West Fork Smith River
Salmonid Life Cycle Monitoring Project

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Introduction

The Salmonid Life Cycle Monitoring Project of the Oregon Department of Fish and Wildlife (ODFW) has guided monitoring of juvenile and adult salmonid fishes (*Oncorhynchus spp.*) in the West Fork Smith River (Umpqua basin) since 1998. These activities are coordinated under the Oregon Plan for Salmon and Watersheds and are part of a broader effort to monitor populations of salmonids in select Oregon coastal streams. Two objectives of this program are to estimate the abundance of returning adult salmonids and downstream-migrating juvenile salmonids, and estimate the marine and freshwater survival rates for coho salmon.

This report summarizes monitoring activities within the West Fork Smith River basin, including population estimation for the 2006-2007 run-year of returning adult fish and year 2007 out-migration of juvenile fish. Supplemental surveys for western brook lamprey spawners were also conducted in spring 2007, and results are included in this report. A full description of sampling methods is provided in Solazzi et al. (2000) and Jepsen et al. (2006). These and other Life Cycle Monitoring Project reports are available on the ODFW Corvallis Research Lab website, http://nrimp.dfw.state.or.us/crl/

Adult Fish Trap Operation

During summer 2006, the floating weir used as a migration barrier at the adult fish trap was completely rebuilt with new pickets and most structural components. In January 2005, a major portion of the head dam that provides increased flow through the trap box was damaged; the head dam was also repaired during summer 2006. The weir was installed and the trap made functional on September 19.

Stream flows increased significantly in early November and the first coho salmon entered the trap on November 5. Stream flows remained high for most of November, causing the floating weir to submerge and permitting most fish to bypass the trap. The weir was submerged for a total of 13 days in November, seven days in December, four days in January, seven days in February, and four days in March. The first winter steelhead entered the trap on January 8, and the last steelhead was trapped on May 2.

All wild coho salmon and both wild and hatchery winter steelhead that entered the trap were tagged with two Floy tags and passed above the trap. Only one fall Chinook salmon was trapped; this fish was passed untagged.

Spawning Ground Surveys

Surveys that provided data for estimation of spawner populations of coho salmon and winter steelhead were conducted in the five principal tributaries and nine reaches of the mainstem at approximately seven day intervals from November 6, 2006 to April 18, 2007. Surveys that specifically focused on western brook lamprey spawning activity continued until May 24, but activity for other spring spawners such as Pacific lamprey and cutthroat trout was also recorded.

Coho salmon spawning activity was widespread throughout all major tributaries and most reaches of the mainstem (Table 1). The estimate of coho salmon spawners within survey reaches, based on area-under-curve calculations, represents 44.7 % of the estimate for the total basin (summarized below).

Spawning activity of winter steelhead was observed in all the major tributaries, but most spawning occurred in the mainstem, (Table 2). Steelhead redds in the mainstem were observed at higher frequency at boulder weirs; within survey reaches containing weirs (n=5), 35.4% of redds were found within the sub-reach 10m upstream of a weir face, while extent of this habitat represented only 5.3% of total reach length.

Table 2 also summarizes redd counts of cutthroat trout and Pacific lamprey.

Fall Chinook spawners were only observed in the mainstem, and only during the first increases in stream flow in early to mid-November.

Table 1. Peak live counts and redd counts for coho salmon, and total coho salmon spawners (based on area-under-curve calculations from survey counts) in the West Fork Smith River during the period November 2006 to January 2007.

	Survey	Section	Length (km)	Peak Live	Peak Redds	Total AUC
Tributaries						
	Coon Cr.		1.11	7	17	12.4
	Crane Cr.	1	1.15	9	10	15.6
	Crane Cr.	2	1.54	17	14	27.7
	Moore Cr.	1	1.33	13	17	33.4
	Moore Cr.	2	1.99	13	13	39.4
	Beaver Cr.	1	2.11	15	10	33.2
	Beaver Cr.	2	1.17	13	11	35.9
	Gold Cr.	1	1.16	7	8	19.5
	Gold Cr.	2	1.86	7	8	19.2
	Gold Cr.	3	1.45	11	10	24.8
Mainstem						
	Trib. B to Crane Cr.		1.71	6	10	19.5
	Moore Cr to Trib. D		2.55	9	8	28.8
	Trib. D to Trib. E		1.40	3	3	4.0
	Trib. F to Beaver Cr.		1.56	8	11	19.0
	Beaver to Gold Cr.		0.84	29	9	31.7
	Gold Cr to left trib.		1.78	34	21	89.6
	Headwaters	2	1.80	8	14	17.8
	Headwaters	3	1.12	11	13	26.0
	Headwaters	4	1.36	10	9	18.1
Total			28.99			516

Estimated Spawner Populations

The estimated spawner populations are based on the number of fish tagged and passed at the adult trap, and number of tagged and untagged fish observed (live fish and spawned-out carcasses) on surveys. Estimates of spawners were made using the adjusted Peterson mark-recapture methodology:

$$N = \frac{(M(1-p^2) + 1)(C+1)}{(R + 1)}$$

where:

N = estimated population above the West Fork Smith River adult trap

M = the number of fish marked with two Floy tags
C = the number of fish observed for presence of tags on spawning surveys (live fish observations plus carcass recoveries), excluding fish for which presence of tag could not be determined
R = the number of tagged fish observed
p^2 = the probability that a fish lost both tags before being observed

The probability that a fish lost one of the two tags implanted was estimated by the formula:

$$p = n_1 / (2n_2 + n_1)$$

where:

n_1 = the number of observations of fish with one tag
n_2 = the number of observations of fish with two tags

Table 2. Total number of winter steelhead, cutthroat trout, and Pacific lamprey redds counted on survey reaches in the West Fork Smith River for the period January to April 2007.

	Survey	Section	Length (km)	Steelhead	Cutthroat	Pacific Lamprey
Tributaries						
	Coon Cr.		1.11	4	0	1
	Crane Cr.	1	1.15	2	0	0
	Crane Cr.	2	1.54	0	0	2
	Moore Cr.	1	1.33	3	4	3
	Moore Cr.	2	1.99	2	2	1
	Beaver Cr.	1	2.11	4	7	2
	Beaver Cr.	2	1.17	1	5	4
	Gold Cr.	1	1.16	5	2	1
	Gold Cr.	2	1.86	8	2	1
	Gold Cr.	3	1.45	4	0	1
Mainstem						
	Trib. B to Crane Cr.		1.71	21	6	0
	Moore Cr to Trib. D		2.55	28	2	2
	Trib. D to Trib. E		1.40	5	0	0
	Trib. F to Beaver Cr.		1.56	25	0	4
	Beaver to Gold Cr.		0.84	12	0	1
	Gold Cr to left trib.		1.78	13	0	2
	Headwaters	2	1.80	9	4	13
	Headwaters	3	1.12	12	4	12
	Headwaters	4	1.36	8	4	1
Total			28.99	166	42	51

Table 3 summarizes annual trap catch and the estimated spawner populations of coho salmon and winter steelhead. The trap catch included three hatchery coho salmon and one hatchery steelhead. There is no hatchery program in the Smith Basin; hatchery coho salmon were likely strays from the North Umpqua River, and hatchery steelhead are likely strays from the Siuslaw River .

Table 3. The number of female (F), male (M) and jack (J) salmonids captured at the West Fork Smith River adult trap and the estimated spawning population above the trap during the return years 1998-99 through 2006-07. For coho salmon, numbers of wild female and male spawners were based on percent representation in spawned-out carcasses recovered on surveys and the adult trap weir. No hatchery coho salmon were observed among 106 carcasses recovered; estimated number of hatchery coho spawners is the same as number trapped.

Return Year	Trap Catch: Wild F	M	J	Trap Catch: Hatchery F	M	J	Estimated Spawning Population: Wild F	M	J	Estimated Spawning Population: Hatchery F	M	J
Coho												
98-99							72	73	na	0	0	na
99-00	38	58	1	0	0	0	130	163	na	0	0	na
00-01	46	56	23	0	0	0	271	279	na	0	0	na
01-02	49	57	6	8	11	0	707	729	189	15	20	na
02-03	100	173	12	3	0	0	1,520	1,924	114	4	3	na
03-04	56	110	2	0	0	0	1,787	1,940	101	0	0	na
04-05	30	32	0	0	0	0	417	561	na	0	0	na
05-06	17	34	0	0	0	0	734	1,111	na	0	0	na
06-07	17	16	0	2	1	0	464	688	na	2	1	na
Fall Chinook												
98-99	0	13	0	0	0	0						
99-00	3	13	0	0	0	0						
00-01	1	32	3	0	0	0						
01-02	5	34	2	0	1	0						
02-03	2	10	0	0	0	0						
03-04	2	20	2	0	0	0						
04-05	8	20	2	6	21	1						
05-06	2	9	4	1	4	0						
06-07	0	1	0	0	0	0						
Steelhead												
98-99	54	48	4	3	2	0	179	173		10	7	
99-00	244	158	0	1	1	0	275	177		1	1	
00-01	141	118	7	1	2	0	175	155		1	2	
01-02	116	86	2	0	1	0	472	362		2	2	
02-03	45	72	0	0	0	0	145	233		0	0	
03-04	104	92	1	0	1	0	281	252		2	1	
04-05	78	79	2	1	3	0	122	121		2	5	
05-06	56	43	0	4	1	0	229	176		16	4	
06-07	58	74	2	0	1	0	164	210		0	3	

Timing of trap catch for the 2006-07 run year generally corresponded with timing of high stream flow events (Figure 1). Most fish bypassed the trap during high stream flows when the floating weir was submerged, thus timing of trap catch was only an approximation of run timing.

Confidence intervals (95%) for coho salmon and winter steelhead total spawner estimates are shown in Table 4. Confidence intervals for coho salmon were calculated using a relationship between the F distribution and the binomial distribution. Confidence intervals for winter steelhead were calculated using a bootstrap analysis (Thedinga et al. 1994, 1000 iterations).

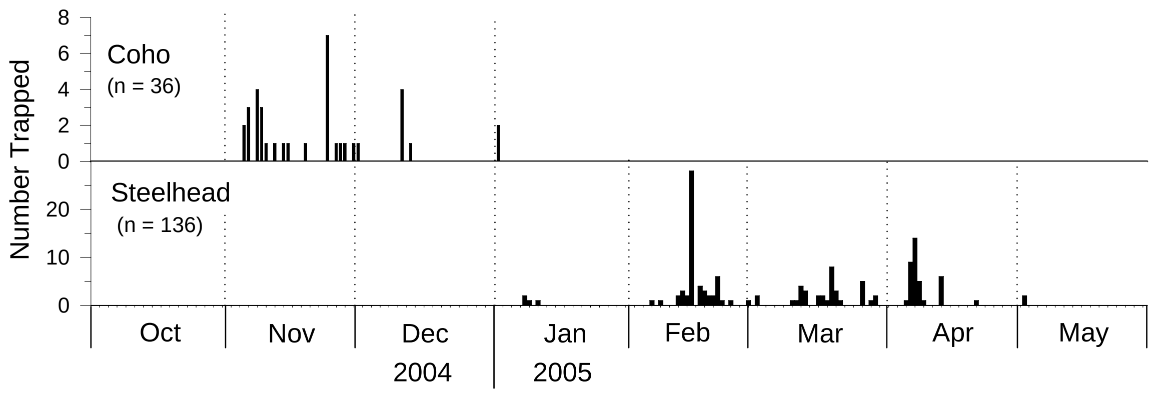

Figure 1. Timing of coho salmon and winter steelhead trapped in the West Fork Smith River during the 2006-2007 run-year.

Juvenile Out-Migrant Trap Operation

The juvenile out-migrant trap was installed in the West Fork Smith River on January 31 and operated until May 28, when it stopped turning due to low stream flows. Operation was continuous except for two days in February during a period of high stream flow.

Capture efficiency of traps was normally evaluated daily for each species and age/size class by marking up to 25 fish from each category with a small clip on the caudal fin, then releasing upstream of the trap. Subsequent recaptures of marked fish were recorded and weekly estimates of out-migrants were made by expanding trap catches using the following equations:

$$N_m = c / e_m$$

and

$$e_m = r / m,$$

where:

N_m = weekly estimated out-migrants
c = number of fish captured
e_m = measured weekly trap efficiency
r = number of recaptured marked fish
m = number of marked fish released

Weekly estimates were summed for season totals. When recaptures were infrequent (< five recaptures/week), totals for an equal number of previous and following weeks were pooled to obtain at least five recaptures. Population estimates were generally not calculated if fewer than five marked fish of a particular category were recaptured over the season, in which case number caught is reported.

Beginning in 2005, a weighted value for trap efficiency was used to calculate confidence intervals. Each weekly estimate of trap efficiency was weighted based on the proportion of total estimated migrants that each weekly estimate of migrants represented, using the equation:

$$e_w = e_m * (N_m / N_t),$$

where e_w = weighted weekly trap efficiency, e_m = measured weekly trap efficiency, N_m = weekly estimated migrants, and N_t = season total migrants. The sum of the weighted trap efficiencies was used in the confidence interval calculations.

Estimated numbers of out-migrants for each species and size class are shown in Table 5.

Table 4. Total estimated spawner populations of coho salmon and winter steelhead in the West Fork Smith River for run years 1998-99 through 2006-07. The adult coho spawner population in 1998-99 was based on area-under-curve estimation from spawner survey data; confidence interval was not calculated. Calculated trap efficiency was based on the percentage of total estimated spawners that were trapped. Repeat steelhead spawners were determined from the percentage of fish that entered the adult trap with tags implanted prior to the current run year.

Return Year	Coho (95% CI)		Trap Effic. (%)	Steelhead (95% CI)		Trap Effic. (%)	Repeat Spawner (%)
98-99	145	na	na	366	(± 128)	na	na
99-00	293	(238-372)	32.0	453	(± 21)	89.3	na
00-01	550	(465-657)	18.3	334	(± 15)	91.2	0.7
01-02	1,471	(1,216-1,794)	7.5	834	(± 205)	28.2	12.3
02-03	3,451	(3,122-3,927)	7.9	375	(± 108)	33.0	4.8
03-04	3,727	(3,220-4,441)	4.5	536	(± 111)	38.8	2.0
04-05	978	(787-1,233)	6.3	247	(± 12)	66.4	1.8
05-06	1,845	(1,458-2,392)	2.7	425	(± 141)	28.8	5.8
06-07	1,154	(831-1,658)	3.4	377	(± 103)	35.4	0.8

Table 5. Estimated number of out-migrants in age or size categories, calculated trap efficiencies, and handling mortalities measured at the juvenile migrant trap at river kilometer 1.6 on the West Fork Smith River for the period January 31 – June 3, 2007. Adult cutthroat trout (> 250mm) were not estimated using mark-recapture methodology; for this and other categories with insufficient mark recoveries, number in parentheses denotes actual catch.

Species	Age (salmon) or size (trout, FL, mm) class	Estimated total migrants	Trap Efficiency	Handling mortalities [a]
Coho	smolts (age 1+)	22,504	0.21	6
	fry (age 0)	30,471	0.05	14
Chinook fry	age-0	40,965	0.26	65
Trout fry	< 60	(546)		1
Steelhead	> 120	6,324	0.04	1
	90 – 119	861	0.20	0
	< 60 - 89	(28)		0
Cutthroat	≥ 250	(10)		3
	160 – 249	(64)		0
	120 – 159	945	0.07	1
	90 - 119	(5)		0
	60 - 89	(3)		0

[a] handling mortalities only; an additional 20 coho smolts were sacrificed for Idaho State University for parasite identification

West Fork Smith River Monitoring Summary: 1998-2007

Coho Salmon

The 1998 brood year was the first brood for which the size of the parent stock and number of eggs deposited was estimated, and thus represents the first brood for which freshwater survival rate could be calculated. Adult coho salmon that returned to the West Fork Smith River in fall 1999 (1996 brood year) represent the first spawners for which the number of smolts that produced these adults was estimated, providing the first opportunity to calculate marine survival rate for this stock. For these and subsequent broods, calculated freshwater and marine survival rates are summarized in Table 7, and trends in these parameters are shown in Figure 5.

Table 8 summarizes data collected on downstream-migrating populations of juvenile coho salmon at the juvenile fish trap. Peak migration generally occurred between mid-April and mid-May, and was likely strongly influenced by patterns of stream flow and water temperature. Trends in coho salmon smolt out-migrants are also shown in Figure 5c.

Figure 6a shows the relationship of number of coho fry and smolt migrants to size of spawner stock. The relationship of fry migrants to spawners displays a close linear correlation, with increased spawner levels corresponding to proportionate increases in fry migrants. When viewed as number of fry migrants per parent, there is relatively little variation in this parameter over a broad range of spawner levels (Figure 5b). This suggests that, within the range of seeding levels observed, a proportion of fry produced from each female tends to move downstream, irrespective of seeding level.

Table 7. Estimated number of female spawners, egg deposition, fry and smolt production, number of wild returning adults, and freshwater (FW) and marine survival rates for coho salmon in the West Fork Smith River. Brood year represents the first year that eggs were deposited for a return year (eg. the 1996 brood year was derived from the 1996-1997 return year, and this brood returned as adults in 1999-2000). Percent freshwater survival represents the number of smolts produced from the estimated number of eggs deposited. Percent marine survival was calculated using number of smolts produced minus handling mortalities.

Brood year	Female spawners Wild	Female spawners Hatchery	Egg deposition [a]	Fry	Smolts	Returning adults (wild) female	Returning adults (wild) male	Percent survival FW	Percent survival marine
1996					22,412	131	164		1.3
1997				2,527	10,866	273	280		5.1
1998	72	0	205,405	3,014	14,851	707	734	7.2	9.8
1999	130	0	376,545	3,605	20,091	1,521	1,926	5.5	17.3
2000	271	0	721,450	13,550	17,358	1,790	1,940	2.4	21.7
2001	707	15	2,044,536	35,851	15,849	417	561	0.8	6.2
2002	1,520	4	4,853,940	80,876	23,054	723	1,095	0.5	7.9
2003	1,787	0	5,130,275	104,402	39,576	465	688	0.8	2.9
2004	417	0	1,169,503	27,598	23,242			2.0	
2005	734	0	1,841,711	36,621	22,504			1.2	
2006	464	2	1,292,703	30,471					

[a] the number of eggs deposited by each female was estimated using the formula: $\sum$ 7.96 * (fork length of female in mm) – 2854. This formula is based on the relationship between length of female coho salmon and fecundity developed from hatchery fish returning to Fall Creek hatchery in the Alsea basin (Johnson 1988).

There is no significant linear correlation between female spawners and smolt production (Figure 6a). In addition to seeding levels and egg to fry survival rates, smolt production is influenced by variables that determine survival of parr during summer and winter. These variables include summer water temperatures, winter stream flows, density of parr and competition between cohorts and other species, and level of parasite infestation. Survival of a cohort is influenced by each variable to greater or lesser degrees each year, thus a linear relationship would not be expected. Despite a lack of a clear correlation between total smolts and spawners, smolt production shows relatively little variation over a broad range of spawners (Figure 6a). Figure 6b shows a close non-linear correlation between number of smolts produced per female and spawner stock, with highest production rates found at low spawner densities. This suggests survival of one or more life-history stages may be density dependent, and by inference, habitats essential to specific life-history stages may be limited.

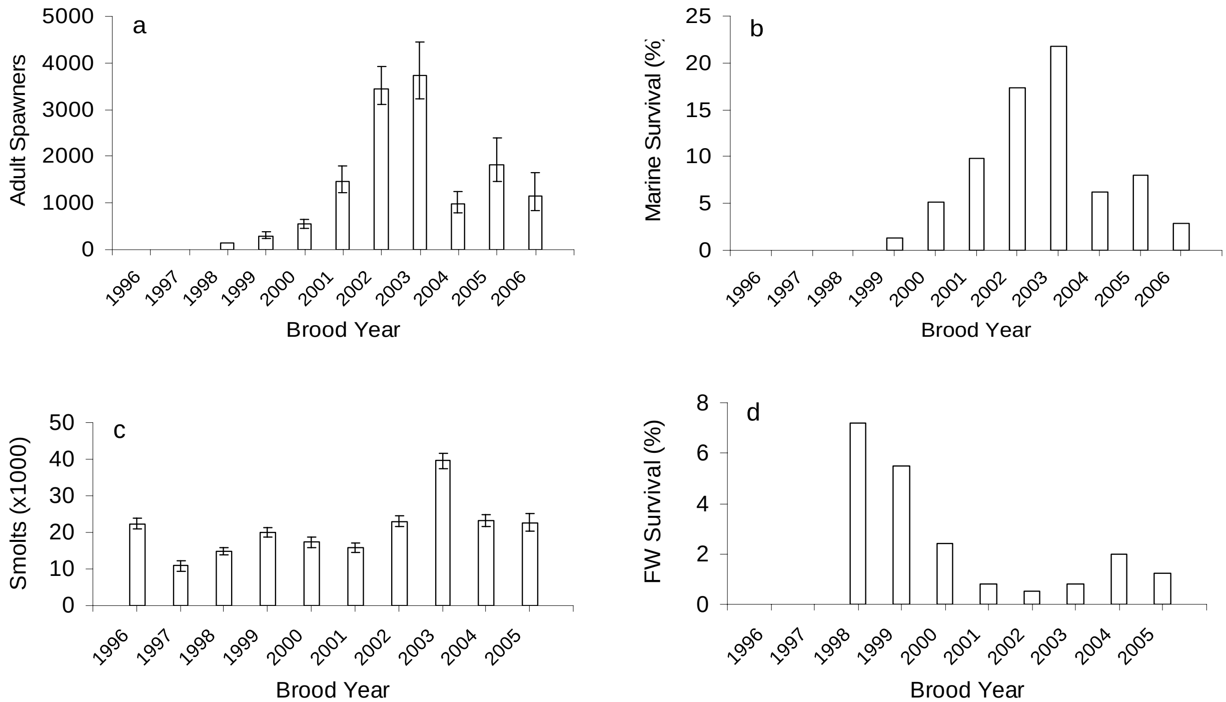

Figure 5. Trends in (a) estimated number of adult spawners, (b) percent marine survival, (c) smolts, and (d) percent freshwater survival for coho salmon in the West Fork Smith River. Error bars show the 95% confidence interval. Marine survival estimates are for the total wild adults returning to spawn from smolts produced from the corresponding brood year. Calendar year of smolt outmigration is brood year +2 years. Calendar year of adult return for marine survival estimate is brood year + 3 years. Freshwater survival (egg to smolt) is based on the estimated number of eggs deposited from the parent spawner population.

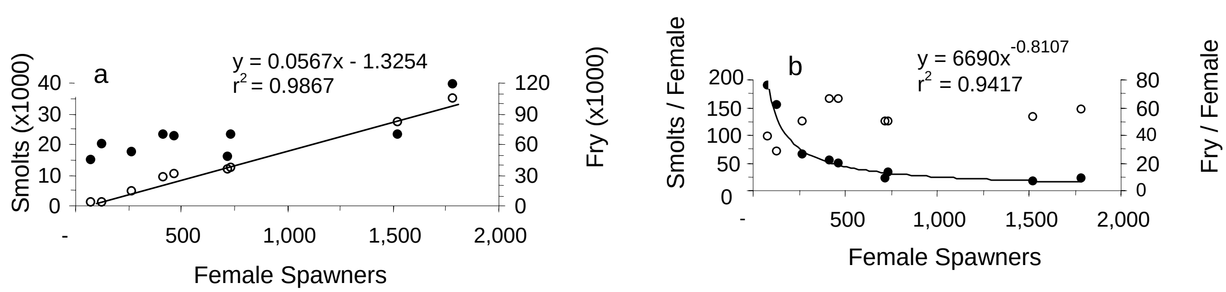

Figure 6 . Relationship of number of fry and smolt migrants to size of spawner stock; (a) total smolt (solid symbol) and fry (clear symbol, regression line shown) migrants produced, to total female spawners; and (b) numbers of smolt (solid symbol, regression line shown) and fry (clear symbol) migrants produced per female, to total female spawners. Regression formulae and r^2 values are for respective trendlines shown.

Table 8. Estimated number of coho salmon smolt and fry migrants, week of peak migration for smolts, and mean fork length of smolts during week of peak migration in the West Fork Smith River. Data for smolts represents fish sampled in the second year following egg deposition (eg. fish sampled in 1998 were the 1996 brood year). Data for fry represents fish sampled the first year following egg deposition. Ninety five percent confidence intervals (CI) are shown.

Sample Year	Smolts ± CI			Fry ± CI			Peak Week	Mean FL (mm) ± CI		
1998	22,412	±	1,584	2,527	±	1,224	4/20-4/26	104.6	±	4.2
1999	10,866	±	1,465	3,014	±	658	5/17-5/23	113.0	±	3.5
2000	14,851	±	1,088	3,605	±	752	4/10-4/16	103.0	±	4.4
2001	20,091	±	1,337	13,550	±	3,557	4/23-4/29	112.1	±	4.3
2002	17,358	±	1,460	35,851	±	5,628	5/06-5/12	112.5	±	2.8
2003	15,849	±	1,239	80,876	±	11,360	5/05-5/11	109.2	±	4.1
2004	23,054	±	1,523	104,402	±	7,963	4/12-4/18	105.4	±	3.8
2005	39,576	±	2,038	27,598	±	3,515	5/02-5/08	110.0	±	5.0
2006	23,242	±	1,550	36,621	±	5,551	5/01-5/07	107.0	±	4.0
2007	22,504	±	2,375	30,471	±	13,585	4/23-4/29	112.0	±	3.0

Winter Steelhead

Marine survival estimates are not calculated for winter steelhead because the spawning population is composed of multiple ages, including fish that may be on a second spawning migration. In addition, the steelhead smolt population in any year may be comprised of different brood years.

Estimated numbers of juvenile steelhead migrants are summarized by size class in Table 9.

Cutthroat Trout

Picket spacing in the floating weir and adult trap in the West Fork Smith River is too wide to effectively retain adult cutthroat trout. Live adults and cutthroat trout redds are counted on spawner surveys, but counts are generally too low to make population estimates using area-under-the-curve calculation.

Estimated numbers of juvenile cutthroat trout migrants are summarized by size class in Table 10. The predominant size classes are fish 120-159 mm and 160-249 mm fork length, although there is considerable variation between years in each size class.

Table 9. Estimated number of juvenile steelhead smolts (≥ 120mm fork length), week of peak smolt migration, mean fork length at peak week, and number of pre-smolt migrants in the West Fork Smith River. Number of fish caught is reported in parentheses when trap efficiency could not be determined for a particular category.

Sample Year	Smolts ± CI			Peak week	Mean FL (mm) ± CI			90-119 (mm) ± CI			60-89 (mm) ± CI		
1998	6,438	±	1,286	4/20-4/26	168.9	±	7.9	761	±	225	27	±	26
1999	2,688	±	846	5/03-5/09	160.9	±	6.8	66	±	86	(10)		
2000	2,836	±	593	5/01-5/07	152.6	±	4.3	193	±	49	1,675	±	1,030
2001	2,737	±	1,338	3/26-4/01	147.5	±	6.5	3,883	±	507	620	±	131
2002	4,681	±	3,558	4/08-4/14	148.8	±	7.5	769	±	513	(10)		
2003	2,448	±	4,306	4/21-4/27	158	±	10	(75)			159	±	111
2004	2,916	±	1,847	4/12-4/18	153.7	±	8.3	1,138	±	410	236	±	158
2005	4,333	±	1,382	3/21-3/27	145	±	7.0	752	±	227	73	±	68
2006	3,840	±	1,504	4/10-4/16	160.0	±	8.0	582	±	213	96	±	163
2007	6,324	±	5,258	4/09-4/15	156.0	±	8.0	861	±	316	(28)		

Table 10. Estimated number of cutthroat trout downstream migrants by size class (± 95% CI) in the West Fork Smith River. Number of fish caught is reported in parentheses when trap efficiency could not be determined for a particular category. No estimates were made in 1998 and 1999 when cutthroat trout in the Umpqua basin were listed as a threatened species under federal 4(d) rules.

Sample year	Fork Length 160-249mm			120-159mm			90-119mm			60-89mm
1998	(192)			(4)			0			0
1999	--			--			--			--
2000	947	±	581	1,148	±	439	(11)			(1)
2001	901	±	251	1,633	±	377	472	±	406	(31)
2002	2,417	±	982	2,748	±	985	(3)			(1)
2003	1,235	±	2,177	(70)			(4)			(5)
2004	713	±	815	135	±	136	(2)			(7)
2005	898	±	646	724	±	454	(2)			0
2006	2,304	±	1,118	1,587	±	471	(8)			(1)
2007	(64)			945	±	1,615	(5)			(3)

Other Species

Total number of select non-salmonid fishes trapped is shown in Table 11. Pacific lamprey captured included both pre- and post-spawned adults. Almost all western brook lamprey were post-spawned. Sculpin (*Cottus* spp.) were also caught in low numbers.

Table 11 . Number of Pacifc and brook lamprey, speckled dace, Umpqua dace, redside shiner, largescale sucker and pikeminnow captured at the West Fork Smith River fish trap, river kilometer 1.6. Numbers represent actual catch; trap efficiency was not measured for these species. Eyed juvenile lamprey are Pacific lamprey that have completed metamorphosis to the life-history stage that is migrating seaward; eyed juveniles were not distinguished from ammoecoetes in 1998 and 1999. Western brook lamprey were not distinguished prior to 2003. Umpqua dace were not distinguished from speckled dace during 1998 through 2001.

	Pacific lamprey			Brook	Speck.	Ump.	R.S.	L.S.	Pike-
Year	Adult	Amm.	Eyed	lamprey	dace	dace	shiner	sucker	minnow
1998	22	585[a]	--	--	7,637[b]	--	913	100	2
1999	1	327[a]	--	--	2,975[b]	--	265	97	0
2000	21	648	32[c]	--	2,440[b]	--	322	85	0
2001	54	144	114[c]	--	5,194[b]	--	271	167	0
2002	4	300	17[c]	--	2,298	45	379	50	4
2003	0	216	7	45	2,830	52	200	10	4
2004	4	309	8	93	4,292	71	974	35	1
2005	7	749	81	74	4,879	103	1,117	21	2
2006	4	405	3	69	5,193	141	1,576	59	0
2007	1	219	0	142	5,133	65	517	71	0

[a] may include some eyed lamprey juveniles
[b] may include some Umpqua dace
[c] may include some western brook lamprey

Western Brook Lamprey Spawner Surveys

Introduction

The natural history and status of lamprey species in Oregon were reviewed by Kostow (2002), where the author noted that poor information on species identity and lack of a systematic monitoring program were major impediments to management of these species. The non-parasitic western brook lamprey (*Lampetra richardsoni*) is thought to be the second most common species in the state and occurs coast-wide, with a distribution extending into the Willamette and Columbia basins (see Figure 2 in Kostow, 2002). The species was petitioned for listing under the ESA in 2003, with petitioners noting the species being vulnerable to habitat losses due to reduced river flows, water diversions, dredging, streambed scouring, channelization, inadequate protection of stream side vegetation, chemical pollution, and impeded passage (ODFW 2006). The species is currently not protected by federal laws (Federal Register, 69 (27 December 2004) 77158-77167), and details of habitat use are among the critical data gaps that limit a fuller status assessment.

Details of behavior and life history stages are cited in Kostow (2002) and Gunckel et al. (2006) and references therein, and will not be repeated here. There have been recent attempts to implement systematic monitoring at the basin scale, using the site selection process of EPA's Environmental Monitoring and Assessment Program (EMAP) protocols (Dias-Ramos et al. 1996, Stevens 2002). Gunckel et al. (2006) adapted an EMAP sampling frame used for salmonids to choose sites (survey reaches) for lamprey surveys in the Smith River Basin in 2004-2005, where they examined spawning distribution, redd characteristics, and habitat associations. In spring 2007 the ODFW Life Cycle Monitoring Project conducted western brook lamprey spawning surveys in the West Fork Smith River basin, and results are reported below.

Methods

Site Selection

In this report we use "Sections" to delineate stream reaches that were surveyed for lamprey spawning in 2007, and "Reaches" to refer to winter habitat inventory surveys (following convention in Moore et al. 2006) that we conducted in 2002 and 2005. Spawning surveys for western brook lamprey conducted in 2004 and 2005 by Gunckel et al. (2006) included three sections in three tributaries and five sections of the mainstem in the West Fork Smith River. In 2007, we surveyed two of the same sections within the tributaries and four of the same sections in the mainstem (Table 12). We also surveyed a section of lower Moore Creek (Section 1), three sections in Beaver Creek (Sections 1-3), a south-slope tributary located between Moore Creek and Beaver Creek (nominally "Tributary F"), a second south-slope tributary located above Gold Creek (nominally "Tributary H"), and a portion of Section 3 of the upper mainstem West Fork Smith River (Figure 7). The sections in Moore Creek, Beaver Creek, and Section 3 of the mainstem were the same as those surveyed by the ODFW Life Cycle Project in spring 2006 when winter steelhead spawner surveys were continued for an additional three weeks to document spawning activity of western brook lamprey.

Two survey sections had natural barriers to fish passage. Tributary F is isolated from the mainstem by a natural 5m waterfall, and the upper portion of Moore Creek Section 2 has a persistent log-jam that blocks fish passage at all but high stream flows. Tributary H was isolated from the mainstem by a culvert prior to 2002, when the culvert was removed.

Spawning and Habitat Surveys

Surveys for western brook lamprey spawner activity were conducted from mid-April through May, 2007. Individual redds were flagged and mapped by recording the survey date and number of the nearest upstream 50m marker. Numbered markers were previously established throughout the watershed at 50m intervals to facilitate mapping. For each discrete redd we recorded redd dimensions, water column depth, associated habitat unit data, percentage of substrate types (within the habitat unit), and presence of spawning adults. Contiguous redds were designated as clusters, and within clusters we noted the number of redds and associated spawning adults.

Aquatic inventory surveys that characterized the broader winter habitat attributes within the major tributaries and the mainstem of West Fork Smith River were completed in 2002 and 2005 (following methods in Moore et al. 2006). These surveys did not include tributaries F and H, but in 2007 we conducted a habitat survey of the lower 900m of Tributary H. We did not observe any spawning activity or fish presence in Tributary F, and therefore no habitat survey was conducted in this tributary.

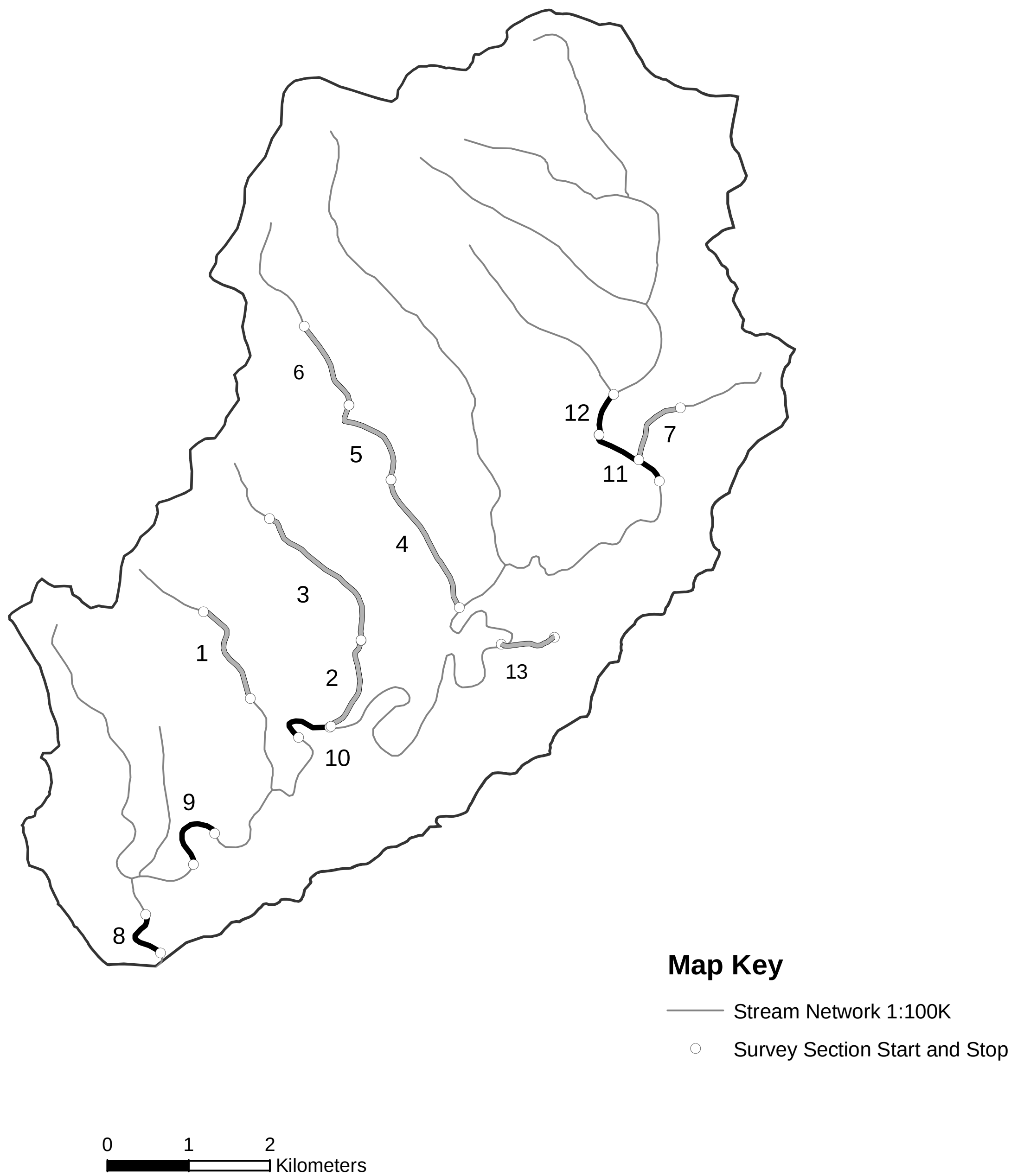

Figure 7. Location of western brook lamprey survey sections in 2007 within the West Fork Smith River basin above the ODFW Life Cycle Monitoring site. Numbers on map indicate individual survey sections, summarized in Table 12. Gray lines are tributary survey sections and black lines are mainstem survey sections.

Results

Table 12 summarizes spawning survey effort and redd counts. Highest redd densities were observed in lower Moore Creek (Section 1) and Tributary H. No redds or fish of any species were observed in Tributary F. The waterfall at the mouth of Tributary F blocks all passage for anadromous fish, and there is no apparent resident population of fishes in the lower portion of that tributary. In Section 2 of Moore Creek, redd density varied above and below a large log jam located 1.9 km above the mouth that blocks fish passage at all but high stream flows; redd density was 6.15 x (m^{-2} x 10^3) in the 750m reach below the barrier, and 0.82 x (m^{-2} x 10^3) in the 1,250m reach above the barrier. This suggests that natural barriers may influence distribution of western brook lamprey within stream reaches that otherwise have suitable spawning habitat.

Clusters of two to five contiguous redds comprised 30% of total redds counted. Most clusters observed (61%) contained spawning adults, with as many as nine adults within a cluster. Clusters of two to five contiguous redds were also noted by Gunckel et al. (2006).

Redd attributes, and proportions of habitat units and substrates used for spawning are summarized in Figure 8. There was no significant difference in redd dimensions between tributaries and mainstem sections (Figure 8a; two-sample t-test, $P \geq 0.15$). Pool tail-outs and riffles, two habitat unit types that are shallow and gravel-rich, encompassed 73.4% of redds observed in tributaries and 76.7% in the mainstem (Figure 8b). This is consistent with other survey sites within the Smith River basin, where 68.5% of western brook lamprey redds were found in these same habitats (Gunckel et al. 2006). The dominant substrate type within the two most-used habitat units was gravel, consistent with the requirement for suitable pea-sized gravel for digging a redd (Figure 8c).

Figures 9 and 10 show proportional distribution of redds within spawning survey sections, and corresponding proportions of two predominant habitat units used for spawning, pool tail-outs (as measured by percent scour pool) and riffles. Proportions of habitat units were taken from winter habitat survey data for reaches that overlapped spawning section surveys. Also included is mean percent gravel within a habitat reach. The relative proportions of pool and riffle habitat units varied between tributary reaches, with pools being predominant in Beaver Creek, and riffles forming a higher percentage in the other tributaries (Figure 9). In the mainstem, riffles were the major habitat unit in survey reaches, but the percentage of pool habitat units was highest within the reach overlapping the spawning section containing the highest redd density, Section 3 of the headwaters (Figure 10).

The habitat characteristic that best corresponded to redd density was mean percent gravel. Linear regressions of mean percent gravel on redd density within the tributaries and the mainstem indicated a significant relationship in both cases ($p \leq 0.05$, Figure 11).

Table 12. Summary of western brook lamprey surveys and total number of redds observed in the West Fork Smith River basin, 2007. Markers were spaced at 50m intervals. Redd densities were calculated using mean wetted channel width following ODFW Aquatic Inventory Project winter habitat survey protocol.

	Section	Map Label	Markers	Length (M)	N of Surveys	N of Redds	Redds/m^2x10^3
Tributaries							
Crane Cr [a]	2	1	24 - 54	1500	5	18	2.64
Moore Cr	1	2	1 - 23	1150	5	44	9.81
	2	3	24-63	2000	5	22	3.02
Tributary F		13	na	~600	7	0	
Beaver Cr	1	4	1 – 40	2000	5	31	2.83
	2	5	41 - 65	1250	5	39	6.25
	3	6	66 - 88	1150	5	13	3.33
Tributary H		7	1 - 18	900	8	34	15.42
Mainstem							
Above adult trap [a]		8	43 - 64	1062	6	8	0.31
Coon Cr reach[a]		9	86 - 106	1027	5	10	0.61
Below Moore Cr [a]		10	A155 - B14	1000	5	7	0.5
Headwater[a]	2	11	95 - 116	1076	6	34	3.42
Headwater	3	12	116 - 126	500	6	19	4.31

[a] Reach was also surveyed for western brook lamprey spawning activity in 2004 or 2005 (Gunckel et al. 2006)

Discussion

Several factors that may influence identification of redds and accuracy of counts were noted by Gunckel et al. (2006). These included the observation that lamprey may move small gravel and cobble from upstream into the redd depression until it is filled and flush with the substrate surface, making them difficult to detect. A second observation was that western brook lamprey may occasionally dig redds within the larger redd depressions made by Pacific lamprey. However, In the West Fork Smith River, counts of Pacific lamprey redds were very low in the tributaries and most sections of the mainstem, and redd superimposition is likely a minor source of error in redd counts. Third, redds could easily be confused with elk tracks, but we were careful to distinguish "apparent" redds from depressions that were likely elk tracks based on presence of nearby tracks on the bank, or disturbed vegetation at an obvious stream crossing. We included "apparent" redds in our counts that did not have spawning adults present, in contrast to the more conservative Gunckel et al. (2006) counts, which included only redds where adults were present. An additional source of error that we noted may occur from confusion with depressions made by spawning cutthroat trout, which make similar-sized redds. However, cutthroat trout and lamprey construct redds in different manners, resulting in depressions that differ in shape; we were careful to distinguish between redds constructed by these species. These combined potential sources of error make it difficult to make total redd counts with high confidence.

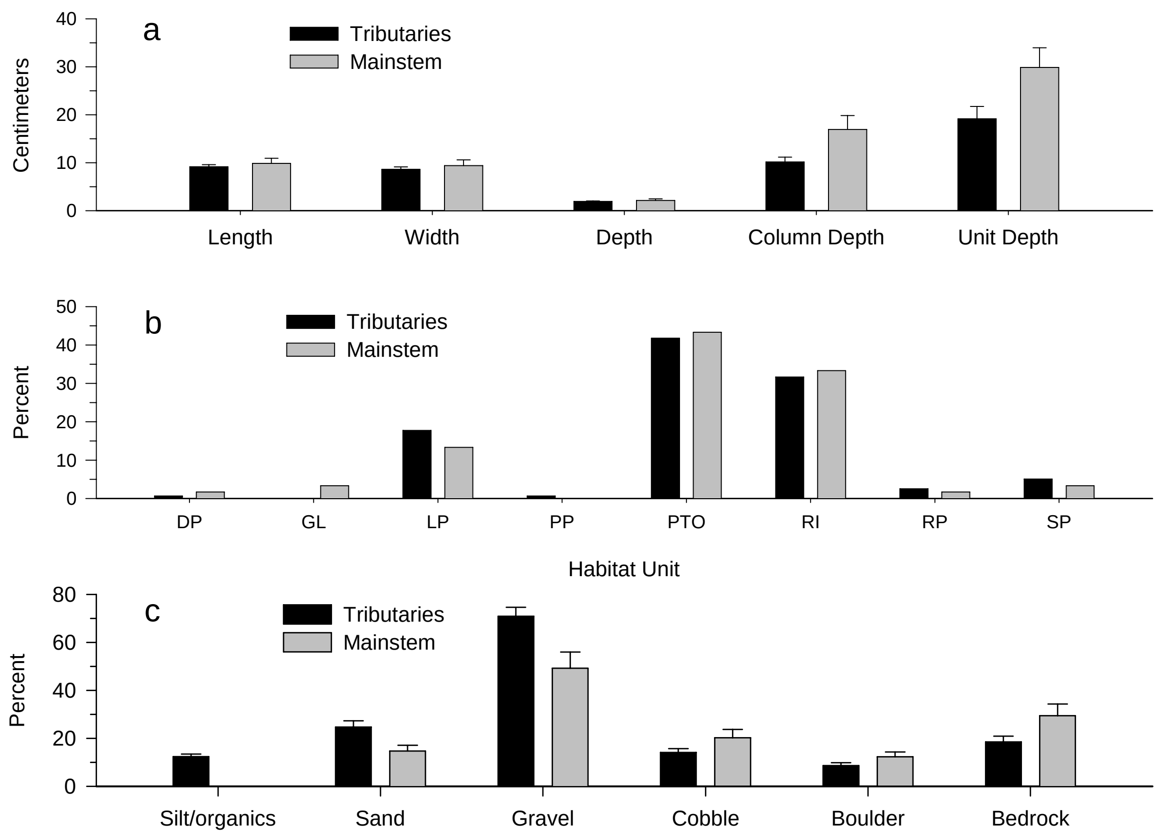

Figure 8. Summary of redd attributes and habitat features from spawning surveys for western brook lamprey in West Fork Smith River basin in 2007. Panel "a" shows redd attributes, where column depth is the mean water depth at redd, and unit depth is the mean maximum water depth of the habitat units containing redds. Panel "b" shows proportions of habitat units used for spawning activity, including dammed pool (DP), glide (GL), lateral scour pool (LP), plunge pool (PP), pool tail-out (PTO), riffle (RI), riffle with pockets (RP), and straight scour pool (SP). Panel "c" shows proportions of substrate type found within habitat units used for spawning activity. Error bars depict 95% confidence intervals.

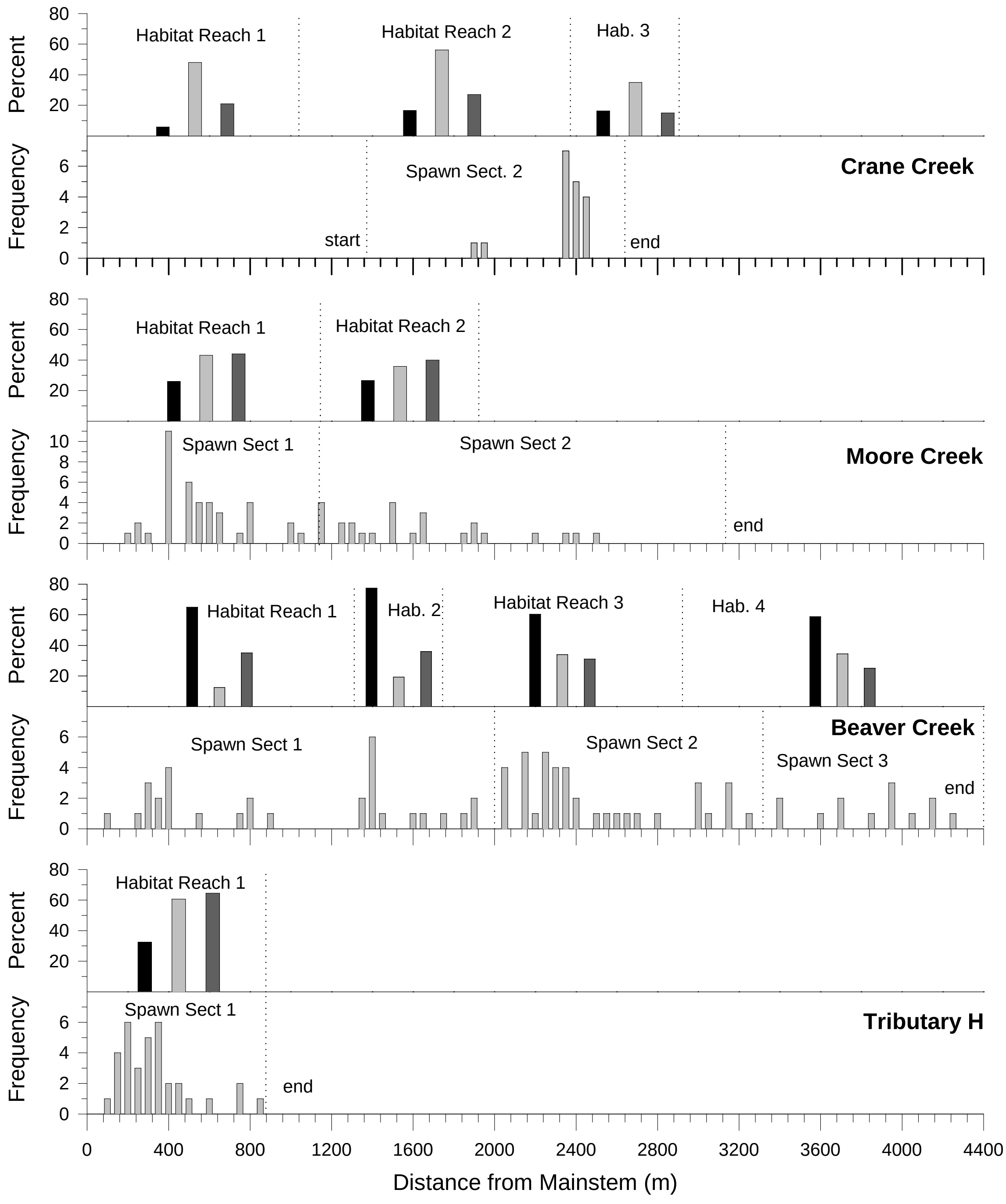

Figure 9. Winter habitat attributes estimated in 2002, 2005, and 2007 (for Tributary H) using methods in Moore et al. (2006), and western brook lamprey redds recorded in 2007 for four tributaries of the West Fork Smith River. Upper plot for each tributary is reach-specific habitat data for the proportion of reach that was scour pools (black bar) or riffles (light gray bar), and mean percent gravel (dark gray bar) within all habitat types for each reach. Lower plot for each tributary displays frequency of lamprey redds across the surveyed length of the tributary, partitioned by survey sections. Dotted lines denote start and end points for surveys.

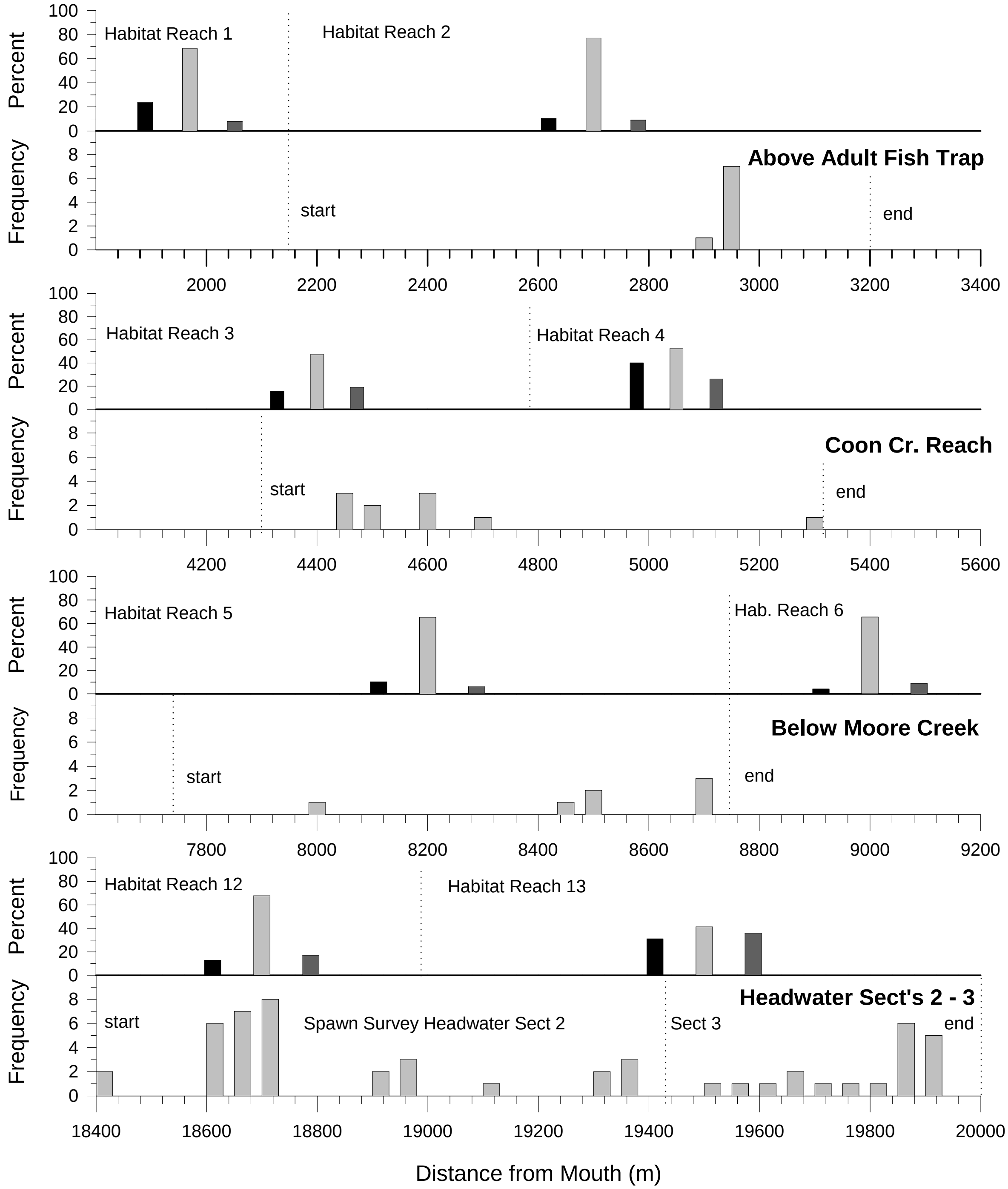

Figure 10. Winter habitat attributes estimated in 2002 and 2005 using methods in Moore et al. (2006), and western brook lamprey redds recorded in 2007 for five mainstem areas of the West Fork Smith River. Upper plot for each area is reach-specific habitat data for the proportion of reach that was scour pools (black bar) or riffles (light gray bar), and mean percent gravel (dark gray bar) within all habitat types for each reach. Lower plot for each tributary displays frequency of lamprey redds across the surveyed length of the tributary, partitioned by survey sections. Dotted lines denote start and end points for surveys.

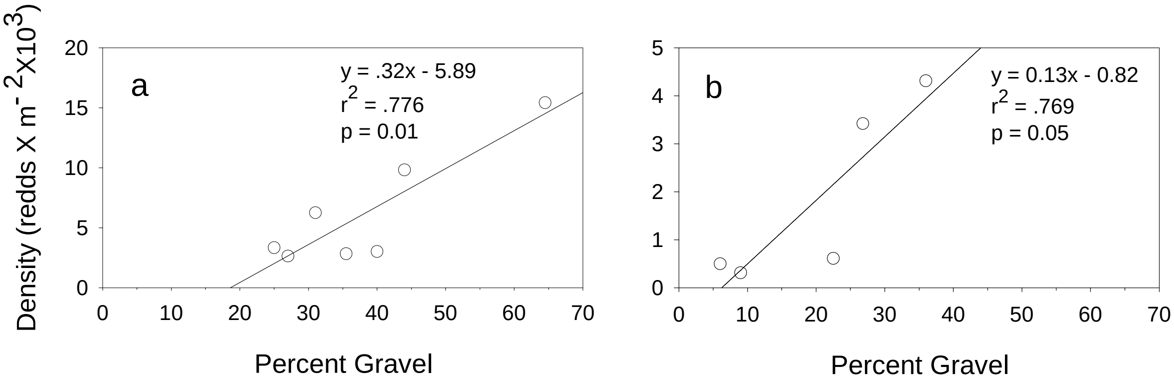

Figure 11. Regression results comparing relationship of percent gravel within habitat survey reaches to density of western brook lamprey redds in (a) three tributary and (b) five mainstem spawning survey sections of the West Fork Smith River.

Gravel is associated with both riffle and scour pool tail-outs, among other habitat types. The apparent correlation of gravel abundance and redd density suggests that spawner distribution and success may be influenced by the nature of riffle and scour pool habitats. Retention of gravel resulting from increased habitat complexity, either from natural causes or instream enhancement projects, is likely to increase spawning habitat available for lamprey. On the other hand, the ammocoete stage requires finer sediment for the four to six year juvenile phase. Smaller ammocoetes rear in fine sediment in shallow water during the first one to two years, and larger ammocoetes use coarser, high-organic sediments in deeper water prior to metamorphosis (Kostow 2002). It is not clear which life-history phase controls population levels, but a stream network with high habitat complexity will provide the full range of habitat types necessary for each life-history stage.

Acknowledgements

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