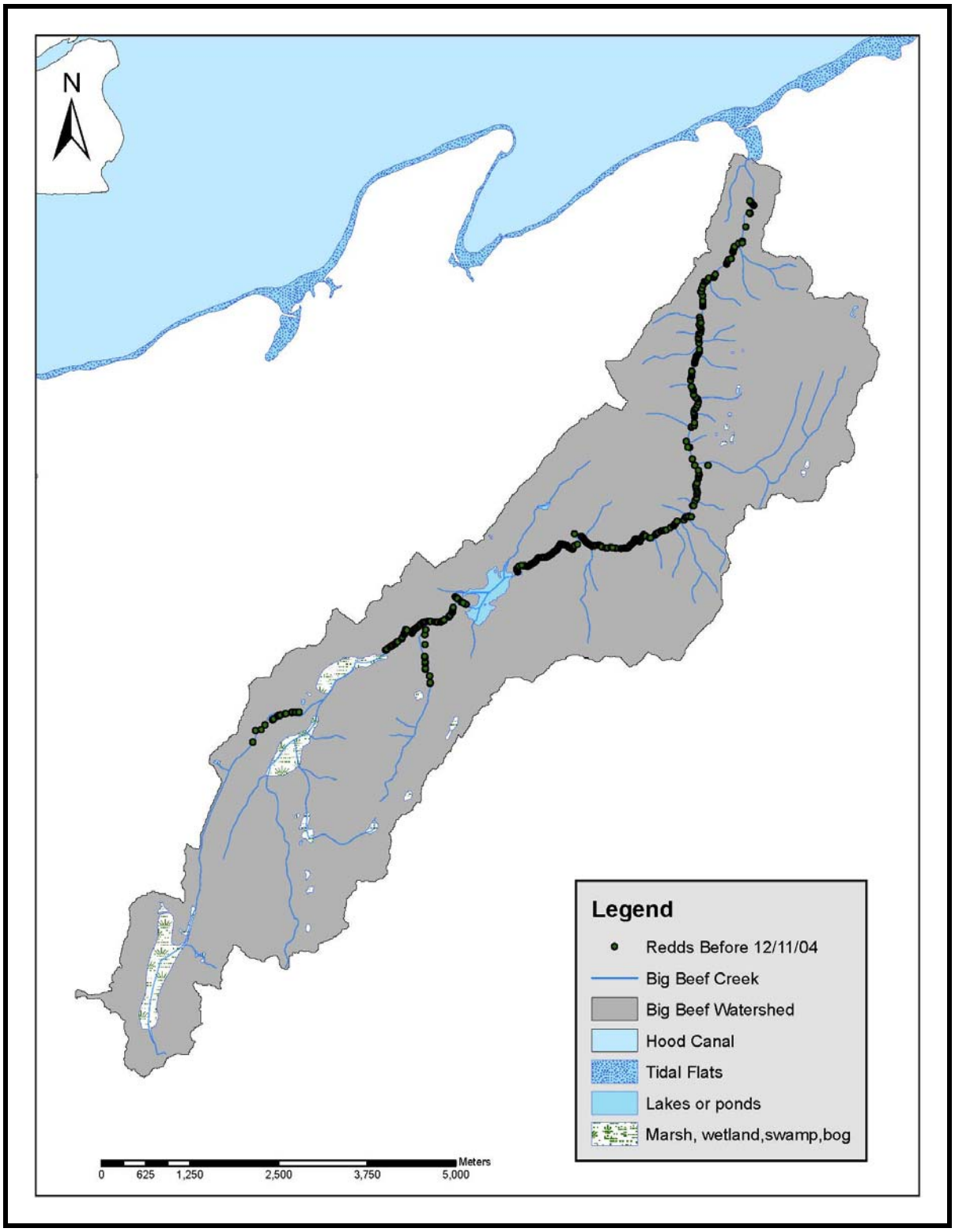

Figure 8. 2004 distribution of Big Beef Creek coho prior to the December 11, 2004 flow event.

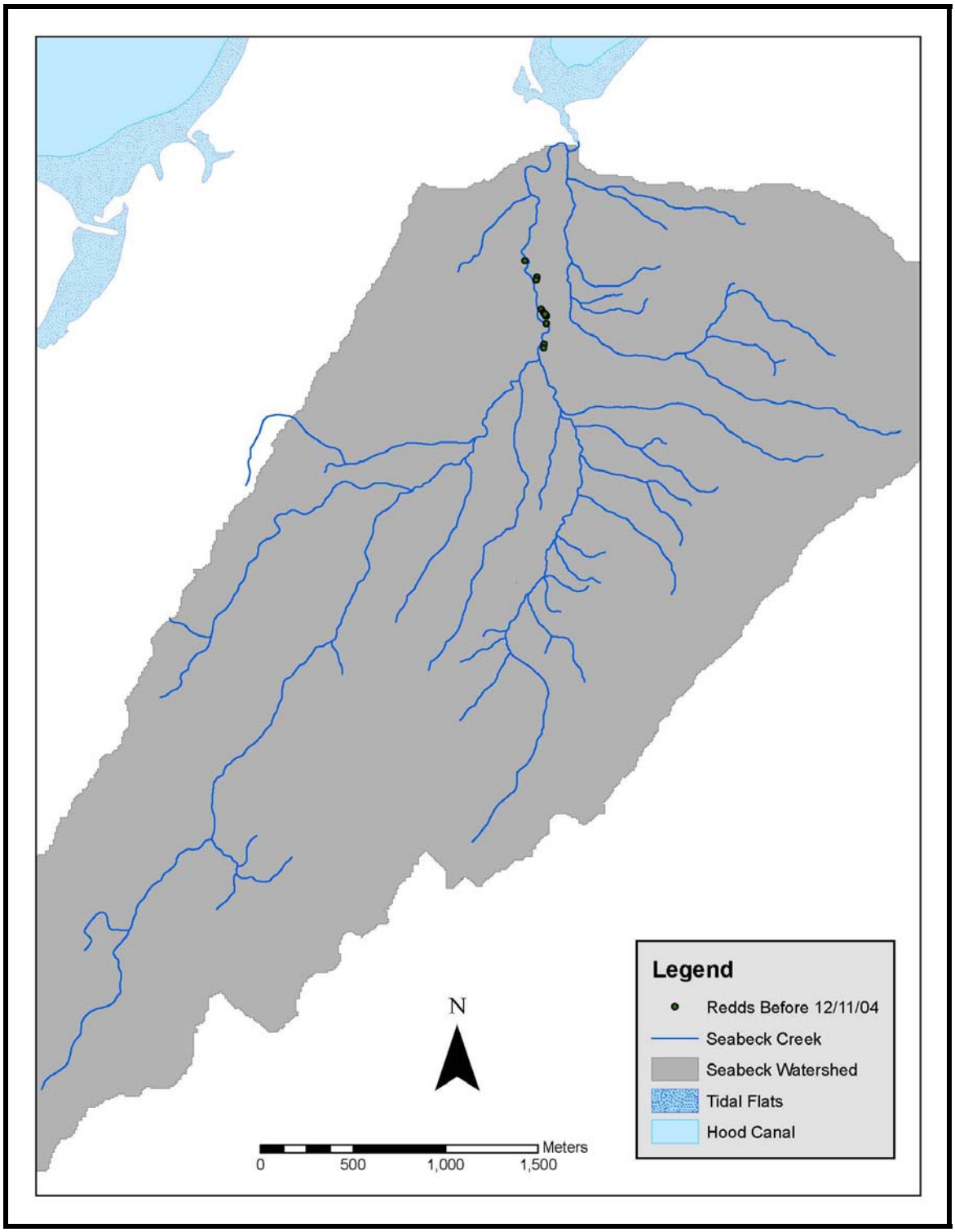

Figure 9. 2004 distribution of coho redds in Seabeck Creek prior to the December 11, 2004 flow event.

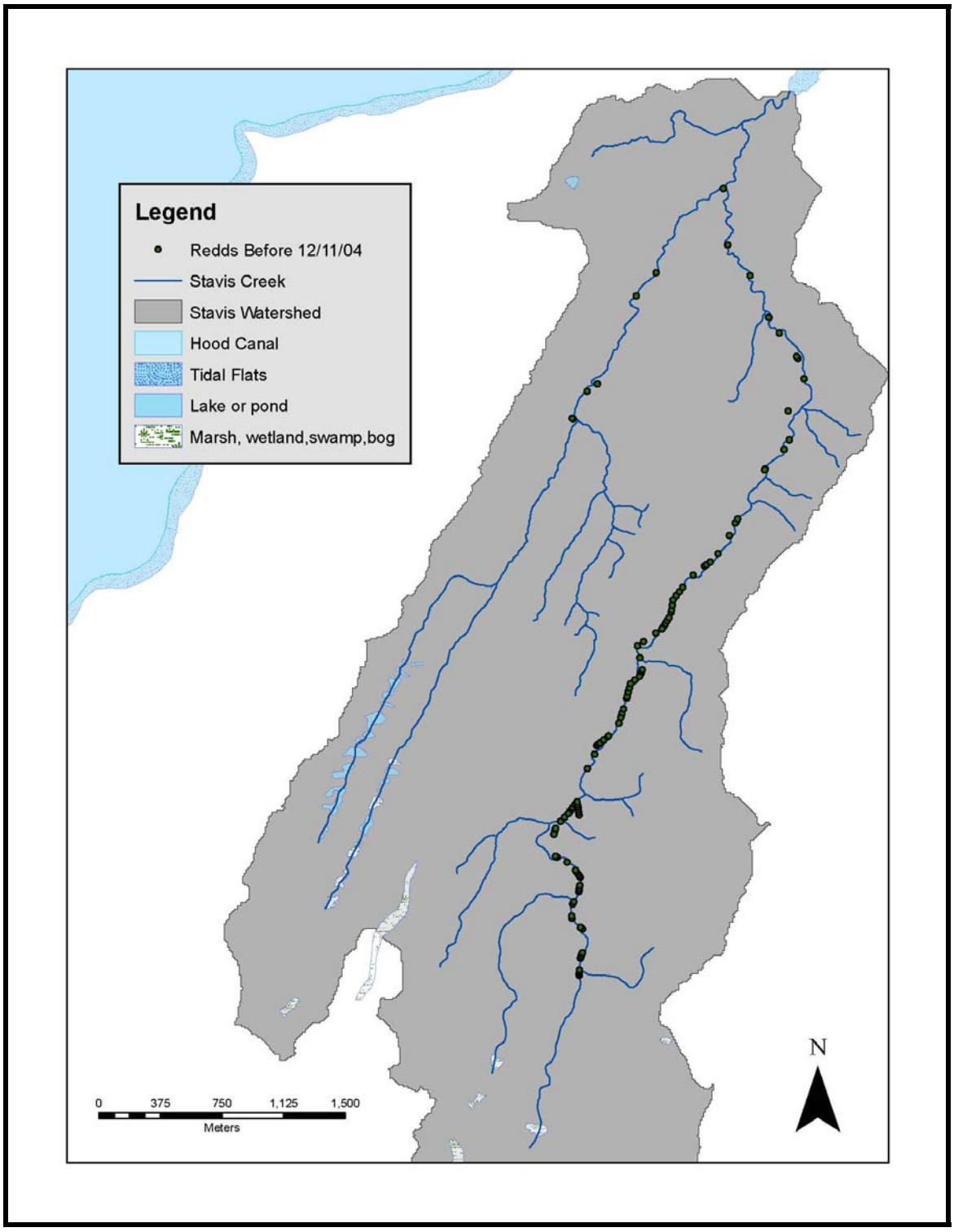

Figure 10. 2004 distribution of coho redds in Stavis Creek prior to the December 11, 2004 flow event.

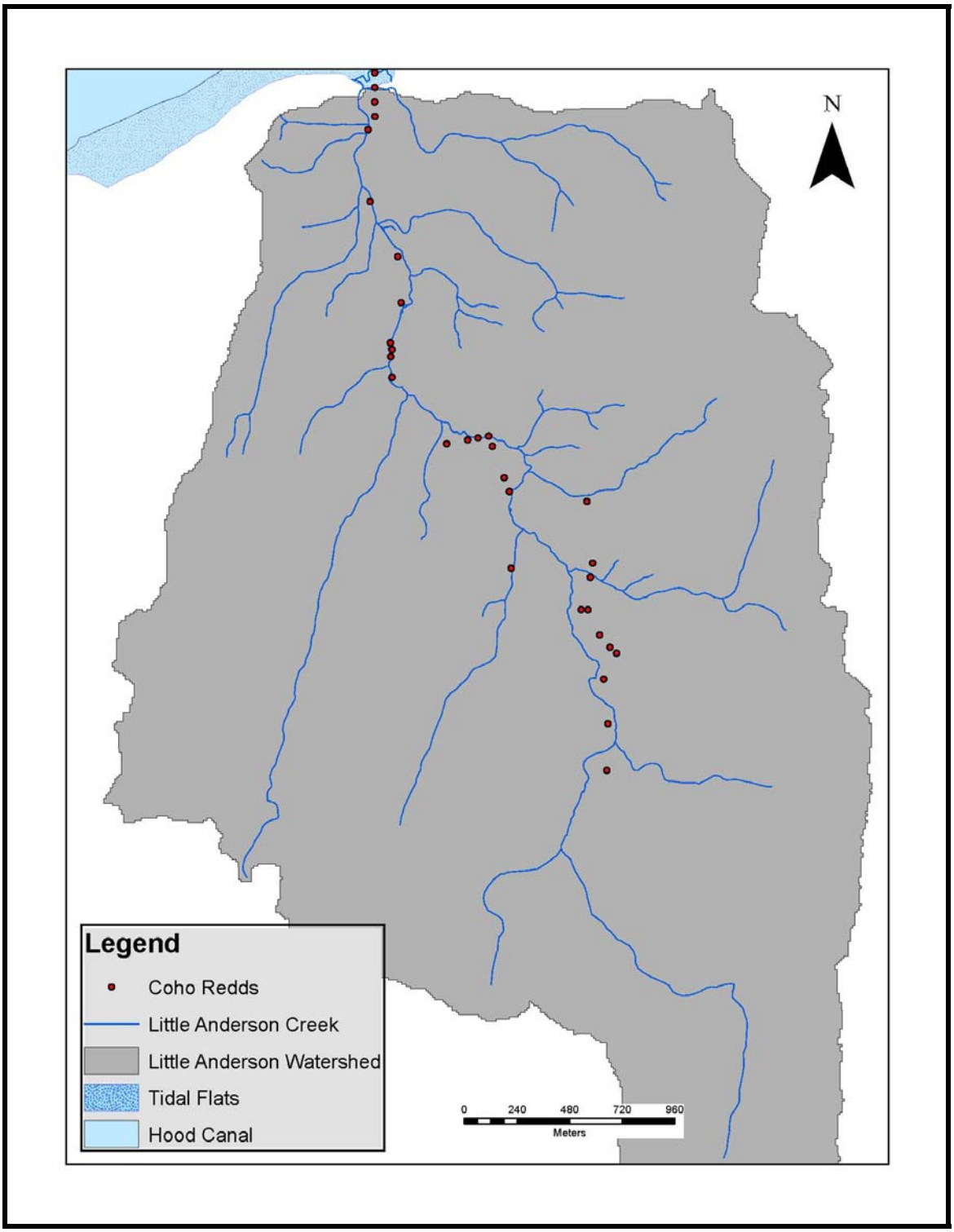

Figure 11. Distribution of all observed coho redds in Little Anderson Creek, 2004.

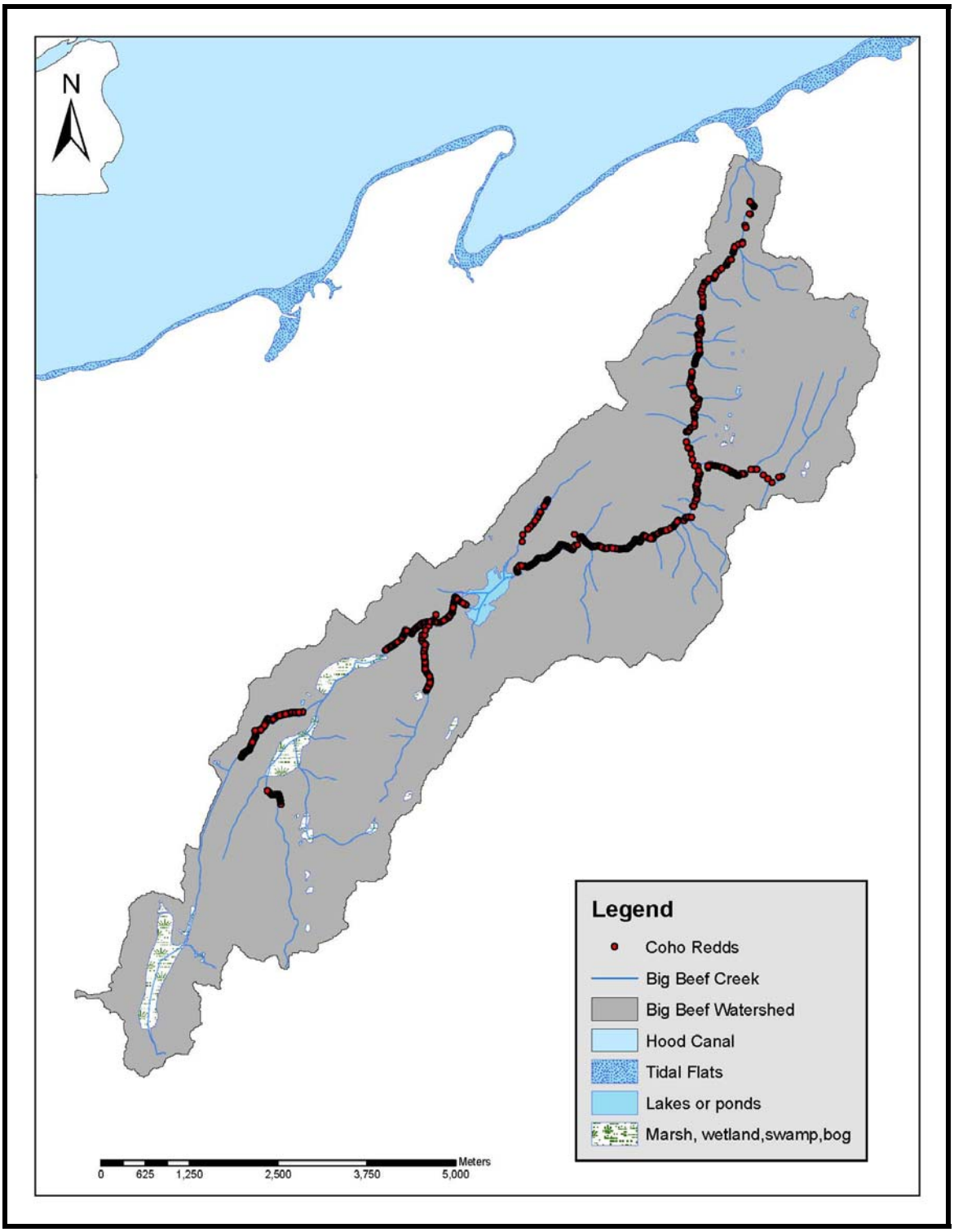

Figure 12. Distribution of all observed coho redds in Big Beef Creek, 2004.

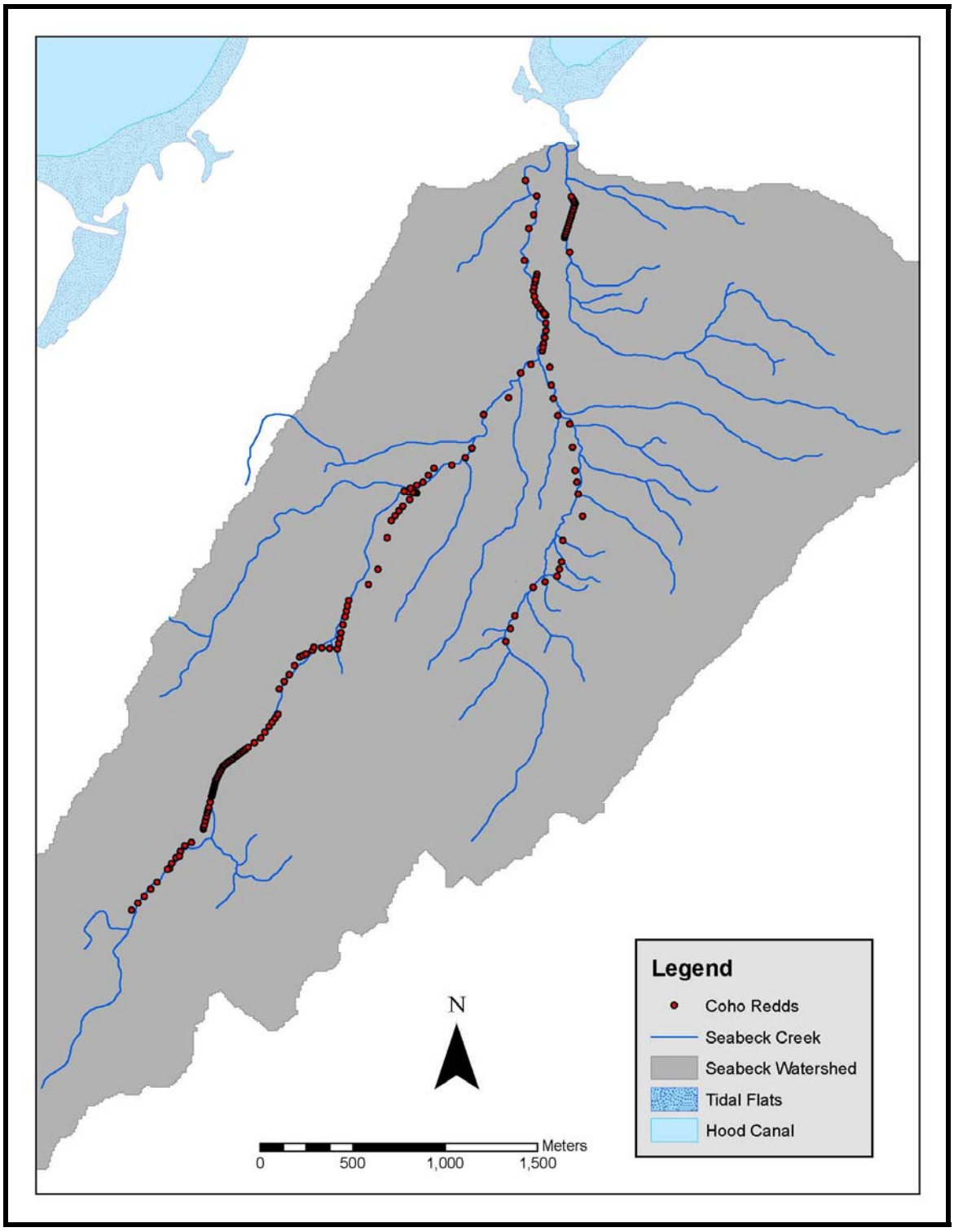

Figure 13. Distribution of all observed coho redds in the Seabeck Creek watershed, 2004.

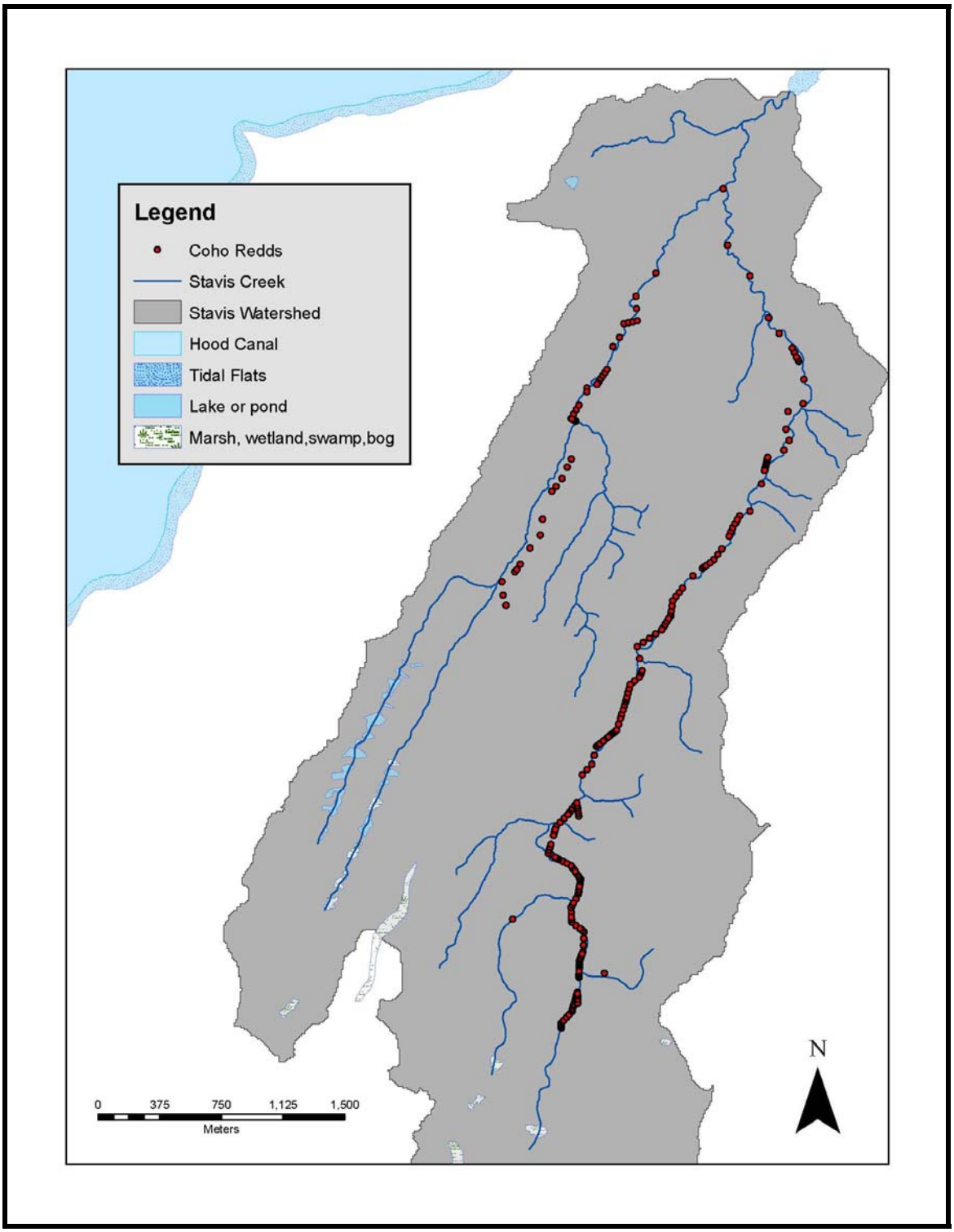

Figure 14. Distribution of all observed coho redds in the Stavis Creek watershed,2004.

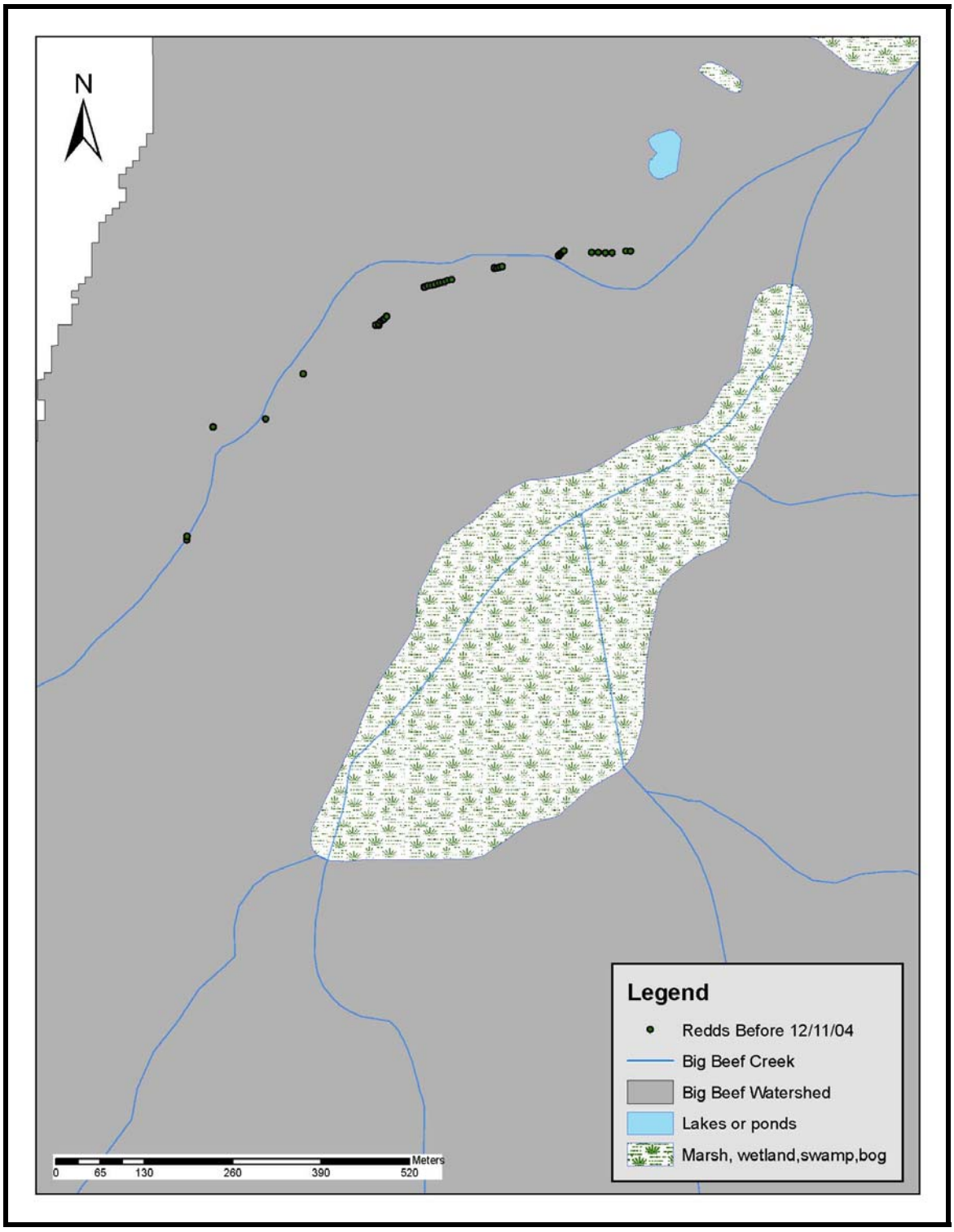

Figure 15. 2004 distribution of coho redds in upper Big Beef Creek and Big Beef Creek Tributary #31 prior to the December 11, 2004 flow event.

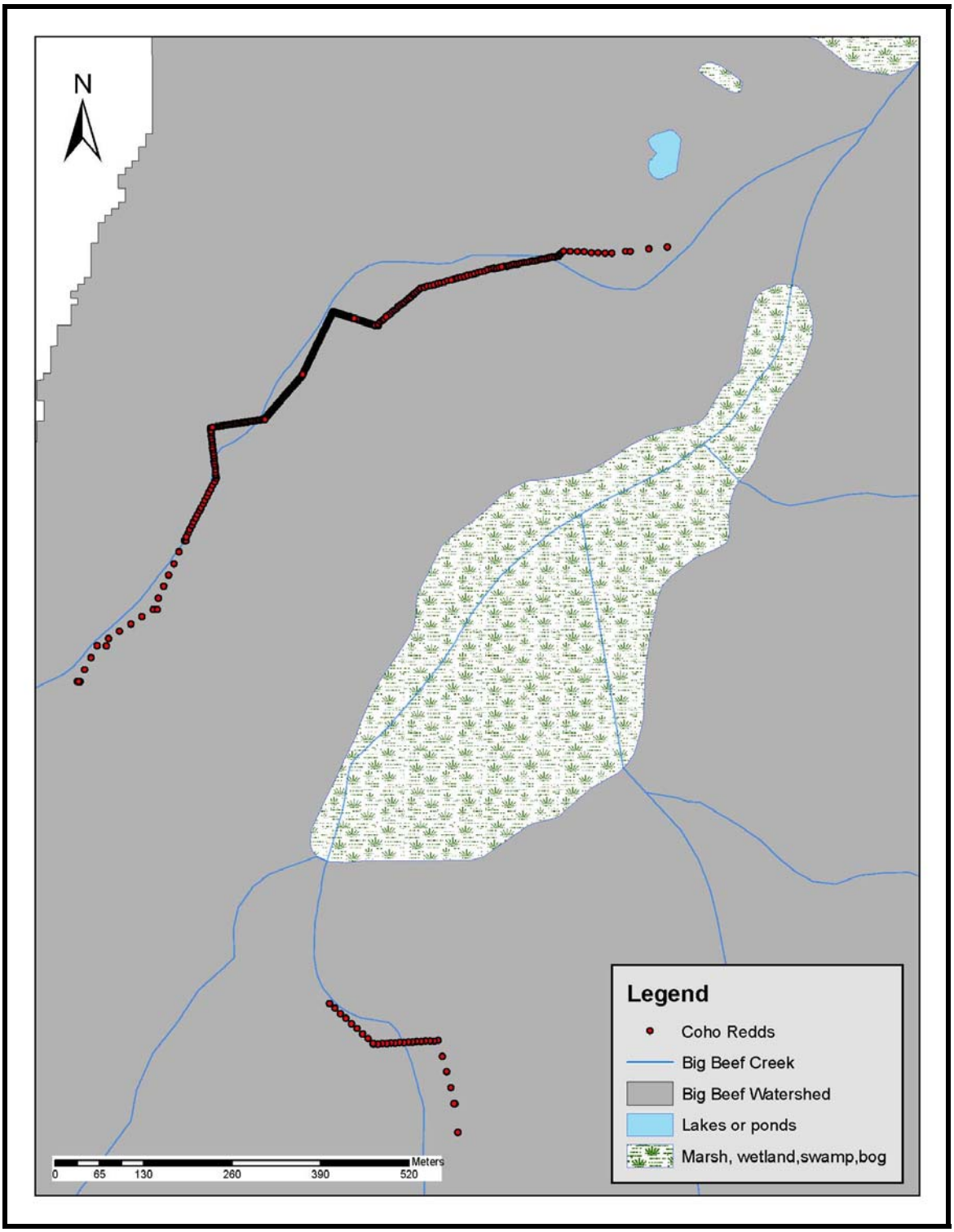

Figure 16. Distribution of all observed coho in upper Big Beef Creek and Big Beef Creek Tributary #31, 2004.

Coho Escapement Estimates: Hood Canal Tributaries

Survival-to-Return Rate Based Estimates

We estimated natural origin coho escapement to Stavis, Seabeck, and Little Anderson Creeks at 1,637, 329, and 51 adults, respectively (Table 19). These estimates were derived via applying the SRR for 2001-brood Big Beef Creek natural origin coho (21.1%) to the 2003 smolt migration estimates from Stavis, Seabeck, and Little Anderson Creeks. This approach assumes that natural origin coho returning to these tributaries have the same SRR as natural origin coho returning to Big Beef Creek.

Since hatchery fish were not excluded from these other streams, as in 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 97.0% (3,993 natural origin coho [Table 10]/4,115 total coho [Table 8]); yielding total escapement estimates of 1,687, 339, and 52 coho, respectively (Table 19).

Table 19. Escapement estimates for 2001-brood adult coho returning to Stavis, Seabeck, and Little Anderson Creeks in 2004, based on 2003 smolt migration estimates and preliminary estimated Big Beef Creek marine survival rates.

Stream	2001 Brood Smolt Migration Estimate	Big Beef Marine Survival	Estimated Natural Origin Escapement	Proportion of Returning Natural origin Coho in the Big Beef Escapement	Estimated Total Escapement
Stavis Creek	7,757	21.1%	1,637	97.0%	1,687
Seabeck Creek	1,565	21.1%	329	97.0%	339
Little Anderson Creek	240	21.1%	51	97.0%	52
TOTAL	9,562		1,989		2,050

Redd-Based Estimate

From observations, we estimated redd life averaged 14 days when Big Beef Creek discharge was less than 30cfs at the USGS gage, 7 days when discharge was between 30cfs and 100cfs, and 1 day when discharge was greater than 100cfs (Figure 6). We applied these redd life estimates to all four streams, assuming the bed altering capability observed at these discharge levels in Big Beef Creek were indicative of conditions in the other streams. Using this approach, we observed an estimated 1,532 redds in the four watersheds (Table 20). These estimates were expanded to account for periods when accessible stream segments were not sampled. This exercise estimated an additional 103 redds in the four watersheds. Assuming two spawners per redd, this estimates coho escapement at 570, 338, and 62 for Stavis, Seabeck, and Little Anderson Creeks, respectively (Table 20).

Redd-based estimates were similar to the Big Beef Creek SRR-based estimates in Little Anderson Creek and Seabeck Creek, but substantially lower than the SRR-based estimates in Big Beef Creek and Stavis Creek (Table 20).

Table 20. Comparison of redd-based and Big Beef Creek survival-to-return rate-based coho escapement estimates for Little Anderson, Big Beef, Seabeck, and Stavis Creeks, 2004.

Stream	Coho Redds			Redd-Based Escapement	BBC Survival-to-Rtn Based Escapement
	Observed	Estimated	Total		
L. Anderson	31	0	31	62	52
Big Beef	1,085	65	1,150	2,300	[a]3,973
Seabeck	167	2	169	338	339
Stavis	249	36	285	570	1,687
Total	1,532	103	1,635	3,270	6,051

[a] Big Beef escapement is a count of the adult coho passed upstream of the weir.

Size Analysis

We measured fork lengths on all unmarked adult coho sampled for scales, which included 255 males (larger than 45 cm), 6 males in the 35 cm to 45 cm size range, and 206 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 78 unmarked/untagged coho (48males and 30 females) and 380 unmarked/coded-wire tagged coho (205 males and 175 females) (Table 21).

Over the season, natural origin unmarked males were slightly larger than unmarked females, averaging 65.3 cm and 64.6 cm, respectively (Table 21). In comparing the size of males from untagged versus tagged groups, the tagged mean was slightly larger (65.5 cm and 63.9 cm). Untagged and tagged females means, however, were nearly identical over the season (64.8 cm and 64.6 cm). The smallest male in this sample was 37 cm, and the largest was 87 cm. The smallest female was 51 cm, while the largest was 78 cm (Table 21).

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 64 samples. Scale analysis determined that 6 were three-year-old males and 58 were two-year-old jacks. Of these, all of the adult males and 51 jacks were of natural origin. The remaining sample (excluded from Table 21) consisted of 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 2004 we measured one adult male at 37 cm. The largest jack was 43 cm.

Table 21. Mean fork length (cm), range, standard deviation, and sample rate of natural origin unmarked adult coho, by statistical week and sex, Big Beef Creek 2004.

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																
40	09/27	10/03	62.0	62	62	---	1	17	5.9%						6	
41	10/04	10/10	61.0	61	61	---	1	0	1.1%	62.3	57	66	4.73	3	70	4.3%
42	10/11	10/17	61.3	41	76	9.58	19	615	3.1%	63.7	60	69	4.73	3	525	0.6%
43	10/18	10/24	75.0	75	75	---	1	128	0.8%						135	
44	10/25	10/31	57.0	50	67	7.16	4	33	12.1%						28	
45	11/01	11/07	68.5	56	80	8.54	13	533	2.4%	65.5	57	75	4.19	20	646	3.1%
46	11/08	11/14						0							2	
47	11/15	11/14						20							17	
48	11/22	11/21						4							9	
49	11/29	12/05						3							6	
50	12/06	12/12	70.3	62	75	7.23	3	128	2.2%	63.3	54	69	8.14	3	204	1.5%
51	12/13	12/19	57.0	57	57	---	1	3	33.3%						4	
		Total	63.9	41	80	9.37	43	1,574	2.7%	64.8	54	75	4.60	29	1,652	1.8%
CWT'd/Unmarked																
40	09/27	10/03	64.3	54	73	7.85	4	11	36.4%						1	
41	10/04	10/10	62.4	43	73	7.85	18	18	100.0%	66.5	55	71	4.25	13	16	81.3%
42	10/11	10/17	62.8	37	81	8.35	96	130	73.8%	63.9	54	71	4.45	52	110	47.3%
43	10/18	10/24	66.1	52	74	5.94	16	31	51.6%	63.0	51	70	4.47	15	27	55.6%
44	10/25	10/31	73.0	73	73	---	1	11	9.1%	65.0	62	68	4.24	2	7	28.6%
45	11/01	11/07	70.1	43	87	7.65	56	118	47.5%	65.0	57	78	4.47	58	169	34.3%
46	11/08	11/14						0							2	
47	11/15	11/14						7		62.5	61	64	2.12	2	5	40.0%
48	11/22	11/21						2		61.0	61	61	---	1	1	100.0%
49	11/29	12/05						1							2	
50	12/06	12/12	70.9	61	78	5.14	8	49	16.3%	65.2	54	72	4.61	24	45	53.3%
51	12/13	12/19	79.0	79	79		1	6	16.7%						8	
		Total	65.5	37	87	8.48	200	384	52.1%	64.6	51	78	4.47	167	393	42.5%
Total Unmarked			**65.3**	**37**	**87**		**243**	**1.958**		**64.6**	**51**	**75**		**196**	**2.045**	

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 (1 untagged female, 5 untagged males, 8 tagged females and 5 tagged males).

Run Timing

Hatchery adult coho returning to Big Beef Creek exhibited an earlier migration timing than their natural-origin adult counterparts (Figure 17). The hatchery run reached 50% of its migration by September 27, while natural origin coho came in on October 30. Both runs were over by mid-December; hatchery coho completing their migration by December 6, whereas natural origin coho finished their migration over a week later, on December 15.

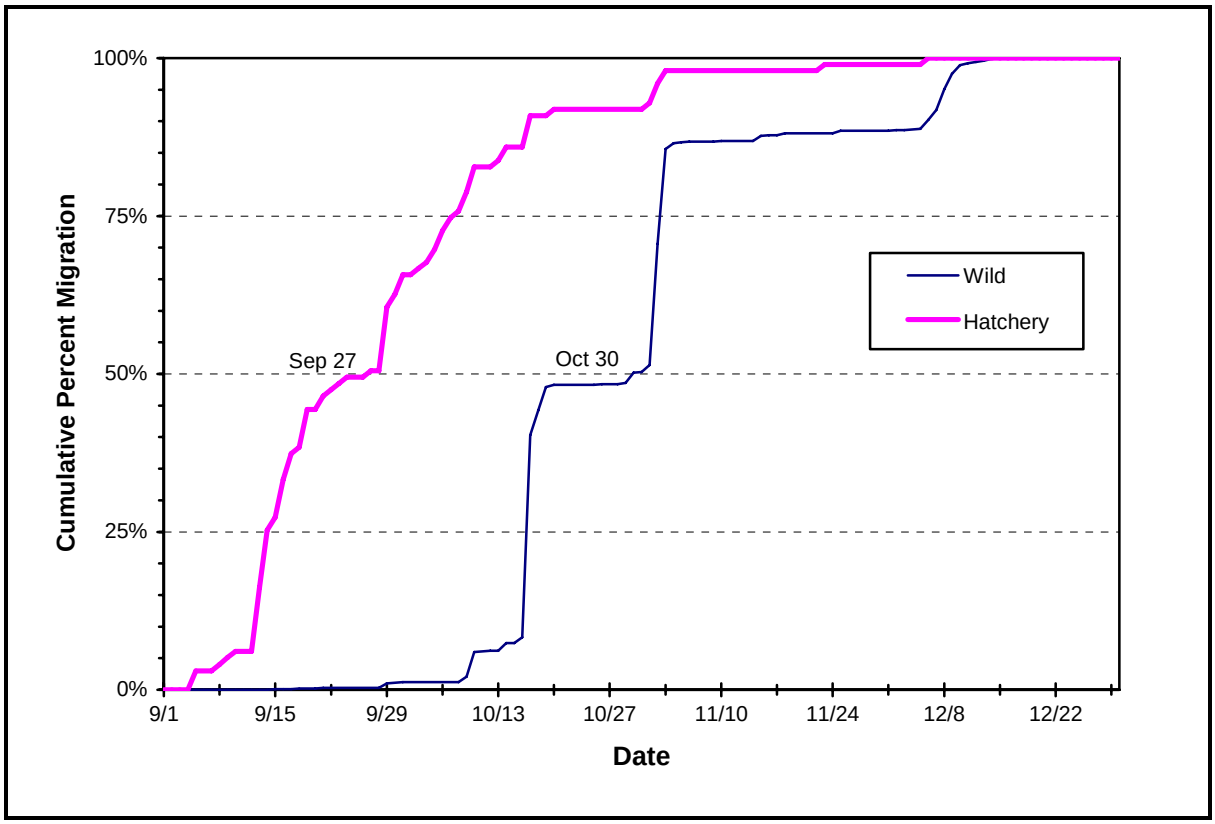

Figure 17. Migration timing of natural origin and hatchery adult coho returning to Big Beef Creek during September 1 through December 31, 2004.

Other Species

Chum

The chum return totaled 4,553 adults; 1,880 summer chum and 2,673 fall chum (Table 22). The first chum was captured on September 2 and the last on December 24 (Table 23). 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 (95.1% of the summer chum and 91.3% of the fall chum). A small percentage of summer (1.5%) and fall (8.2%) chum spawned below the weir. In addition, 3.4% of returning summer chum were transferred to the University of Washington's (UW) hatchery for artificial production. (Table 22).

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 22. Disposition of chum returning to Big Beef Creek, 2003.

Disposition		Male	Female	Total	Percent
Summer Chum	Released upstream unspawned	976	812	1,788	95.1
	Spawned below weir	snd	snd	29	1.5
	Transferred to hatchery	33	30	63	3.4
	Total Return Summer Chum	**1,009**	**842**	**1,880**	**100.0%**
Fall Chum	Released upstream unspawned	1,526	914	2,440	91.3
	Released into UW spawning channel unspawned	8	14	22	.8
	Spawned below weir	9	4	13	.4
	Total Return Fall Chum	67	131	198	7.4
TOTAL CHUM		**2,340**	**1,610**	**1,063**	**2,673**

Chinook

Returning chinook were transferred to the FRI hatchery for artificial propagation. Numbers of chinook captured and transferred to the hatchery during the 2004 season will be reported by the UW Fisheries Research Institute.

Steelhead

Four steelhead were captured in Fall 2004 (Table 23). However, this catch represents an unknown portion of the total steelhead return. We opened the weir on January 3, 2004, and it remained open through March 18, 2005, when we installed the downstream migrant traps.

Cutthroat

The first upstream migrating cutthroat trout was captured on September 7, and the last on December 26. In total, we captured and released upstream 28 males and 15 females (Table 23). As with steelhead, this is an unknown portion of the total return.

Table 23. 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**
08/30	09/05	36	35	22	**57**									
09/06	09/12	37	64	29	**93**							1	2	**3**
09/13	09/19	38	357	229	**586**							0	1	**1**
09/20	09/26	39	267	282	**549**							0	1	**1**
09/27	10/03	40	232	226	**458**				1	0	**1**	1	0	**1**
10/04	10/10	41	47	51	**98**									
10/11	10/17	42	7	3	**10**	0	4	**4**				2	0	**2**
10/18	10/24	43				7	4	**11**						
10/25	10/31	44				72	26	**98**						
11/01	11/07	45				406	154	**560**				3	2	**5**
11/08	11/14	46				502	330	**832**						
11/15	11/14	47				273	234	**507**				1	0	**1**
11/22	11/21	48				195	225	**420**				1	1	**2**
11/29	12/05	49				73	56	**129**				0	1	**1**
12/06	12/12	50				73	33	**106**				13	2	**15**
12/13	12/19	51				4	1	**5**				3	4	**7**
12/20	12/26	52				1	0	**1**	1	1	**2**	3	1	**4**
TOTAL			1,009	842	**1,851**	1,610	1,063	**2,673**	2	2	**4**	28	15	**43**

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 continued through 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;

$$\hat{R}_{fj} = \frac{C_{fj}}{T_{fj}} \qquad \textbf{Equation 2}$$

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;

$$V(\overline{R}_{fj}) = \frac{\sum (\hat{R}_{fj} - \overline{R}_{fj})^2}{n(n-1)} \qquad \textbf{Equation 3}$$

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;

$$V(\hat{C}_{uj}) = V(R_{fj})\hat{T}_{uj}^{\,2} \qquad \textbf{Equation 4}$$

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;

$$\hat{e}_i = \frac{r_i}{m_i} \qquad \textbf{Equation 5}$$

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;

$$V(\hat{e}_i) = \frac{\hat{e}_i(1-\hat{e}_i)}{m_i} \qquad \textbf{Equation 6}$$

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;

$$V(\hat{N}) = \hat{N}^2 \left(\frac{V(\overline{e})}{\overline{e}^2} + \frac{\sum V(\hat{C}_{uj})}{\left(\sum C_{fj} + \sum \hat{C}_{uj}\right)^2} \right) \qquad \textbf{Equation 7}$$

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. Where strata were defined that had only a single efficiency test and no variance could be calculated, the variance of a Peterson estimate was used to estimate the variance if the migration estimate over the stratum. 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 2 near rkm 0.64, in the same location utilized in 2003. At times, temporary 2.4-meter plywood weir panels were placed upstream of the trap to direct flow and fish into the trap and increase trap efficiency. We began fishing on April 3 at 1230 hours and continued fishing uninterrupted until trap removal on June 30, a total of 2,109 hours over 88 days. The trap was checked at least twice daily, depending on water and debris conditions.

Coho

Catch

On the first day of trapping, we captured 6 coho smolts. Daily catches increased through April, and peaked during the second week of May with a high catch of 133 on May 8. Catches remained steady, but gradually declined through the end of May. By the second week of June, the migration was virtually over, as catches averaged 1-2 migrants a day. A total of 2,180 coho smolts were caught over the trapping period.

Size

Average coho smolt fork lengths varied little throughout the trapping interval (Table 24, Figure 18). Size ranged from 84 mm to 153 mm, and averaged 112 mm over the season.

Table 24. Mean fork length (mm), standard deviation, range, and sample size of coho and steelhead smolts measured by statistical week, Abernathy Creek 2004.

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	04/04	04/04						6						2
15	04/05	04/11	101.3	9.8	88	128	16	42	174.7	26.7	139	210	6	23
16	04/12	04/18	115.4	13.9	84	137	48	105	178.7	18.4	151	226	21	59
17	04/19	04/25	113.9	14.4	92	137	21	240	175.4	10.3	163	210	20	150
18	04/26	05/02	117.3	12.0	92	153	35	155	167.1	16.3	134	209	34	166
19	05/03	05/09	112.3	11.0	84	131	45	428	158.9	15.2	137	200	38	394
20	05/10	05/16	111.6	9.6	90	145	45	479	159.8	14.0	126	200	48	229
21	05/17	05/23	111.9	9.9	96	139	55	333	154.9	13.7	130	186	45	162
22	05/24	05/30	110.7	11.1	96	139	30	266	154.6	12.1	134	173	12	60
23	05/31	06/06	109.8	8.2	97	128	36	84	150.6	11.7	129	172	20	30
24	06/07	06/13	110.7	11.1	97	125	6	35	147.0	12.9	136	169	5	9
25	06/14	06/20						7	140.7	13.3	132	156	3	4
26	06/21	06/27						0	141.0	2.8	139	143	2	2
27	06/28	07/01						0						0
Season Totals			112.3	11.5	84	153	337	2,180	162.0	17.4	126	226	264	1,290

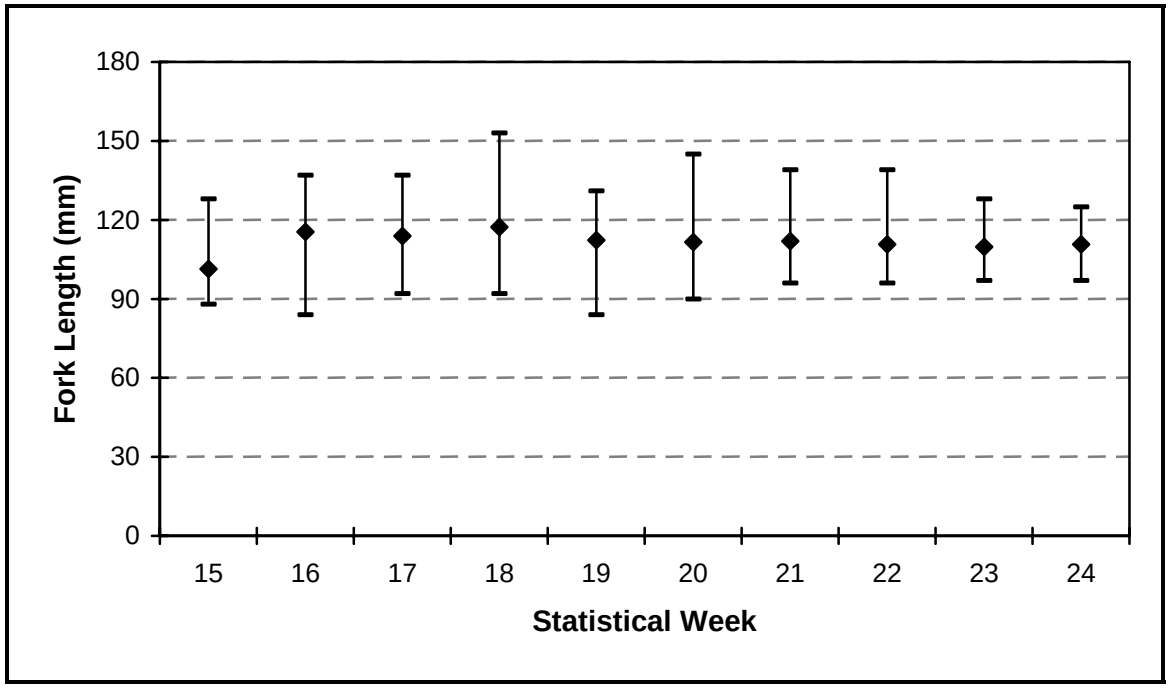

Figure 18. Weekly average, minimum, and maximum coho smolt fork lengths (mm) measured at the Abernathy Creek screw trap, 2004.

Trap Efficiency

A total of 1,601 coho in 50 groups were marked and released upstream of the trap. The number of fish released in each group ranged from four to 72 smolts. The final mark release group consisted of two releases, on June 8 and 11, consisting of five total smolts. This group was omitted from the analysis because we had little confidence in the accuracy of the results from this test given the small group size. Recapture rates were not calculated for individual releases due to their small size and the protracted migration timing observed in some of the marked fish. Efficiency tests were grouped by mark type and trapping interval, based on changes made to the trap structure or trap position.

Five strata were developed for the analysis. During the first period, April 4-14 (Stratum 1), we only conducted one efficiency test, measuring 11%. To concentrate flow and increase water velocity at the trap, we added another starboard weir panel to the existing row leading upstream to the left bank. From April 15 through May 4 (Stratum 2), grouped trap efficiency tests ranged from 10.4% to 45.7%, and averaged 33.5%. We then added a fourth starboard panel to the existing left bank row and one port side panel along the right bank. From May 5- 28 (Stratum 3), grouped trap efficiency tests ranged from 27% to 49%, and averaged 40.2%. Following heavy rain showers on May 27-28, stream flow increased and inundated the panels. The port panel and two starboard panels were removed to accommodate the rise in water. From May 29 through June 2 (Stratum 4), grouped trap efficiency tests decreased, averaging 19.7%. Panels were reinstalled and remained through the season. From June 3 till the end (Stratum 5), grouped trap efficiency tests ranged from 38% to 47%, and averaged 42.7% (Table 25).

Mean trap efficiencies between adjacent groups (Stratums 2 – 5) were tested using a z-test for comparing two means and found to be significantly different ($\alpha = 0.05$). Therefore, we used all five strata in estimating migration past the trap.

Production Estimate

Total coho production was estimated at 6,448 smolts with a coefficient of variation of 7.4% and a 95% confidence interval of 5,515 to 7,381 smolts (Figure 19). This estimate is based on our catch estimate of 2,180 migrants and the estimated average trap efficiency for each trap position.

Table 25. Grouped capture efficiency tests for coho smolts by trap position, Abernathy Creek 2004.

Trap Position	Dates		# Marked		Trap Efficiency
	Release	Recapture	Released	Recaptured	
Stratum 1	4/13	4/15	9	1	11.1%
	Sum		9	1	
	Average				11.1%
	Variance				
	n				1
Stratum 2	4/15-4/17	4/16-4/18	65	18	27.7%
	4/18-4/21	4/19-4/22	69	27	39.1%
	4/22-4/23	4/23-4/24	105	48	45.7%
	4/24-4/25	4/25-4-26	77	34	44.2%
	4/26-4/27	4/27-4/30	51	18	35.3%
	4/28-4/29	4/29-5/2	40	17	42.5%
	4/30-5/1	5/1-5/2	48	5	10.4%
	5/2-5/3	5/3-5/7	30	7	23.3%
	Sum		485	174	
	Average				33.5%
	Variance				1.88E-03
	n				8
Stratum 3	5/4-5/5	5/5-5/6	56	25	44.6%
	5/6-5/7	5/7-5/8	138	62	44.9%
	5/8-5/9	5/9-5/10	117	57	48.7%
	5/10-5/11	5/11-5/14	114	51	44.7%
	5/12-5/15	5/13-5/16	94	28	29.8%
	5/16-5/18	5/17-5/20	93	25	26.9%
	5/19-5/20	5/20-5/21	79	30	38.0%
	5/21-5/22	5/22-5/24	88	43	48.9%
	5/23-5/24	5/24-5/26	87	39	44.8%
	5/25-5/26	5/26-5/29	81	25	30.9%
	Sum		947	385	
	Average				40.2%
	Variance				6.75E-04
	n				10
Stratum 4	5/29-5/30	5/30-5/31	54	11	20.4%
	5/31-6/1	6/1-6/2	42	8	19.0%
	Sum		96	19	
	Average				19.7%
	Variance				4.90E-05
	n				2
Stratum 5	6/2-6/3	6/3-6/4	17	8	47.1%
	6/4-6/7	6/5-6/8	47	18	38.3%
	Sum		64	26	
	Average				42.7%
	Variance				1.94E-03
	n				2

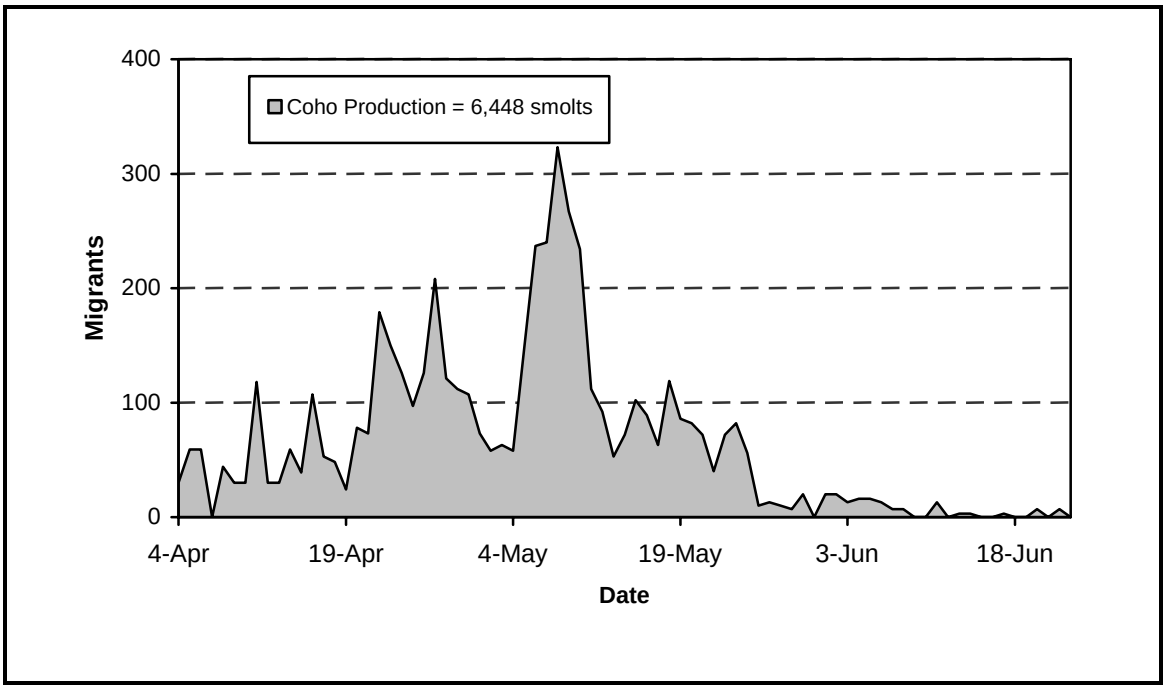

Figure 19. Estimated daily and seasonal coho smolt migration, Abernathy Creek screw trap 2004.

Steelhead and Cutthroat

Catch

On the first day of trapping we captured two steelhead and zero cutthroat smolts. The steelhead catches gradually increased through April, and peaked during the second week of May, with a high catch of 98 smolts on May 8. By June, the catches averaged less than 5 per day, with zero catch after June 22. The first cutthroat smolt was caught on the second day of trapping and the last on June 24. The catch peaked on May 8 when 11 smolts were caught. Catches remained steady through late May. A total of 1,290 wild steelhead and 190 cutthroat smolts were caught throughout the trapping period.

In addition to wild smolts, we captured 4,109 hatchery-reared steelhead smolts. All of the hatchery steelhead smolts were adipose marked. In addition, some fish were coded-wire tagged (CWT), or tagged with a passive integrated transponder (PIT) tags, or both. Out the total hatchery steelhead captured, we estimate 261 were Ad+PIT tagged, 1 was an unmarked hatchery PIT tag, 1 was an unmarked-untagged hatchery smolt, 3,832 were Ad+CWT'd, and 14 were hatchery unmarked CWT'd. Unmarked hatchery steelhead were most likely holdovers from the 2003 release.

Size

Average wild steelhead fork lengths decreased slightly during the trapping interval (Figure 20). Sizes of wild steelhead ranged from 126 mm to 226 mm, and averaged 162 mm over the season (Table 24). Only five cutthroat fork lengths were recorded during the trapping season. Sizes ranged from 135mm to 216mm and averaged 171mm.

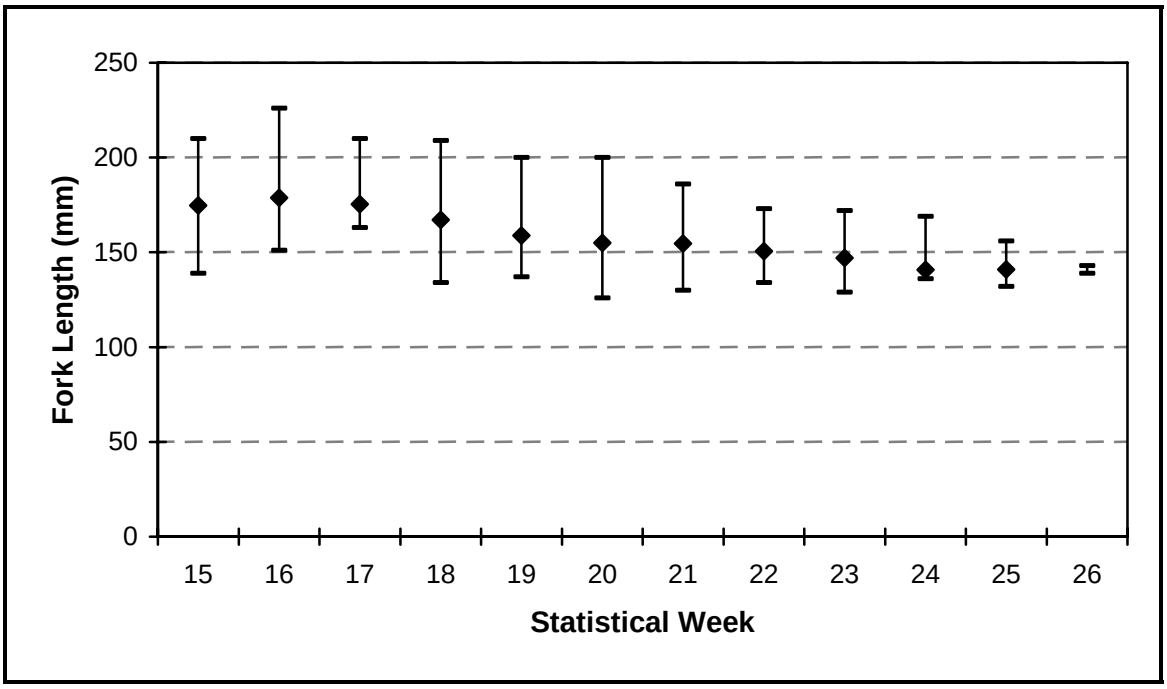

Figure 20. Weekly average, minimum, and maximum natural origin steelhead smolt fork lengths (mm) measured at the Abernathy Creek screw trap, 2004.

Trap Efficiency

A total of 734 wild steelhead in 40 groups were marked and released upstream of the trap. The number of steelhead released in each group ranged from two to 59 smolts. Recapture rates were not calculated for individual releases due to small release sizes and protracted migration. Releases and recoveries were pooled by mark type and trap position. Three efficiency strata were developed for the analysis. While stratums 1 and 2 were applied to the same time periods as coho stratums 1 and 2, steelhead stratum 3 encompassed coho stratums 3, 4, and 5. During the first period, April 4-14 (Stratum 1), no mark groups were released due to low steelhead catches. Instead we applied a rate of 6.8%, which was the ratio measured between the coho efficiency rates in Strata 1 and Strata 2 times that measured in Strata 2 for steelhead. From April 15- May 4 (Stratum 2), grouped trap efficiency tests ranged from 16% to 30%, and averaged 21%. From May 5- 28 (Stratum 3), grouped trap efficiency tests ranged from 16% to 42%, and averaged 30% (Table 26).

In addition to the marked releases described above, a total of 169 wild steelhead smolts were PIT tagged and released above a PIT tag antennae maintained by the USFWS Abernathy Fish Technology Center at approximately RM 1.8. These fish were released in 41 groups during the trapping season. Overall trap efficiency for the wild PIT tagged smolts was 22.5%, estimated from 39 of 169 PIT tagged smolts recaptured at the trap. This independent estimate of trap efficiency is similar to the combined season average efficiency (24.6%) estimated with the fin clipped steelhead

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.

A total of 150 wild cutthroat smolts were PIT tagged and released in 48 groups above a PIT tag antennae array maintained by the USFWS Abernathy Fish Technology Center at approximately RM 1.8. Overall cutthroat trap efficiency was 37.3%, estimated from 56 PIT tagged smolts recaptured at the trap. Since 96% of the PIT tagged cutthroat were recaptured during the steelhead interval defined as Stratum 3 above (30% avg.), this independent test of efficiency is within the range of that used for steelhead.

Table 26. Trap efficiency tests using steelhead smolts grouped by trap position, Abernathy Creek 2004.

Trap Position	Dates		# Marked		Trap
	Release	Recapture	Released	Recaptured	Efficiency
Stratum 2	4/16-4/17	4/17-4/18	14	4	28.6%
	4/18-4/21	4/19-4/21	32	4	12.5%
	4/22-4/23	4/23-4/24	52	5	9.6%
	4/24-4/25	4/25-5/2	34	9	26.5%
	4/26-4/27	4/27-4/28	44	7	15.9%
	4/28-4/29	4/29-4/30	32	5	15.6%
	4/30-5/1	5/2-5/5	10	3	30.0%
	5/2-5/3	5/2-5/9	19	5	26.3%
	Sum		237	42	
	Average				20.6%
	Variance				0.00081
	n				8
Stratum 3	5/4-5/5	5/5-5/6	38	9	23.7%
	5/6-5/7	5/7-5/13	102	41	40.2%
	5/8-5/9	5/9-5/13	108	44	40.7%
	5/10-5/11	5/11-5/16	65	19	29.2%
	5/14-5/15	5/15-5/16	36	7	19.4%
	05/18	5/19-5/25	25	8	32.0%
	5/19-5/20	5/20-5/21	33	13	39.4%
	05/21	5/22-6/1	19	8	42.1%
	5/23-5/24	5/24-5/28	37	6	16.2%
	5/25-6/11	5/26-6/15	34	7	20.6%
	Sum		497	162	
	Average				30.4%
	Variance				0.000986
	n				10

Production Estimates

During the period of screw trap operation, we estimated that 5,238 wild steelhead and 733 cutthroat smolts passed the trap. The steelhead estimate has a coefficient of variation of 7.6% and a 95% confidence interval of 4,461 to 6,015 smolts (Figure 21). The cutthroat production

estimate has a coefficient of variation of 7.8% and a 95% confidence interval of 621 to 845 smolts (Figure 21). These estimates reflect migration during the trapping period only. Whereas nearly the entire wild steelhead migration was sampled, cutthroat did not exhibit a migration trend. An unknown portion of the cutthroat migration may have occurred outside of the trapping interval.

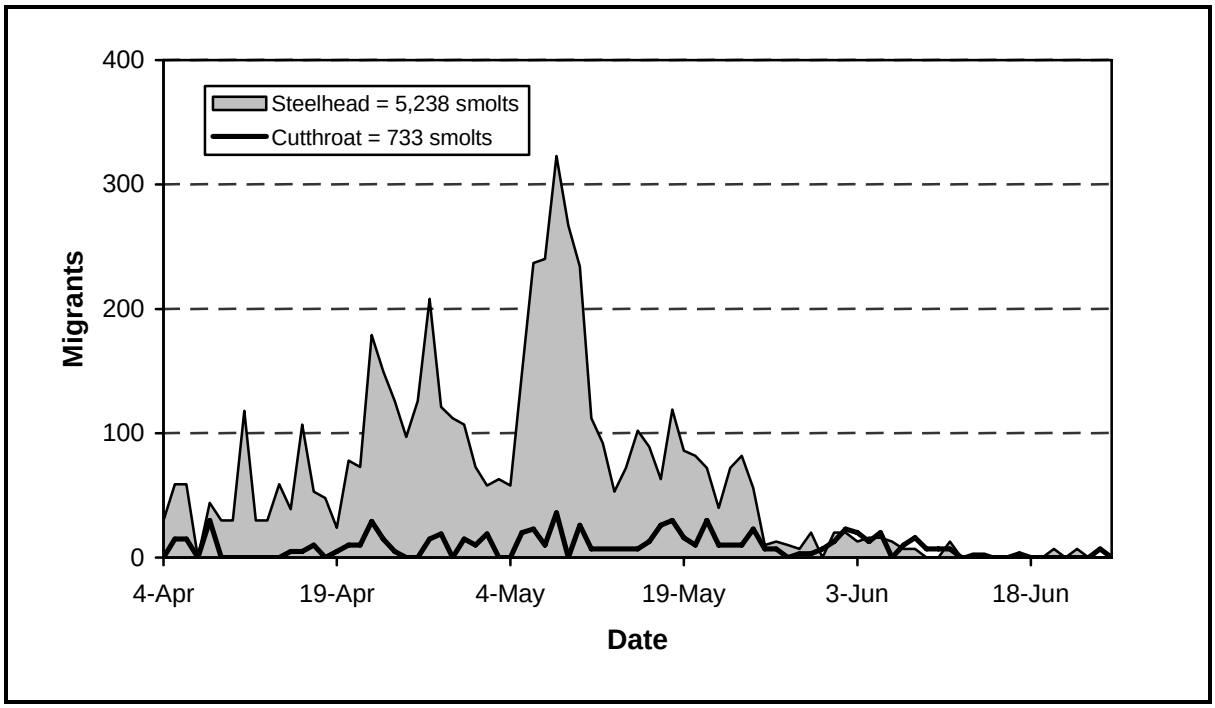

Figure 21. Estimate of daily natural origin steelhead and cutthroat smolt migrations, Abernathy Creek 2004.

Germany Creek

The screw trap was installed on April 3 at RM 0.3 and began fishing at 1600 hours. The trap was checked at least twice a day, depending on flow conditions and debris loads. It was operated continuously throughout the season, except for two periods. On April 20, a log stopped the screw for 9.7 hours and on June5-6 the trap was pulled for 26.5 hours due to extremely high catches of peamouth (*Mylocheilus caurinus*), a species of minnow abundant in the Lower Columbia River. We initially tried to operate the trap in the same location used in previous years. However, changes in the channel bed morphology and flow patterns made this site unsuitable and the trap was relocated upstream on April 5. Only occasional minor position adjustments to the trap were necessary through the rest of the season, and only minimal changes were measured in overall trap efficiency. The trap was removed on the morning of June 30.

Coho

Catch

Coho began entering the trap on the second day of operation, with the capture of 6 smolts. Catches increased throughout April and peaked on May 13 when 167 smolts were caught. Daily catches then gradually decreased through May and by mid-June the migration was virtually over. A total of 2,890 coho smolts were caught throughout the trapping period.

Size

Average coho smolt fork length varied little throughout the trapping interval (Table 27,Figure 22). Size ranged from 85mm to 145mm, and averaged 114mm over the season.

Table 27. Mean fork length (mm), standard deviation, range, and sample size of coho smolts measured by statistical week, Germany Creek 2004.

Statistical Week			Average	s.d.	Range		Number	
#	Begin	End			Min	Max	Sampled	Caught
14	04/03	04/04					0	6
15	04/05	04/11	105.3	11.44	85	131	17	55
16	04/12	04/18	113.7	14.08	88	145	25	50
17	04/19	04/25	110.5	11.91	93	132	11	98
18	04/26	05/02	115.3	9.97	96	134	44	164
19	05/03	05/09	117.8	8.73	90	134	45	460
20	05/10	05/16	116.5	8.03	100	135	55	1,002
21	05/17	05/23	115.4	7.58	97	133	50	612
22	05/24	05/30	110.5	7.86	94	127	40	354
23	05/31	06/06	114.4	8.54	97	132	30	61
24	06/07	06/13	112.5	6.94	99	123	18	22
25	06/14	06/20					0	6
26	06/21	06/27						0
27	06/28	07/01						0
Season Totals			**114.3**	**9.58**	**85**	**145**	**335**	**2,890**

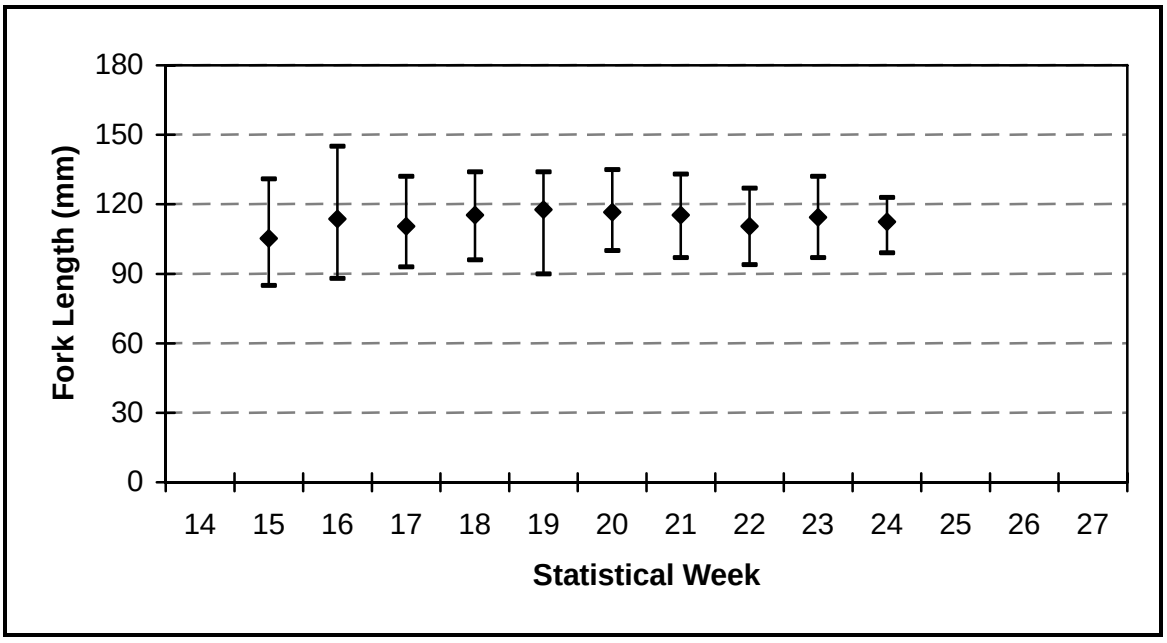

Figure 22. Weekly average, minimum, and maximum coho smolt fork lengths (mm) measured at the Germany Creek screw trap, 2004.

Trap Efficiency

A total of 1,608 coho were marked and released upstream of the trap on 56 days. The number of fish released each day ranged from one to 60 smolts. Recapture rates were not calculated for individual releases due to the small size of the release groups and due to the protracted migration timing exhibited by some of the test fish. For example, on two occasions, marked smolts were caught 7 days after being released. Efficiency tests were grouped by mark type. For the most part, trap movements throughout the season were minor and did not affect trap efficiency. However, one position change occurring on April 30, resulted in a higher overall efficiency. The average of trap efficiency occurring after this position change were found to be significantly different ($\alpha = 0.05$) from the average before this change using a z-test for comparing two means. Therefore, two trap position strata were developed. Trap efficiency tests conducted during Stratum 1 (through April 30), ranged from 31% to 56.1% and averaged 41.2%; whereas those occurring in Stratum 2 (after April 30) ranged from 48.4% to 82.5% and averaged 60.5% (Table 28). We believe one mark group, released June 2-5 was effected by the trap outage that occurred between June 5-6. This efficiency test was omitted from the analysis.

Production Estimate

Total coho production is estimated to be 5,062 smolts with a coefficient of variation of 3.4% and a 95% confidence interval of 4,728 to 5,396 smolts (Figure 23). This estimate is based on our expanded catch estimate of 2,915 migrants and the estimated average trap efficiency for each of the two trap positions. Although a few smolts were possibly already migrating at the beginning of trap operation, we believe the number to be minimal and no additional smolts were estimated outside this period.

Table 28. Grouped capture efficiency tests for coho smolts by mark type, Germany Creek 2004.

Efficiency Stratum	Dates		# Marked		Trap Efficiency
	Release	Recapture	Released	Recaptured	
Stratum 1	04/10-04/15	04/11-04/17	37	15	40.5%
	04/16-04/20	04/17-04/21	38	17	44.7%
	04/22-04/23	04/23-04/28	41	23	56.1%
	04/24-04/25	04/25-04/28	18	7	38.9%
	04/26-04/27	04/27-05/03	64	23	35.9%
	04/28-04/29	04/29-05/01	29	9	31.0%
	Sum		227	94	
	Average				41.2%
	Variance				1.2E-03
	n				6
Stratum 2	04/30-05/01	05/01-05/08	25	14	56.0%
	05/02-05/03	05/03-05/04	64	42	65.6%
	05/04-05/05	05/05-05/12	59	29	49.2%
	05/06-05/07	05/07-05/14	104	59	56.7%
	05/08-05/09	05/09-05/10	120	64	53.3%
	05/10-05/11	05/11-05/14	95	58	61.1%
	05/12-05/14	05/13-05/20	105	67	63.8%
	05/15-05/16	05/16-05/22	110	68	61.8%
	05/17-05/18	05/18-05/20	100	62	62.0%
	05/19-05/21	05/20-05/23	100	59	59.0%
	05/22-05/23	05/23-05/25	100	80	80.0%
	38496	05/25-05/28	50	27	54.0%
	05/25-05/26	05/26-05/31	63	52	82.5%
	05/27-05/28	05/28-06/03	100	60	60.0%
	05/29-05/30	05/30-05/31	100	56	56.0%
	05/31-06/01	06/01-06/02	31	15	48.4%
	06/07-06/13	06/08-06/14	32	19	59.4%
	Sum		986	623	
	Average				60.5%
	Variance				4.9E-04
	n				17

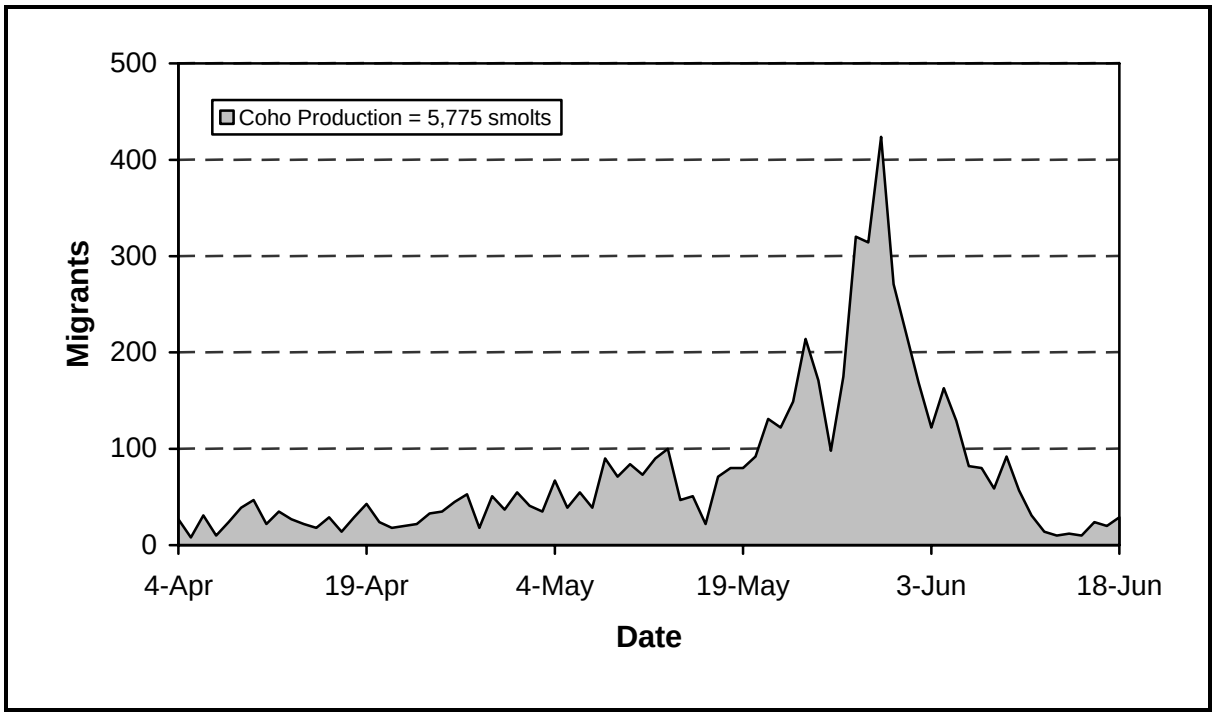

Figure 23. Estimate of daily coho smolt migration, Germany Creek screw trap 2003.

Steelhead and Cutthroat

Catch

No steelhead or cutthroat smolts were captured during the first day of trapping. The following day, we caught six steelhead and their catches continually increased through April, and peaked on May 7 when 107 smolts were caught. Cutthroat catch peaked on May 12, when 9 smolts were caught. After the peak, catches of both species declined through the end of the trapping season. A total of 2,504 steelhead and 165 cutthroat smolts were caught throughout the trapping period.

Size

Average steelhead fork lengths increased slightly during the beginning of trapping interval and then declined toward the end of the trapping period (Table 29, Figure 24). Steelhead fork lengths ranged from 120 mm to 237 mm, and averaged 166 mm over the season. Cutthroat fork lengths ranged from 142 mm to 232 mm, and averaged 164.4 mm over the season (Table 29).

Table 29. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of steelhead and cutthroat smolts measured by statistical week, Germany Creek 2004.

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	04/03	04/04						5						0
15	04/05	04/11	164.9	32.484	120	225	23	155	239.7	78.932	184	330	3	5
16	04/12	04/18	173.6	23.193	122	230	42	231	168.0	49.497	133	203	2	2
17	04/19	04/25	181.3	20.575	141	237	21	392	207.5	24.692	158	243	11	12
18	04/26	05/02	174.1	15.718	132	212	45	516	203.9	32.093	156	272	16	21
19	05/03	05/09	162.3	12.901	136	191	45	516	186.5	17.468	172	217	8	13
20	05/10	05/16	158.6	13.151	132	191	49	436	181.3	28.043	100	243	22	30
21	05/17	05/23	158.1	12.143	130	189	46	178	183.9	18.465	144	220	25	43
22	05/24	05/30	159.5	14.696	130	198	43	58	185.0	16.531	157	215	15	19
23	05/31	06/06	149.4	11.067	130	165	10	10	212.0	41.213	165	268	5	6
24	06/07	06/13	142.0	11.314	134	150	2	2	177.5	24.486	142	233	12	12
25	06/14	06/20	141.0	5.6569	132	146	5	5	208.0		208	208	1	2
26	06/21	06/27						0	183.0		183	183	1	0
27	06/28	07/01						0						0
Season Total			**164.4**	**19.2**	**120**	**237**	**331**	**2,504**	**190.4**	**29.3**	**100**	**330**	**121**	**165**

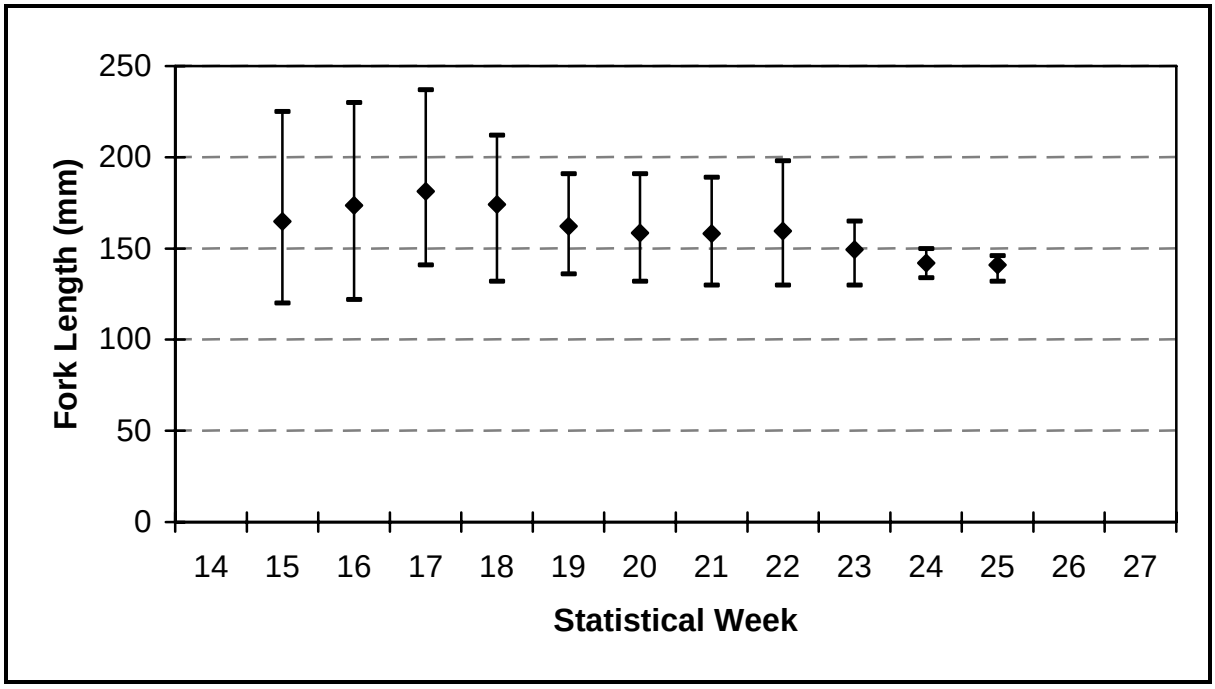

Figure 24. Weekly average, minimum, and maximum steelhead smolt fork lengths (mm) measured at the Germany Creek screw trap, 2003.

Trap Efficiency

A total of 2,053 steelhead were marked and released upstream of the trap over 55 days. The number of fish released in each group ranged from one to 78 smolts. Recapture rates were not calculated for individual releases due to the small size of some release groups and the protracted migration timing observed in some of the marked fish. On two occasions, marked smolts were caught seven days after being released. As with coho salmon, little variation in trap efficiency was observed as a result of minor adjustments in the trap's position. However, after a moderate rain event on May 7, capture efficiency increased in response to increased water flow and velocity. Mean trap efficiencies calculated from tests conducted before and after this event were significantly different ($\alpha = 0.05$) using a z-test for comparing 2 means. Therefore, two efficiency strata.were used to estimate steelhead migration past the trap. Trap efficiency tests conducted from the start of the season through May 7 (Stratum 1) ranged from 18% to 40% and averaged 30.3%. Tests conducted from the May 8 through the end of the season (Stratum 2) ranged from $40% to 79% and averaged 55.9% (Table 30). The last mark group, totaling 4 smolts, released June 5-11 was excluded from the analysis, since this test was effected by the trap outage occurring on June 5-6..

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 7,426 smolts with a coefficient of variation of 4.9% and a 95% confidence interval of 6,707 to 8,145 smolts (Figure 25). Total cutthroat production is estimated at 395 smolts with a coefficient of variation of 4.1% and a 95% confidence interval of 363 to 427 smolts (Figure 25). This estimate is based on our expanded catch estimate of 2,530 steelhead and 167 cutthroat migrants (includes estimated catch during trap outages), and the estimated average trap efficiency for each of the two trap positions. As few smolts were migrating at the beginning of trap operation, wee estimated no additional smolts outside the period trapped.

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.

Table 30. Trap efficiency tests using steelhead smolts grouped by mark type, Germany Creek 2004.

Efficiency Stratum	Dates		# Marked		Trap Efficiency
	Release	Recapture	Released	Recaptured	
Stratum 1	04/08-04/12	04/09-04/18	133	54	40.6%
	04/13-04/15	04/14-04/21	95	22	23.2%
	04/16-04/17	04/17-04/22	82	29	35.4%
	04/18-04/21	04/19-04/28	107	34	31.8%
	04/22-04/23	04/23-04/29	112	37	33.0%
	04/24-04/25	04/25-04/26	124	34	27.4%
	04/26-04/27	04/27-05/01	114	38	33.3%
	04/28-04/29	04/28-04/30	104	19	18.3%
	04/30-05/01	05/01-05/08	122	31	25.4%
	05/02-05/03	05/03-05/06	153	47	30.7%
	05/04-05/05	05/09-05/10	121	37	30.6%
	05/06-05/07	05/07-05/15	117	40	34.2%
	Sum		1,384	422	
	Average				30.3%
	Variance				3.0E-04
	n				12
Stratum 2	05/08-05/09	05/09-05/17	120	59	49.2%
	05/10-05/11	05/11-05/14	105	42	40.0%
	05/12-05/14	05/13-05/21	100	58	58.0%
	05/15-05/16	05/16-05/19	96	48	50.0%
	05/17-05/18	05/18-05/22	75	40	53.3%
	05/19-05/21	05/25-05/28	68	32	47.1%
	05/22-05/23	05/23-05/24	34	23	67.6%
	05/24	05/25	11	7	63.6%
	05/25-05/26	05/26-05/27	25	15	60.0%
	05/27-05/28	05/28-06/03	14	11	78.6%
	05/29-06/02	05/30-06/03	17	8	47.1%
	Sum		665	343	
	Average				55.9%
	Variance				1.1E-03
	n				11

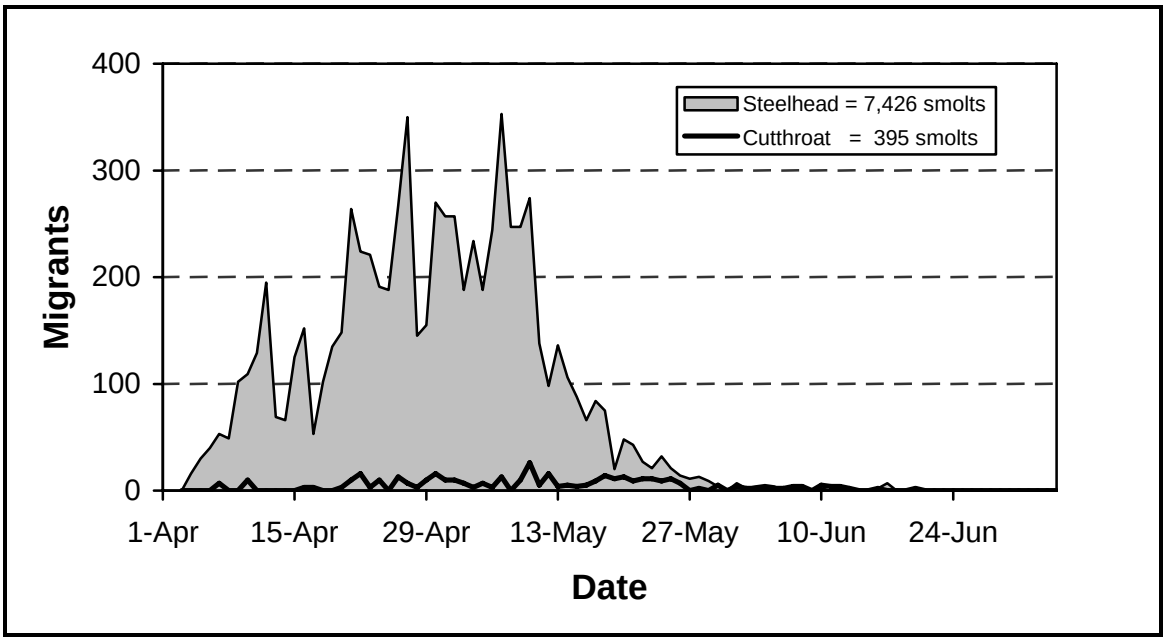

Figure 25. Estimate of daily steelhead and cutthroat smolt migrations, Germany Creek 2004.

Mill Creek

The screw trap was installed on April 3 at rkm 0.5 at the same site used in the previous two years, and began fishing at 1030 hours. The trap was checked at least twice a day, and fished continuously throughout the 89 day season. To direct flow into the trap, we placed fence posts and screened weir panels above the trap, angled upstream to each bank. This helped increase the speed of the screw and overall capture efficiency. This setup remained the same throughout the year, until the trap was removed on the morning of June 30.

Coho

Catch

On the first day of trapping, we captured two coho smolts. Catches steadily increased peaking on May 29 when 148 smolts were caught. Daily catches then decreased, averaging less than three smolts per day by mid-June. None were caught after June 18. A total of 3,507 coho smolts were caught throughout the trapping season.

Size

Average coho smolt fork length increased slightly in the beginning of the season, and again late in the season, but varied little during mid season. (Table 31, Figure 26). Fork lengths ranged from 81 mm to 152 mm, and averaged 110.5 mm over the season.

Table 31. Mean fork length (mm), standard deviation, range, and sample size of coho smolts measured by statistical week, Mill Creek 2004.

Statistical Week			Average	s.d.	Range		Number	
#	Begin	End			Min	Max	Sampled	Caught
14	04/03	04/04						2
15	04/05	04/11	102.5	9.50	84	121	18	54
16	04/12	04/18	110.9	13.21	83	152	40	184
17	04/19	04/25	111.9	7.04	99	123	30	311
18	04/26	05/02	106.6	10.19	81	130	45	359
19	05/03	05/09	109.9	9.67	93	141	35	566
20	05/10	05/16	111.0	8.95	95	129	55	620
21	05/17	05/23	106.3	8.52	88	123	55	444
22	05/24	05/30	113.5	9.29	95	140	50	677
23	05/31	06/06	114.9	11.57	92	138	51	228
24	06/07	06/13	114.1	9.93	93	128	26	50
25	06/14	06/20	119.0	4.24	116	122	2	12
26	06/21	06/27						
27	06/28	07/01						
Season Totals			**110.5**	**10.41**	**81**	**152**	**407**	**3,507**

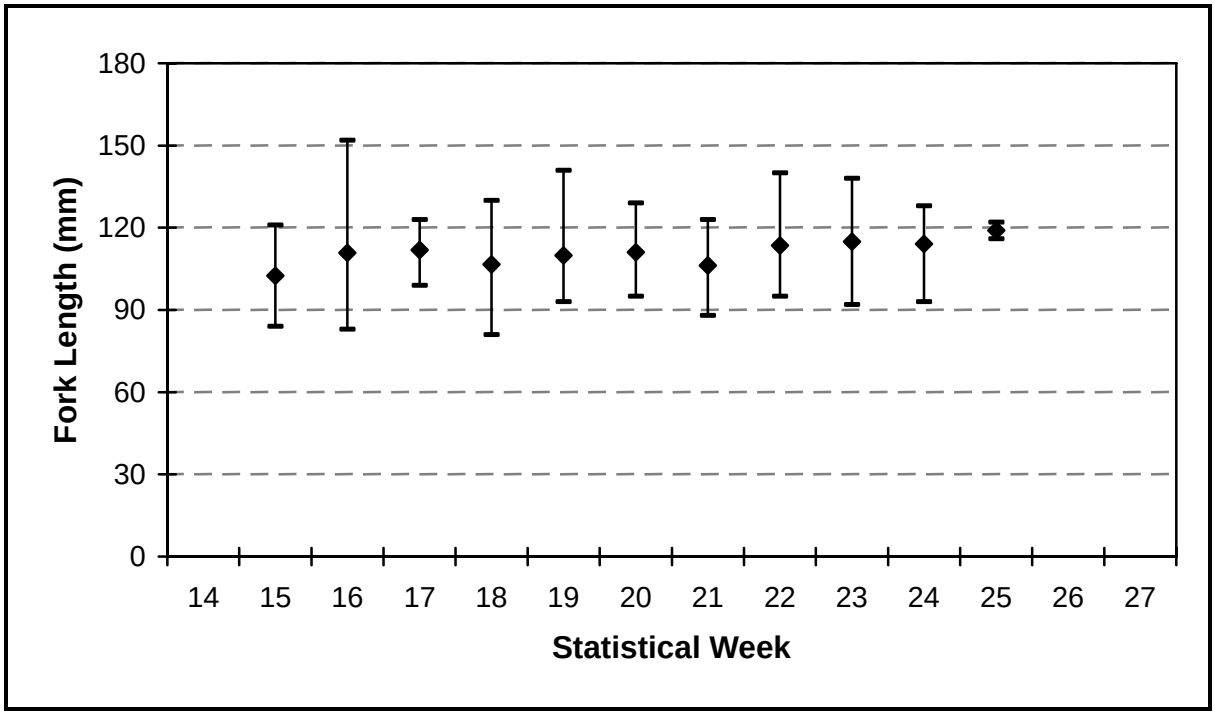

Figure 26. Weekly average, minimum, and maximum coho smolt fork lengths (mm) measured at the Mill Creek screw trap, 2004.

Trap Efficiency

A total of 2,652 coho in 61 groups were marked and released upstream of the trap. The number of fish released in each group ranged from two to 108 smolts. Recapture rates were not calculated for individual releases due to the small size of some of the release groups and the protracted migration timing observed in some of the marked fish. Efficiency tests were grouped by mark type and efficiency stratum. Increased flows, velocity and stream color, following two days of moderate rainfall resulted in an increase in capture efficiency beginning on April 22. This rate remained relatively constant for the remainder of the season, even as the stream flow decreased. This likely was due to the weir panels becoming more functional over time (essentially plugging up), effectively helping to maintain stream velocity and the speed of the screw.

Average trap efficiency rates before and after April 22 were found to be significantly different ($\alpha = 0.05$) using a z-test for comparing 2 means. Thus, two efficiency strata were developed. From the start of the season through April 21 (Stratum 1), grouped efficiency tests ranged from 45% to 56%, and averaged 49.2%. From April 22 through season's end (Stratum 2), grouped efficiency tests ranged from 39% to 77%, and averaged 63.2% (Table 32).

Production Estimate

Total coho production is estimated at 5,677 smolts with a coefficient of variation of 3.4% and a 95% confidence interval of 5,298 to 6,056 smolts (Figure 27). This estimate is based on our catch of 3,507 migrants and the estimated average trap efficiency for each stratum.

Table 32. Grouped capture efficiency tests for coho smolts by efficiency strata, Mill Creek 2004.

Efficiency Stratum	Dates		# Marked		Trap Efficiency
	Release	Recapture	Released	Recaptured	
Stratum 1	04/10-04/13	04/11-04/13	60	27	45.0%
	04/14-04/16	04/15-04/23	88	41	46.6%
	04/17-04/20	04/18-04/21	93	52	55.9%
	Sum		241	120	
	Average				49.2%
	Variance				1.2E-03
	n				3
Stratum 2	04/21-04/22	04/22-04/25	176	118	67.0%
	04/23-04/24	04/24-04/30	111	83	74.8%
	04/25-04/26	04/26-05/04	82	58	70.7%
	04/27-04/29	04/28-05/02	120	73	60.8%
	04/30-05/01	05/01-05/05	158	109	69.0%
	05/02-05/03	05/03-05/05	193	106	54.9%
	05/04-05/05	05/05-05/06	160	81	50.6%
	05/06-05/07	05/07-05/08	170	66	38.8%
	05/08-05/09	05/09-05/10	123	84	68.3%
	05/10-05/11	05/11-05/15	110	83	75.5%
	05/12-05/13	05/13-05/19	98	63	64.3%
	05/14-05/15	05/15-05/19	105	55	52.4%
	05/16-05/17	05/17-05/24	100	59	59.0%
	05/18-05/19	05/19-05/21	38	28	73.7%
	05/21-05/22	05/22-05/24	100	66	66.0%
	05/23-05/24	05/24-05/30	100	53	53.0%
	05/25-05/26	05/26-05/27	98	48	49.0%
	05/27-05/28	05/28-05/29	31	13	41.9%
	05/29-05/30	05/30-05/31	30	22	73.3%
	05/31-06/01	06/01-06/04	33	22	66.7%
	06/02-06/03	06/03-06/04	18	6	33.3%
	06/04-06/05	06/05-06/06	21	6	28.6%
	06/07-06/12	06/08-06/13	44	16	36.4%
	Sum		2,219	1,318	
	Average				63.2%
	Variance				5.5E-04
	n				23

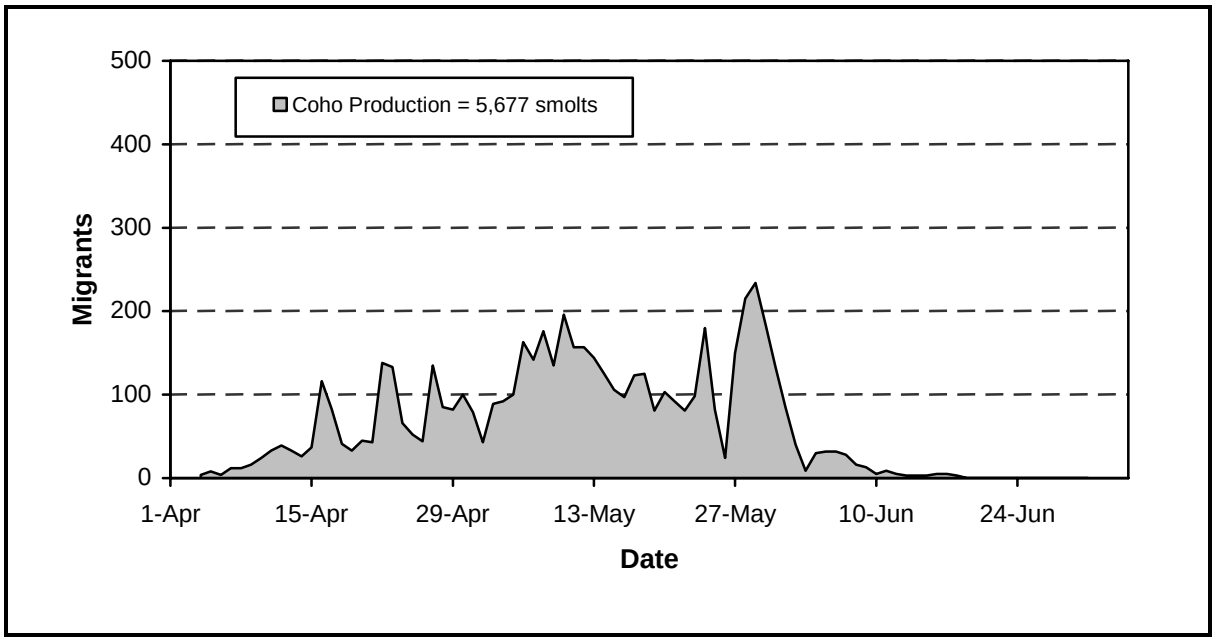

Figure 27. Estimate of daily natural origin coho smolt migration, Mill Creek screw trap 2004.

Steelhead and Cutthroat

Catch

We captured between zero and two steelhead and cutthroat smolts each day in the first two days after trapping began. Steelhead catches gradually increased in April, and peaked in the third week of April, with a two day catch of 77 April 22-23. Though gradually declining, catches remained steady through mid-May, before tapering off in June, when catches averaged 1-2 smolts/day, with the last smolt captured on June 24.

Cutthroat smolt catches remained steady through mid May, averaging 2-4 smolts/day. Catches increased in late May- early June, with a peak catch of 23 smolts on June 4. Thereafter, catches tapered off with the last smolt captured on June 25.

A total of 608 steelhead and 316 cutthroat smolts were caught throughout the trapping season.

Size

Steelhead weekly fork length averages remained fairly constant throughout the trapping season, although smaller averages were noted in both the early and late weeks. (Table 33, Figure 28). Sizes of steelhead ranged from 110 mm to 238 mm, and averaged 160 mm over the season. Sizes of cutthroat ranged from 124 mm to 273 mm, and averaged 179.8 mm over the season (Table 33, Figure 28).

Table 33. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of steelhead and cutthroat smolts measured by statistical week, Mill Creek 2004.

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	04/03	04/04						2						
15	04/05	04/11	154.3	29.6	110	199	16	41	174.2	27.1	129	215	10	15
16	04/12	04/18	172.7	19.3	130	211	30	112	195.3	20.7	160	235	9	21
17	04/19	04/25	165.6	23.5	121	205	28	132	181.4	33.1	124	227	16	19
18	04/26	05/02	165.5	17.6	135	202	45	139	192.5	24.8	155	245	17	30
19	05/03	05/09	153.7	14.4	124	190	27	62	191.0	18.0	166	216	10	18
20	05/10	05/16	161.1	27.3	132	238	24	31	170.6	16.9	145	192	9	16
21	05/17	05/23	163.0	18.8	140	209	15	26	183.3	23.6	150	237	14	19
22	05/24	05/30	165.2	13.0	135	187	17	10	175.3	16.1	138	208	14	13
23	05/31	06/06	173.5	14.9	154	197	17	25	179.3	22.9	146	273	34	62
24	06/07	06/13	164.6	10.0	145	178	10	13	173.1	16.2	142	205	19	52
25	06/14	06/20	141.3	5.1	137	147	3	8	171.0	24.8	146	204	4	37
26	06/21	06/27	144.5	13.8	136	165	4	7	148.4	15.9	133	172	5	7
27	06/28	07/01						2						5
Season Total			**163.6**	**20.5**	**110**	**238**	**236**	**608**	**179.8**	**23.8**	**124**	**273**	**161**	**316**

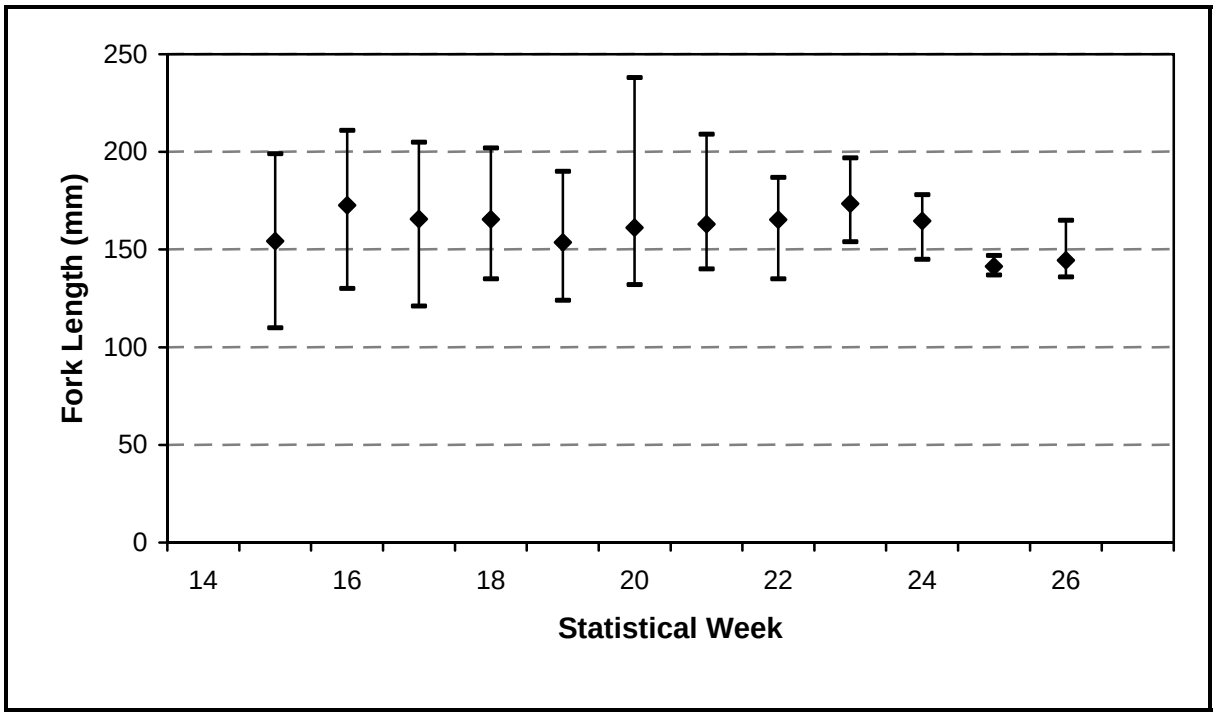

Figure 28. Weekly average, minimum, and maximum steelhead smolt fork lengths (mm) measured at the Mill Creek screw trap, 2004.

Trap Efficiency

A total of 536 steelhead smolts in 53 groups were marked and released upstream of the trap. The number of fish released in each group ranged from one to 32 smolts. Recapture rates were not calculated for individual releases due to the small size of the release groups and protracted migration. Efficiency tests were grouped by mark type and efficiency stratum. As was the case with the coho, we experienced a sustained increase in capture efficiency through the season, following the rain event that occurred on April 20-21. Average trap efficiencies before and after this event were found to be significantly different ($\alpha = 0.05$) using a z-test for comparing 2 means. Thus, two efficiency strata were developed. From the start of the season through April 21 (Stratum 1), grouped efficiency tests ranged from 14% to 24%, and averaged 19.0%. From April 22 through season's end (Stratum 2), grouped efficiency tests ranged from 19% to 42%, and averaged 32.8% (Table 34).

Cutthroat trap efficiency tests were not conducted during the season due to low catches in the season. Steelhead trap efficiency was used to estimate cutthroat migration.

Table 34. Trap efficiency tests using steelhead smolts grouped by mark type and efficiency stratum, Mill Creek 2004.

Efficiency Stratum	Dates		# Marked		Trap Efficiency
	Release	Recapture	Released	Recaptured	
Stratum 1	04/10-04/13	04/11-04/16	46	9	19.6%
	04/14-04/16	04/15-04/17	44	6	13.6%
	04/17-04/20	04/18-04/21	59	14	23.7%
	Sum		149	29	
	Average				19.0%
	Variance				8.6E-04
	n				3
Stratum 2	04/21-04/22	04/22-04/24	49	14	28.6%
	04/23-04/24	04/24-04/25	41	15	36.6%
	04/25-04/26	04/26-05/27	26	11	42.3%
	04/27-04/29	04/28-04/30	70	27	38.6%
	04/30-05/01	05/01-05/02	38	15	39.5%
	05/02-05/03	05/03-05/05	24	6	25.0%
	05/04-05/05	05/05-05/06	16	3	18.8%
	05/06-05/07	05/07-05/14	22	6	27.3%
	05/08-05/09	05/09-05/10	18	7	38.9%
	05/10-05/11	05/11-05/12	18	6	33.3%
	05/12-05/19	05/13-05/23	21	6	28.6%
	05/24-06/12	05/27-06/13	44	16	36.4%
	Sum		387	132	
	Average				32.8%
	Variance				4.2E-04
	n				12

Production Estimates

Total steelhead production is estimated to be 2,250 smolts with a coefficient of variation of 7.5% and a 95% confidence interval of 1,921 to 2,579 smolts (Figure 29). Total cutthroat production is estimated to be 1,053 smolts with a coefficient of variation of 5.9% and a 95% confidence interval of 930 to 1,176 smolts (Figure 29). 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 occur outside of the trapping interval, the proportion is unknown and could not be estimated.

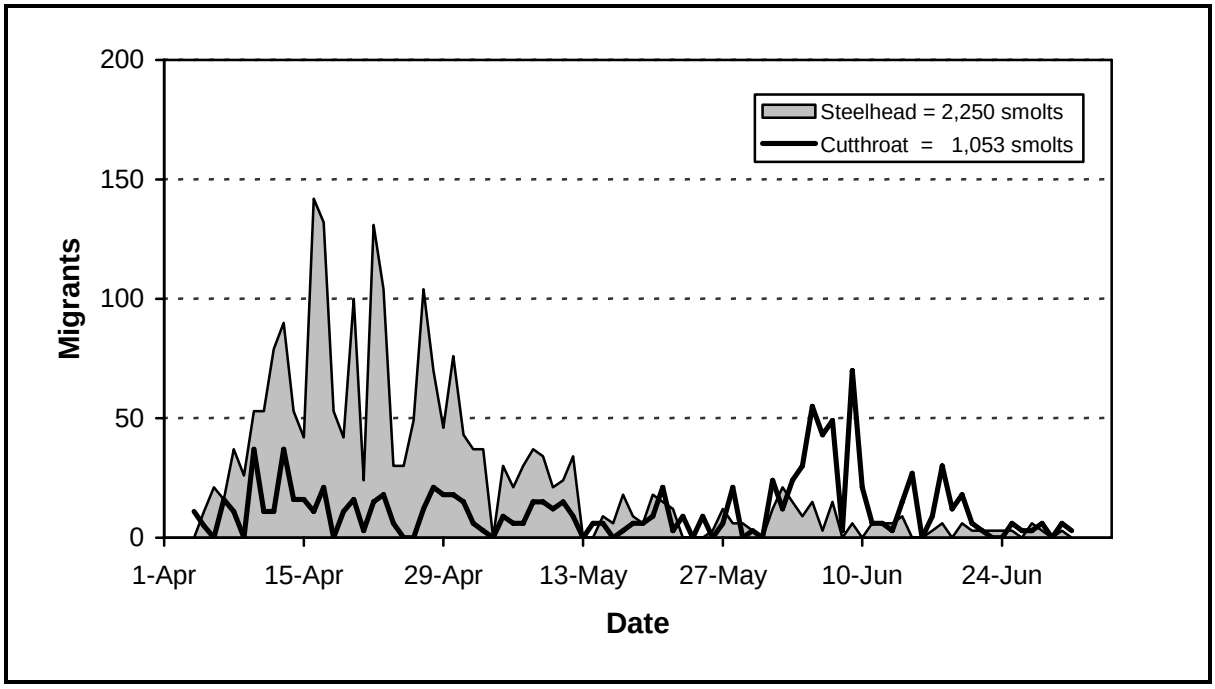

Figure 29. Estimate of daily steelhead and cutthroat smolt migrations, Mill Creek 2004.

Lower Columbia IMW Escapement and Spawner Distribution

Methods

Spawning ground surveys were conducted from October, 2004 to January, 2005, on Mill and Abernathy Creeks to assess the escapement and distribution of adult coho in these systems. Surveys were not conducted in Germany Creek since we were unable to obtain permission to access much of the upper watershed (approximately 35% of the known coho habitat) prior to the commencement of surveys.

WDFW's Salmonscape web site (http://wdfw.wa.gov/mapping/salmonscape/) was used to identify the known and presumed/potential spawning habitat for coho and steelhead in Mill and Abernathy Creeks. Since coho spawning ground surveys had not been routinely performed prior to 2004, we had little confidence that the known coho habitat identified in Salmonscape included all habitat used by coho salmon. Therefore, in planning the surveys, we considered all known, presumed, and potential coho and steelhead habitat identified in Salmonscape (Figure 30 and Figure 31). Combined, this totaled 110 kilometers (km) for the two basins (approximately 28 km known coho and 82 km presumed/potential coho and steelhead).

We could not survey the entire potential spawning area on a weekly basis with our available manpower. Therefore, we opted to survey the known coho habitat and a random sample of 15 sites within the presumed/potential coho and steelhead habitats on a weekly basis (Figure 30 and Figure 31). Additional surveys of presumed/potential habitat were conducted to try to determine the upstream extent of coho distribution in these two watersheds.

Survey sites within the presumed/potential habitats were sampled from a spatially balanced, probabilistic sample of 60 sites within each basin (Phil Larsen, EPA, Pers. Comm.). We combined samples for Mill and Abernathy Creeks and selected the first 15 sites found within the presumed/potential habitats to represent redd densities within un-sampled habitats. One of the selected sites was found to be upstream of an impassible barrier and was replaced in the sample. Surveys ranged from 500 to 1400-meters in length at each of the sample locations. Our goal was to survey at least 600-meters of stream at each sample point, but in two cases, the distance between adjacent sample points only allowed for 500-meter survey reaches.

Steelhead spawning ground surveys were conducted during the spring, 2005 in all three Lower Columbia IMW watersheds. Since the fieldwork for this effort was only completed just prior to the due date for this report, results from this activity will be discussed in the 2006 annual report.

During each of the spawning ground surveys, surveyors recorded observations of live and dead salmon, and salmon redds (spawning nests) by species. Redds were flagged in the field and GPS coordinates were taken at each coho redd location where satellite availability allowed. Accuracy was rated at less than 15-meters or 3-meters where WAAS satellite reception was available. In some cases, the GPS could not pick up a signal. In those cases, the redd was orientated to reference points that were established in the stream channel at 100-meter intervals.

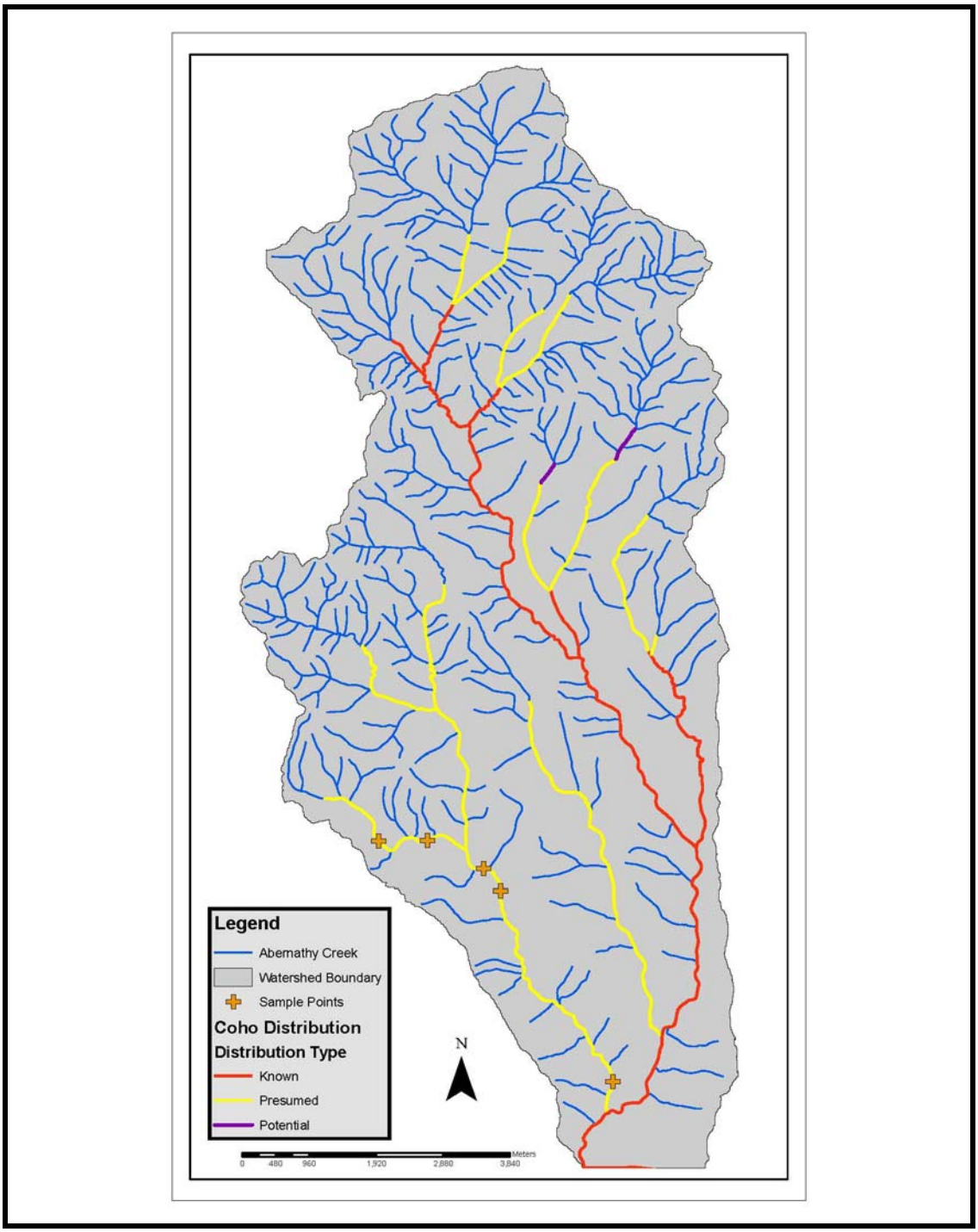

Figure 30. Location of known, presumed, and potential coho habitats in Abernathy Creek, along with 2004 sample survey points in the presumed/potential habitat.

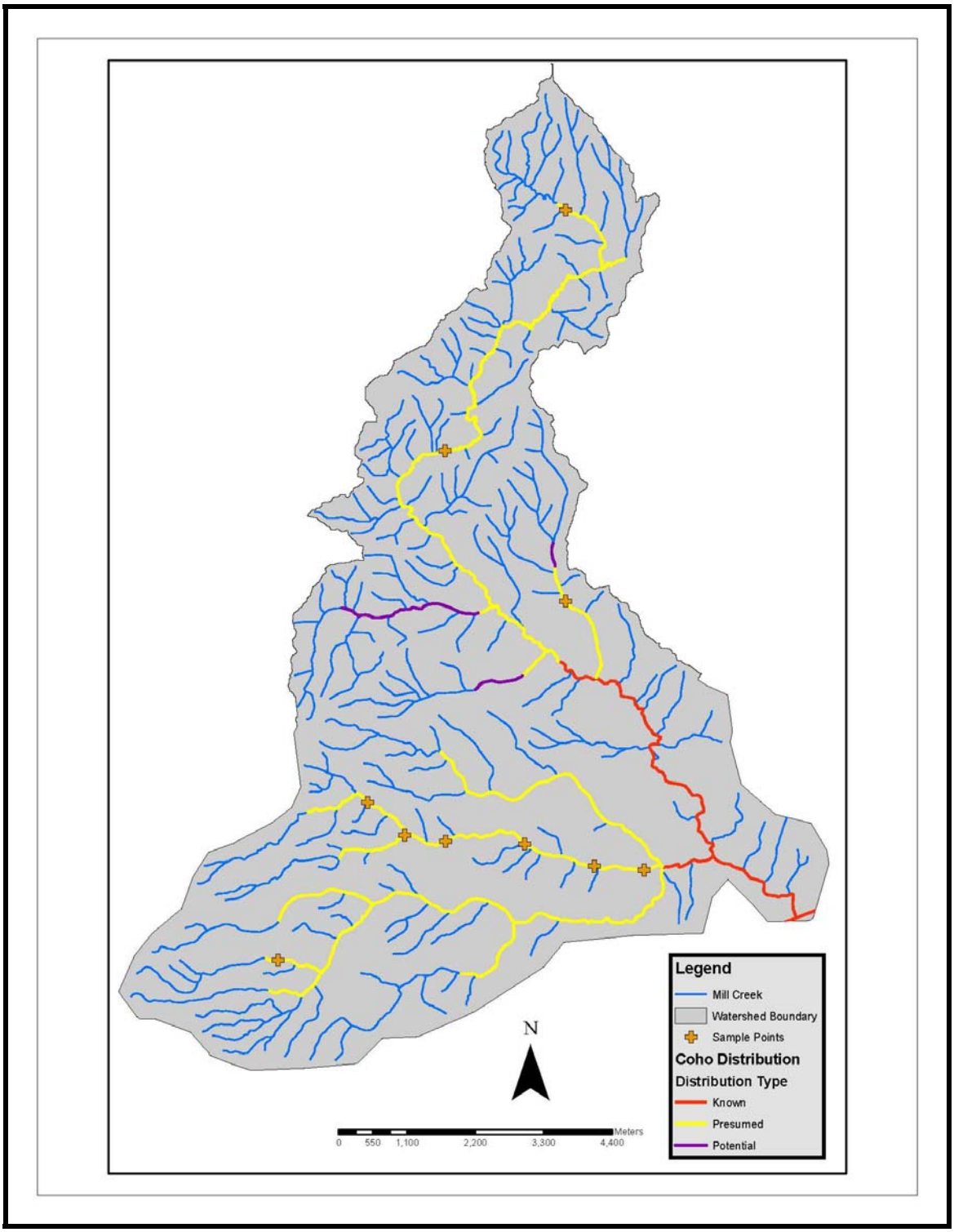

Figure 31. Location of known, presumed, and potential coho habitats in Mill Creek, along with 2004 sample survey points in the presumed/potential habitat.

Data Analysis

Coho escapement and spawner distribution was estimated using redd counts. Redd densities (new redds) were estimated weekly for each survey reach. Since all of the known coho habitats were surveyed, weekly redd counts in this stratum were considered a census. Only a portion of the presumed/potential coho and steelhead habitats were surveyed weekly. Sample sites were divided into 100-meter sections so that mean redd density (redds/100-meters) and a variance could be estimated for each sample site. Using the collected data, we first estimated the upstream extent of coho distribution in each basin and sub-basin. We then extrapolated redd densities from representative samples to estimate spawning activity in accessible habitats.

Two approaches were used to estimate redd deposition in un-surveyed reaches within presumed/potential habitats. Where un-surveyed reaches fell between sampled sites, we interpolated redd deposition by multiplying the mean weekly redd density from the adjacent sampled sites by the un-surveyed reach length. We assumed the variance of the redd densities between the sampled sites was similar to the variance within the un-surveyed reach. Therefore, the variance in weekly redd deposition in the un-surveyed reach was estimated by:

$$V(R_{ij}) = V(\overline{D}_j)L_i^2 \qquad \text{Equation 8}$$

Where:

$V(R_{ij})$ = the variance of the redd estimate for reach i during week j,

$V(\overline{D}_j)$ = the variance of redd density for reaches adjacent to un-surveyed reach i found in week j,

L_i = the length of un-surveyed reach i.

Where only a portion of a reach was surveyed in a given week (a sample site) or a sample point was found on only one side of an un-surveyed reach (e.g. in the nearest downstream reach), the mean redd density for the 100-meter sections within the sampled site was multiplied by the number of 100-meter sections in the entire reach, or the un-surveyed reach, to estimate redd deposition within the reach. We assumed the variance among redd densities within the 100-meter sections was similar to the redd density among all 100-meter sections within the reach. Therefore, the variance of the weekly redd deposition estimate was found using:

$$V(R_{ij}) = V(\overline{S}_j)\left(\frac{L_i}{100}\right)^2 \qquad \text{Equation 9}$$

Where:

$V(\overline{S}_j)$ = the variance of redds for 100-meter sections within the sample site during week j

Results

Coho

Weekly coho spawning ground surveys began the week of October 25, 2004 and ended the week of January 24, 2005. Since this was our first year conducting coho spawning ground surveys, additional surveys were conducted beginning on October 11 to determine migration timing. Over this period, we counted 356 redds in the two watersheds (Table 35). In Mill Creek, 64 redds (60%) were observed in known coho habitats and 43 redds (40%) were observed in presumed/potential habitats (Table 35). Whereas in Abernathy Creek, 203 redds (82%) were observed in known coho habitats and 46 redds (18%) were observed in presumed/potential habitats.

Table 35. Observations of live and dead coho adults and redds in Mill and Abernathy Creeks, Oct 2004 to Jan 2005.

Watershed	Live Coho	Dead Coho			Redds
		Males	Females	Jacks	
Mill Creek	105	18	24	1	107
Abernathy Creek	219	64	66	3	249
Total	**324**	**82**	**90**	**4**	**356**

The extent of coho distribution was determined by surveying the weekly survey sites, additional sites in un-sampled tributaries, and by best professional judgment using habitat attributes (stream size and gradient) given the stream flow conditions that occurred during the spawning period. Using this approach, we estimated 31 and 34-kilometers of habitat were available to coho in Mill and Abernathy Creeks, respectively (Figure 32 and Figure 33).

In Mill Creek, redd density ranged as high as 0.875 redds/100-meters for surveyed EDT reaches and as high as one redd/100-meters for sample sites in presumed/potential habitats in Mill Creek (Table 36). Densities ranged to 0.875 redds/100-meters for surveyed EDT reaches in Abernathy Creek and to 0.571 redds/100-meters for sample sites in presumed/potential habitats.

To estimate total escapement, we assumed two spawners per redd. Total escapement was therefore estimated at 624 adults +/- 172 in Mill Creek and 602 adults +/- 135 in Abernathy Creek (Table 36).

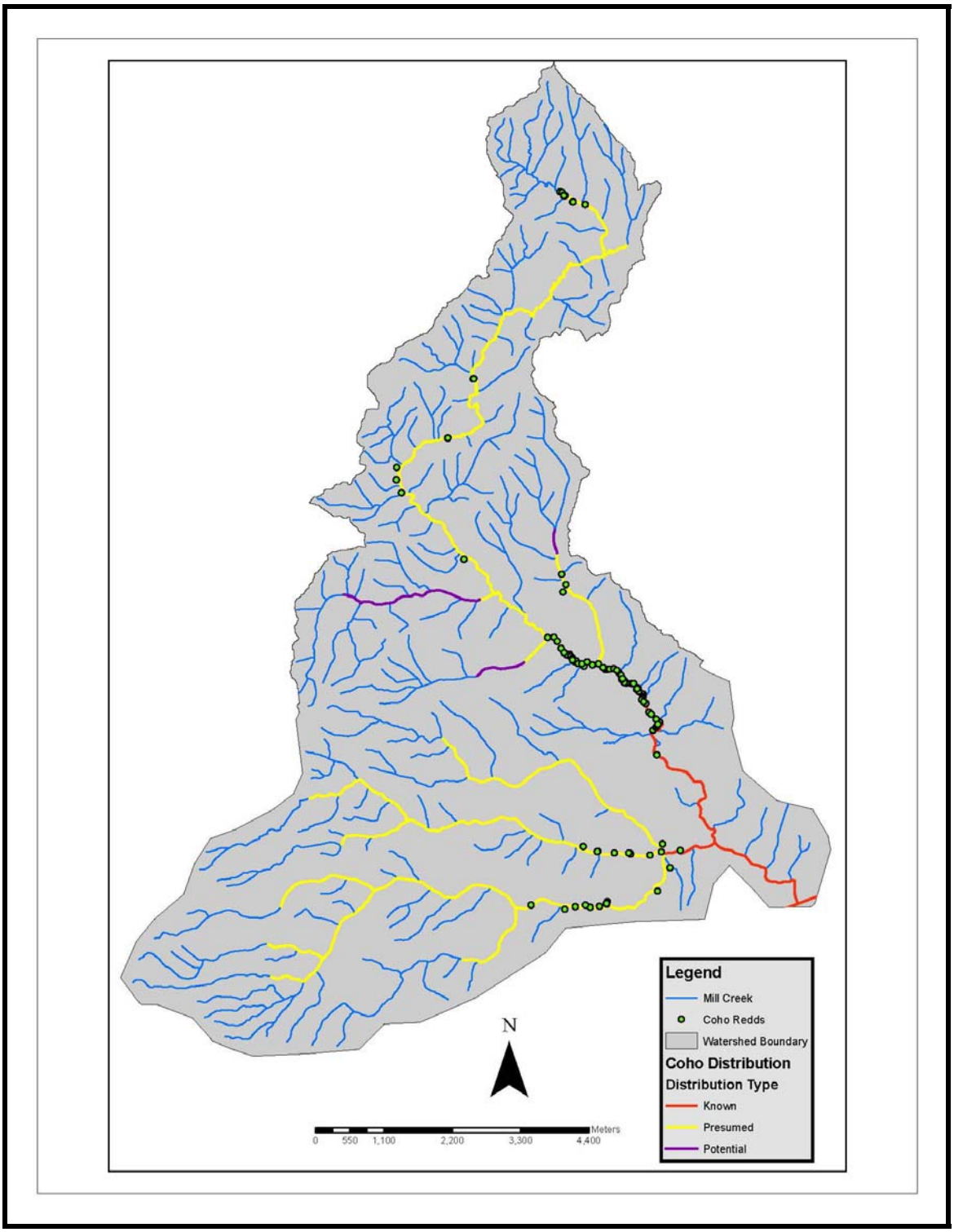

Figure 32. 2004 coho redd observations and upstream spawning extent in Mill Creek, 2004.

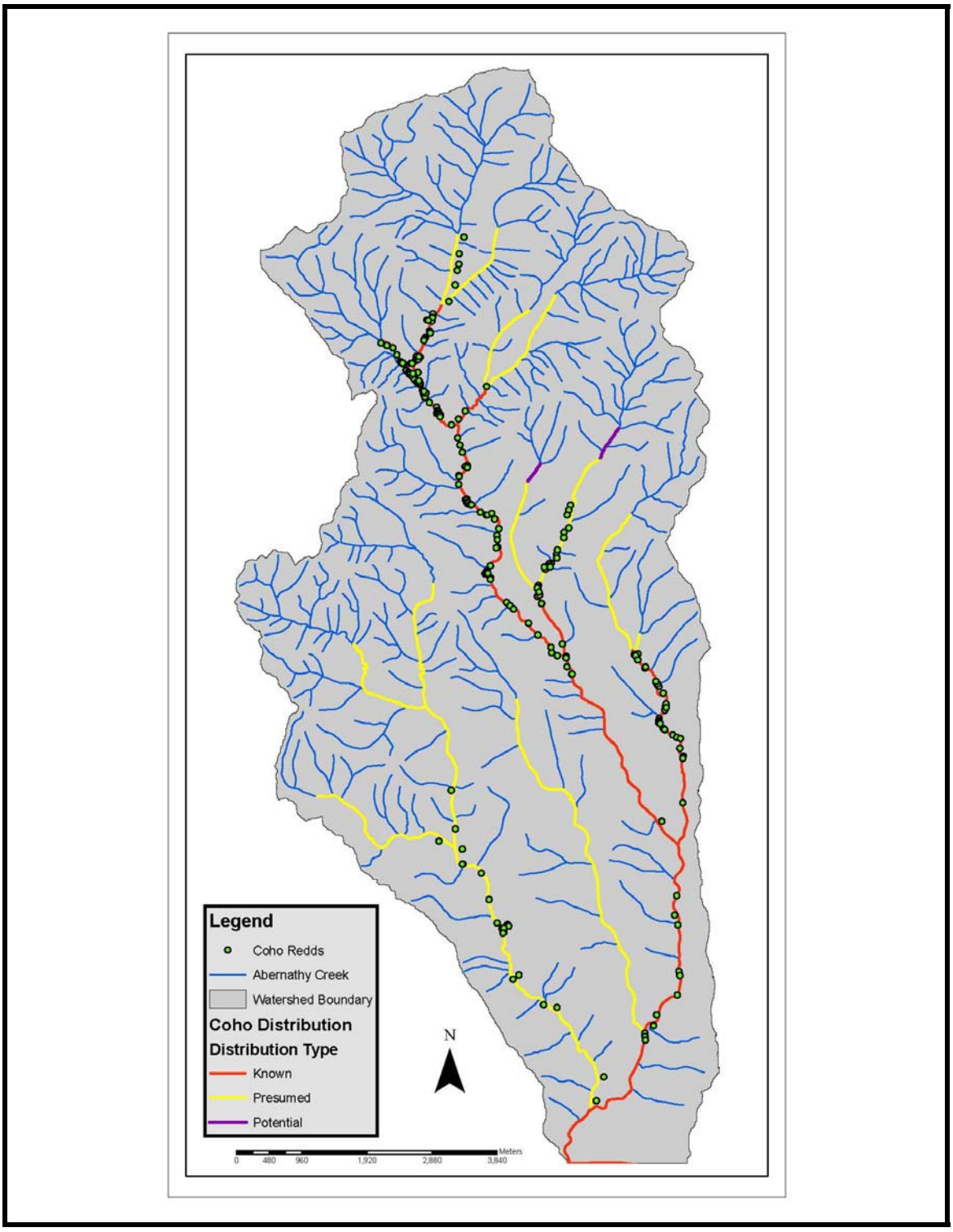

Figure 33. 2004 observed coho redds and the upstream spawning extent in Abernathy Creek.

Table 36. Coho redd density and estimated redd deposition and escapements with confidence intervals for known and previously undocumented habitats used by coho salmon in Mill and Abernathy Creeks, 2004.

Watershed	Observed Redds	Redd Density		Estimated Values	95% CI	
		Min	Max		Low	High
Mill Creek						
Redds - Known Habitat	64	0	0.875	64	64	64
Redds - Presumed/Potential Habitat	43	0	1.0	248	162	334
Total Redds	*107*			*312*	*226*	*398*
Adults/Redd				2		
Estimated Escapement				*624*	*452*	*796*
Abernathy Creek						
Redds - Known Habitat	203	0	0.875	205	197	213
Redds - Presumed/Potential Habitat	46	0	0.571	96	29	162
Total Redds	*249*			*301*	*234*	*368*
Adults/Redd				2		
Estimated Escapement				*602*	*467*	*736*
Grand Total Escapement	356			1,226	907	1,345

Discussion

Hood Canal IMW Streams

Downstream Migrant Trapping

Smolt production from the Hood Canal IMW streams was 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 (6:1), Seabeck (7:1), and Little Anderson (0.4:1) creeks, whereas the ratio for Big Beef Creek (16:1) 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.

Upstream Migrant Trapping

Total escapements of coho and chum salmon into Big Beef Creek are 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 0.6% of the unmarked fish released upstream to spawn in Big Beef Creek in 2004 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 2004, we recovered 14 hatchery origin tags (six unmarked and eight ad-marked) from four hatchery sources (Table 13). Unlike in past years, more unmarked coho were sampled for coded wire tags than for scale analysis. This is primarily a result of the large number of unmarked carcasses sampled during spawning ground surveys. Expanding the tag recoveries indicates 3,211 of the 3,237 tagged adult coho passed upstream of the weir were of Big Beef (natural) origin and 26 of the tagged coho were of hatchery origin. These estimates, although similar, cannot be compared to the

estimates of 3,994 Big Beef and 25 hatchery origin coho passed upstream of the weir derived from scale analysis. Whereas the scale analysis method estimates origin for all coho passed upstream of the weir, the coded wire tagged estimate only applies to the tagged component of the escapement. Expanding this estimate to reflect the total escapement is problematic due to assumptions that need to be made regarding 1) equal tag loss rates among Big Beef and hatchery tag groups, and 2) that proportions of unmarked tagged/unmarked untagged components in the hatchery releases are accurately reported. Even if these assumptions could be validated, expansions of hatchery tags could not be made due to the small number of recoveries from each hatchery facility. Therefore, we believe scale analysis is the best approach for estimating the hatchery component in the Big Beef escapement.

It should be noted, that the magnitude of the proportion of hatchery fish 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.

Coho Escapements into Little Anderson, Seabeck, and Stavis Creeks

Three methods were employed to estimate escapement into the four Hood Canal streams: 1) a count of escapement into Big Beef Creek, 2) a Big Beef Creek SRR-based approach, and 2) redd count surveys. The redd count approach resulted in nearly identical escapement estimates as the SRR method for Little Anderson and Seabeck Creeks, but produced much lower estimates than the counted escapement into Big Beef Creek and the SRR approach for Stavis Creek. These later streams are larger and more complex than the former. Big Beef and Stavis Creeks generally contain more wood and log jams than either Seabeck or Little Anderson Creeks; therefore it is likely that a higher proportion of the redds were not observed in these streams compared to Little Anderson and Seabeck Creeks. In addition, portions of Big Beef Creek flowing through wetlands were not surveyed. Some spawning habitat may be available in these sections of the watershed. Another bias results from the mass coho spawning that occurs in Trib 31 (Figure 16). This tributary has the highest observed coho spawning densities in the Big Beef watershed. Individual redds were often difficult to identify as a result of the high level of spawning activity that occured in this stream. It is likely our redd counts underestimate the true number of deposited redds in this tributary.

The SRR-based coho escapement estimates for Little Anderson, Seabeck, and Stavis Creeks assume the proportions of the outmigrating smolts that return as adults to these streams was the same as for Big Beef Creek. It further assumes that the hatchery stray rates are the same. The degree that these assumptions are being violated is unknown. 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. In 2004, we observed that a higher proportion of the fishing occurred in the vicinity of Big Beef Creek, compared to the other streams. If the distribution in fishing effort resulted in higher impacts to Big Beef coho compared to the other IMW streams, then SRR-based escapement estimates for Little Anderson, Seabeck, and Stavis Creeks may be low.

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 Germany Creek, and the interruption in trapping in that site only estimated a lost catch of 25 coho.

Production estimates were best for coho with coefficients of variation ranging from 3.4% to 7.4%, depending on trap site. Germany and Mill Creeks had the highest precision, whereas lower precision was noted for Abernathy Creek. Differences in the precision of production estimates among streams were largely a function of trap efficiency. The Germany and Mill Creek traps operated at a higher trap efficiency than the Abernathy trap.

Precision was also relatively high for the steelhead and cutthroat estimates; however, variance estimates are valid only if the following assumptions are true:

> **Steelhead**: The difference in Abernathy trap efficiency for steelhead between Stratums 1 and 2 were proportionately equal to the difference measured for Abernathy coho.
>
> **Cutthroat**: Trap efficiency and its variability for steelhead and cutthroat are identical.

Differences in trap efficiency between species is a function of swimming ability, with smaller migrants generally being more susceptible to capture. Trap efficiencies are generally positively correlated with environmental conditions such as velocity, turbidity, and noise. Changes in trap efficiency in Abernathy Creek between strata were largely a result of changes in these three factors. While we believe coho and steelhead trap efficiencies were both affected by these changes in the same way, we are uncertain whether the change in trap efficiency for steelhead was proportionally identical for that measured for coho salmon. Since the approximation of Stratum 1 trap efficiency was only applied to 3% of the catch, less-than-perfect adherence to this assumption had a very small impact on the accuracy of the steelhead production estimate.

Similarly, since steelhead and cutthroat smolts were similar in size, we believe it likely that the smolt traps captured a similar proportion of the total downstream migrants of these species. However, it is unlikely that these proportions were identical. Therefore, while we believe production estimates for cutthroat are reliable, the precision of these estimates is probably underestimated.

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