Summary of Habitat and Fish Monitoring Data From East Fork and Upper Mainstem Lobster Creeks: 1988-2000

Since 1988, the Oregon Department of Fish and Wildlife (ODFW) has been monitoring the smolt production, adult returns, summer abundance of juvenile salmonids, and stream habitat in East Fork and Upper Mainstem Lobster Creeks, in the Alsea watershed (Figure 1). The primary purpose of this monitoring is to study the affects that stream habitat modification has on the freshwater survival and abundance of coho salmon (*Oncorhynchus kisutch*). This work has been partially funded by the Bureau of Land Management's (BLM) Salem District Office since 1996. The purpose of this report is to provide BLM with an update of ODFW's sampling in East Fork and Upper Mainstem Lobster Creek during the 1999-00 sampling season and to put these data in context with past data collected by ODFW.

Habitat

The watershed characteristics of the two study streams are shown in Table 1. In 1991, extensive instream habitat modification was conducted by the BLM in Upper Mainstem Lobster Creek. A detailed description of the effects of this habitat modification on smolt production may be found in Solazzi et al. (2000). Peak annual streamflows in East Fork Lobster Creek from 1986 to 1997 are shown in Table2. During the February 1996 flood, a number of large debris torrents entered Upper Mainstem and significantly impacted the habitat structures resulting in the loss of considerable overwinter habitat for juvenile coho salmon. Similar high streamflows in the winter of 1998-99 caused significant channel changes in East Fork Lobster Creek. In the summer of 1999, the BLM used 65 pieces of large wood with a total volume of 265m^3 to created seven in channel debris jams in East Fork.

Table 1. Watershed characteristics of East Fork and Upper Mainstem Lobster Creek.

Stream	Basin Area (km^2)	Stream Length (km)	Mean summer wetted width (m)	Average gradient (%)
E.F. Lobster Cr.	14.2	3.5	3.5	4.0
U.M. Lobster Cr.	12.4	4.7	3.2	2.6

Table 2. Peak annual streamflow above base flow in East Fork Lobster Creek, 1986-1999.

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Peak Discharge (ft^3/sec)	375	603	N/A	430	468	N/A	282	313	551	N/A	1360	334	N/A	N/A

Since 1988 we have conducted instream habitat surveys using the methods of Hankin and Reeves (1988). Surface area for each habitat unit was visually estimated, and every tenth unit was measured to calibrate the visual estimates. In addition, we classified the substrate in each habitat unit by visually estimating the percentage of each category of substrate present. Substrate

composition was separated into the following categories: clay (extremely fine sediment that is tightly packed), silt (fine sediment often containing a large proportion of organic material that when disturbed will become suspended in the water column); sand (<0.2 cm); gravel (particles between 0.2 and 6 cm. in diameter); cobble (6 to 25 cm.); small boulders (26 to 100 cm.); large boulders (>100 cm); and bedrock. We also measured the maximum depth of each pool, and estimated the surface area of undercut bank, the percent of the stream channel shaded by riparian vegetation, and the wood complexity for each habitat unit. Wood complexity was estimated on a scale of 1-5 using the following criteria: 1) no wood present; 2) some wood present, but it provides little refuge from predators or fast water velocity; 3) moderate amount of wood present, providing fair refuge; 4) moderate to large amount of wood present, providing good refuge; and 5) moderate to large amount of wood present, providing excellent refuge.

Summaries of habitat surveys conducted in East Fork Lobster Creek are shown in Table 3. The surface area of glides and all pools were lower in 2000 than the 13- year average for East Fork Lobster Creek. Riffle area was higher than the average. Summaries of habitat surveys conducted in Upper Mainstem Lobster Creek are shown in Table 4. Surface areas of all habitat types except lateral scour, straight scour and rapids were lower than the 13- year average. Most of the loss of pool habitat in Upper Mainstem was due to the effects of the 1996 flood that removed many of the instream habitat restoration structures.

Juvenile Salmonid Summer Population Estimates

After completing the habitat surveys, we estimated the number of young-of-the-year coho salmon, young-of-the-year trout (steelhead and cutthroat combined), age 1+ steelhead trout, and age 1+ cutthroat trout rearing in each stream. To estimate the number of fish rearing in the pools, we (1) estimated the mean number of fish per pool by snorkeling every third pool, (2) adjusted the mean fish per pool estimate by a calibration factor derived from electrofishing population estimates in a subset of the snorkeled pools, and then (3) multiplied this adjusted mean by the total number of pools in the stream (Hankin and Reeves 1988). Snorkel estimates were impractical in habitat with shallow depths. Therefore, we estimated the mean density of fish for a subset of glide, riffle, and rapid habitats by electrofishing. For each habitat type, we then multiplied this mean density by the surface area of the habitat type in the entire stream (Hankin 1984).

We estimated the population size for each species and size group of juvenile salmonid in each sample unit by using either a mark-recapture estimate (Chapman 1951) or a removal estimate with two or more passes (Seber and LeCren 1967). Mark-recapture estimates were generally used in pool habitat that was characterized by high levels of wood complexity or presented special

Table 3. Habitat survey results for East Fork Lobster Creek, 1988-2000.

Habitat Variable	1988	1989	1990	1991	1992	Year 1993	1994	1995	1996	1997	1998	1999	2000	Average
Glide (m^2)	1,252	2,108	2,737	1,474	912	1,842	1,144	1,635	1,801	1,259	781	735	804	1,422
Cascade (m^2)	32	0	39	0	0	32	30	0	0	28	0	50	0	16
Rapid (m^2)	1,965	1,948	4,398	4,723	3,933	6,132	2,678	1,915	1,433	6,187	4,756	5,445	3,350	3,759
Riffle (m^2)	3,257	2,428	1,847	1,849	1,662	3,046	3,900	5,479	4,392	2,860	4,532	2,707	6,143	3,392
Lateral Scour Pool (m^2)	2,160	2,075	2,710	3,048	2,753	2,613	1,990	1,397	2,440	2,355	2,440	2,361	2,239	2,352
Plunge Pool (m^2)	0	344	667	340	238	234	133	214	113	65	52	19	35	189
Alcove Pool (m^2)	166	12	0	91	281	270	28	11	10	0	0	0	0	67
Dam Pool (m^2)	1,673	1,273	168	170	145	354	211	0	82	25	0	169	115	337
Beaver Dam Pool (m^2)	2,885	1,759	687	1,081	1,160	1,622	991	263	273	463	458	369	430	957
Trench Pool (m^2)	585	716	62	60	60	30	40	0	0	0	47	15	17	126
Straight Scour Pool (m^2)	1,299	1,575	1,661	2,454	1,893	2,690	2,109	1,810	924	2,370	2,692	1,299	937	1,824
Backwater Pool (m^2)	0	22	231	52	105	318	187	147	0	44	70	23	99	100
Isolated Pool (m^2)	0	0	211	204	244	193	91	108	245	241	195	167	134	156
% Clay	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0	0.0
% Silt	N/A	5.1	4.2	5.8	7.4	7.3	7.0	4.4	1.2	7.3	4.9	2.1	1.3	4.8
% Sand	N/A	2.2	1.1	0.2	0.9	1.4	3.4	2.0	10.0	2.0	1.5	3.0	2.4	2.5
% Gravel	N/A	37.5	28.2	25.8	20.1	39.9	33.0	38.0	39.8	23.6	30.3	29.1	22.8	30.7
% Cobble	N/A	32.6	37.1	43.6	40.7	30.7	36.1	32.5	27.1	36.8	32.7	42.5	35.9	35.7
% Small Boulder	N/A	15.2	23.8	19.0	25.0	15.1	15.2	16.3	14.7	24.2	20.6	14.6	29.3	19.4
% Large Boulder	N/A	0.6	0.1	0.3	0.2	0.4	0.3	0.4	0.1	0.1	3.2	0.6	0	0.5
% Bedrock	N/A	6.8	5.5	5.4	5.7	5.2	4.9	6.3	7.1	6.6	6.8	8.0	8.3	6.4
No. Large Boulders	N/A	0.8	0.6	0.9	0.7	0.5	0.6	0.2	0.7	0.8	0.4	0.8	0.7	0.6
Wood Complexity	N/A	1.7	1.9	1.8	2.0	1.7	1.6	1.6	1.6	1.6	1.4	1.7	1.6	1.7
% Shade	N/A	76.4	76.9	87.9	81.8	80.7	82.0	73.8	80.1	80.0	63.0	82.8	83.8	79.1
Width (m)	N/A	3.3	3.3	3.5	3.2	3.9	3.0	3.2	3.2	3.4	3.5	3.2	3.7	3.4

Table 4. Habitat survey results for Upper Mainstem Lobster Creek, 1988-2000.

| Habitat Variable	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Average
						Year								
Glide (m^2)	1,442	2,522	2,320	2,041	1,590	2,592	3,086	3,209	2,334	N/A	2,339	1,182	1,146	2,173
Cascade (m^2)	84	65	584	14	71	37	6	0	20	N/A	84	76	0	87
Rapid (m^2)	1,168	2,072	4,726	1,552	1,552	1,814	1,213	1,232	2,407	N/A	5,929	7,795	6,643	3,175
Riffle (m^2)	6,610	4,892	5,134	3,063	3,414	4,498	3,800	5,528	8,574	N/A	4,214	3,744	4,706	4,848
Lateral Scour Pool (m^2)	3,424	4,020	3,891	3,639	3,609	2,120	2,312	1,154	4,667	N/A	3,920	5,599	5,212	3,631
Plunge Pool (m^2)	811	891	1,243	1,573	1,228	931	832	1,288	1,141	N/A	512	657	343	954
Alcove Pool (m^2)	175	0	0	1,072	847	1,108	731	834	118	N/A	131	245	222	457
Dam Pool (m^2)	2,506	384	1,411	6,931	6,784	6,445	5,165	4,410	1,277	N/A	0	0	283	2,966
Beaver Dam Pool (m^2)	0	4,946	992	1,564	2,548	1,968	1,928	1,792	558	N/A	243	127	412	1,423
Trench Pool (m^2)	113	245	194	0	0	0	0	0	0	N/A	13	99	19	57
Straight Scour Pool (m^2)	1,552	1,579	0	1,067	985	4,017	2,553	2,851	3,664	N/A	4,049	2,655	3,950	2,410
Backwater Pool (m^2)	0	95	645	90	76	127	125	60	30	N/A	70	116	60	125
Isolated Pool (m^2)	0	0	72	41	59	58	9	14	22	N/A	112	58	23	39
% Clay	N/A	0.0	N/A	0.0	0.0	0.0	0.0	0.0	N/A	N/A	0.0	0.1	0.0	0.0
% Silt	N/A	20.1	N/A	32.9	29.8	33.8	30.0	24.0	N/A	N/A	8.5	15.6	4.1	20.6
% Sand	N/A	4.7	N/A	2.1	2.5	5.0	17.9	21.9	N/A	N/A	8.3	14.1	9.8	8.4
% Gravel	N/A	31.1	N/A	30.6	36.7	32.1	33.2	33.4	N/A	N/A	29.7	25.1	30.0	31.8
% Cobble	N/A	27.0	N/A	21.6	21.2	17.1	12.9	13.5	N/A	N/A	32.1	28.6	33.5	24.6
% Small Boulder	N/A	13.8	N/A	11.1	8.0	10.1	3.8	5.3	N/A	N/A	16.5	11.5	16.6	11.1
% Large Boulder	N/A	1.0	N/A	0.3	0.4	0.2	0.3	0.3	N/A	N/A	1.6	2.2	1.9	0.7
% Bedrock	N/A	2.2	N/A	1.5	1.5	1.7	2.1	2.3	N/A	N/A	3.3	2.8	4.1	3.0
No. Large Boulders	N/A	2.2	N/A	1.0	1.0	1.1	0.5	0.9	N/A	N/A	1.5	2.0	1.2	1.1
Wood Complexity	N/A	1.8	N/A	2.6	2.0	2.0	1.8	1.8	N/A	N/A	1.7	1.8	1.8	1.9
% Shade	N/A	78.0	N/A	75.3	72.2	88.5	82.3	74.8	N/A	N/A	64.5	59.0	65.3	76.0
Width (m)	N/A	3.0	N/A	3.3	3.1	3.9	3.1	3.4	N/A	N/A	3.3	3.7	3.8	3.3
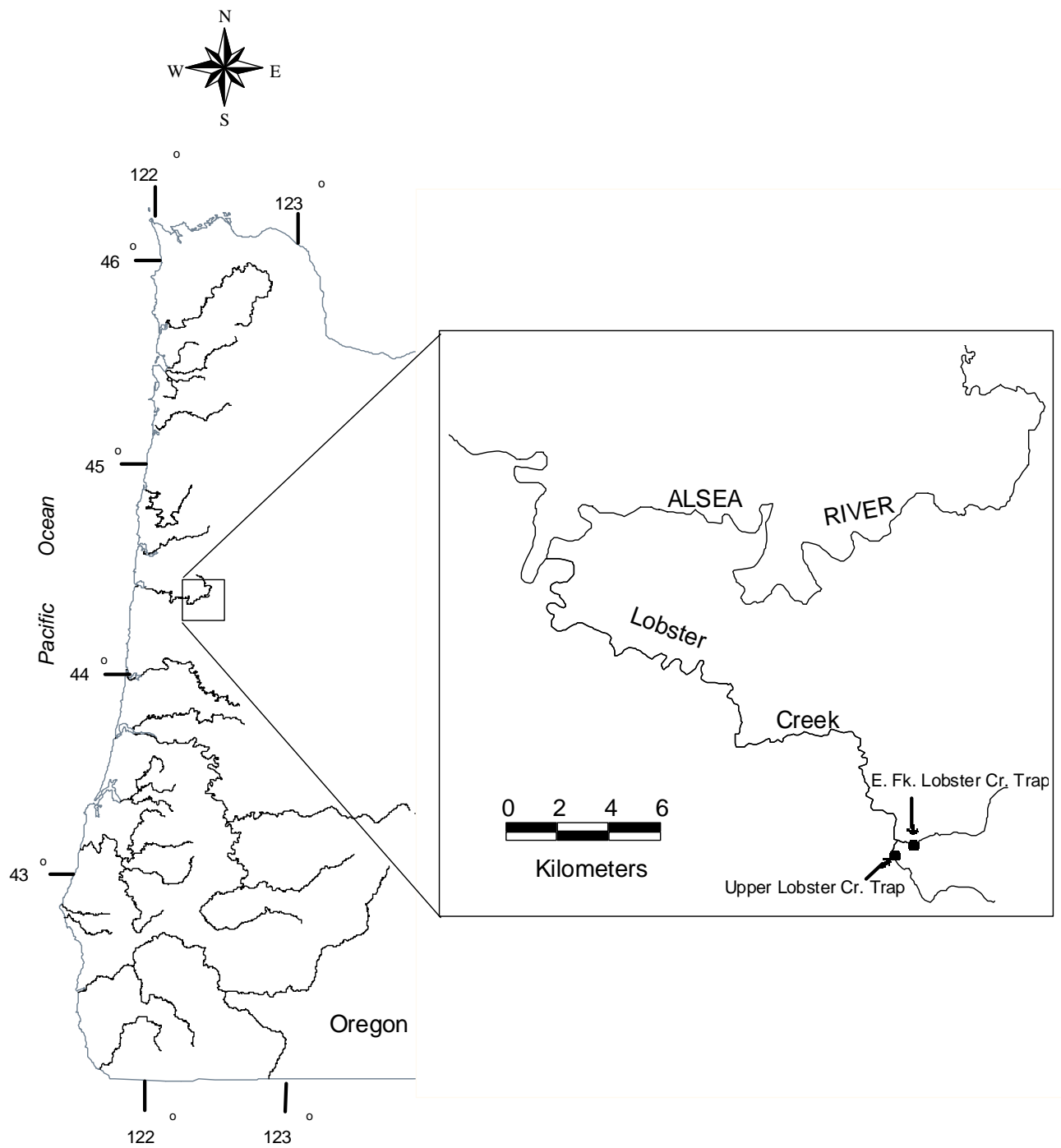
Figure 1. Locations of traps in East Fork and Upper Mainstem Lobster creeks in the Alsea Basin.

sampling problems where removal estimation methods have been shown to be less accurate (Rodgers et al. 1992). Every habitat unit was blocked by seines on both ends and sampled for juvenile salmonids using 1000-volt D.C. backpack electrofishers. Specific criteria for sampling intensity were established to control the size of the confidence interval derived from the population estimate and to prevent exposing the fish to unnecessary repeated electrofishing. When using the removal method, we continued to sample until we achieved a 50% reduction in the number of fish captured on the previous pass, if the catch on the first pass was fewer than 10 fish. If the catch on the first pass was greater than or equal to 10 fish, then a 66% reduction was required before discontinuing the sampling effort. For the mark-recapture estimates, we attempted to retrieve 50% of the marked fish released. We electrofished 9 pools and 10 riffle/rapids in East Fork Lobster Creek and 9 pools and 16 riffle/rapids in Upper Mainstem Lobster Creek during the summer of 2000.

Table 5 shows the yearly results of summer population sampling for juvenile salmonids in East Fork Lobster and Upper Mainstem Lobster Creek. Coho salmon populations in 2000 were close to the 12-year averages for both creeks.

Table 5. Juvenile salmonid population size during summer in East Fork Lobster and Upper Mainstem Lobster Creek, 1988-2000.

Brood Year	Sample Year	E.F. Lobster Creek				U.M. Lobster Creek			
		Coho	Trout <90mm	Steelhead ≥90mm	Cutthroat ≥90mm	Coho	Trout <90mm	Steelhead ≥90mm	Cutthroat ≥90mm
1987	1988	11,462	5,098	530	368	10,667	2,916	437	338
1988	1989	13,694	2,279	792	961	6,406	3,242	248	596
1989	1990	19,278	2,837	474	1,811	18,161	2,288	766	792
1990	1991	9,964	3,490	543	686	7,633	1,776	235	525
1991	1992	7,716	3,096	363	1,255	8819	2951	216	1268
1992	1993	15,842	2,298	672	2,793	23,012	1,327	148	3,337
1993	1994	6,432	2,278	468	998	15,486	2,562	150	729
1994	1995	8,085	2,884	803	583	9,619	3,357	112	1,288
1995	1996	3,767	2,355	412	592	940	2,501	520	893
1996	1997	11,055	4,619	133	444	N/A	N/A	N/A	N/A
1997	1998	4,863	3,516	667	827	6,842	3,153	909	1,018
1998	1999	2,358	5,012	578	917	1,690	10,346	806	2,296
1999	2000	8,001	5,478	800	488	9,385	4,815	1,300	788
	Average	9,452	3,480	557	979	10,159	3,508	516	1,293

Downstream Migrant Juvenile Sampling

In the spring we operate a motor driven floating scoop trap in each study stream to estimate the number of juvenile downstream migrants leaving each system. A detailed description of the methods used to operate these traps may be found in Solazzi et al. (2000).

The estimated numbers of juvenile salmonids migrating downstream from East Fork Lobster Creek in the spring of 2000 are shown in Table 6. Age 1+ coho peaked during the week of April 17-23. The number of downstream migrating 1+ coho salmon was equal to the 13-year average for East Fork Lobster Creek. Coho salmon fry were slightly below the average while the number of trout were well above the average (Table 7).

The estimated numbers of juvenile salmonids migrating downstream from Upper Mainstem Lobster Creek in the spring of 2000 are shown in Table 8. Age 1+ coho salmon peaked during the week of May 8-14. With the exception of age 1+ coho salmon all species/age group migrant numbers were substantially above the 13-year average for Upper Mainstem (Table 9).

Overwinter Survival

Table 10 shows the overwinter survival of juvenile coho salmon in both study streams. The overwinter survival in East Fork was above the average while Upper Mainstem was below the average.

Table 6. Weekly estimates of the number of juvenile salmonids migrating downstream from East Fork Lobster Creek, February 28 through June 4, 2000.

Week	Coho 1+	Coho Fry	Trout Fry	Chinook Fry	Trout 60-89mm	Steelhead $\geq$90mm	Cutthroat $\geq$90mm
Feb 28-Mar 5	26	378	0	0	32	8	6
Mar 6-12	81	1,481	0	0	81	17	11
Mar 13-19	107	1,006	0	0	19	8	13
Mar 20-26	146	1,485	0	0	133	24	29
Mar 27-Apr 2	162	472	0	0	278	135	22
Apr 3-9	112	1,232	0	0	95	197	102
Apr 10-16	147	4,439	0	0	60	149	76
Apr 17-23	183	249	754	0	14	46	40
Apr 24-30	90	1,594	513	0	10	17	115
May 1-7	93	2,394	2,866	0	7	85	127
May 8-14	25	881	1,287	0	0	19	65
May 15-21	13	511	793	0	4	9	45
May 22-28	4	711	1,156	0	4	0	32
May 29-Jun 4	0	275	656	0	0	0	8
Total	1,189	17,108	8,025	0	737	714	691

Table 7. The estimated number of juvenile salmonids migrating downstream each spring in East Fork Lobster Creek. 1988-2000.

Brood Year	Trap Start Date	Coho 1+	Coho Fry	Trout Fry	Chinook Fry	Trout 60-89mm	Steelhead ≥90mm	Cutthroat ≥90mm
1986	9-Mar-88	1,178	19,044	3,204	2,130	14[a]	15[a]	15[a]
1987	1-Mar-89	2,691	48,133	3,594	264,733	43	1[a]	268
1988	5-Feb-90	3,549	22,736	4,381	0	99	32	110
1989	4-Feb-91	2,121	8,422	2,984	0	76	45	296
1990	4-Feb-92	2,627	6,992	1,486	0	123	49	251
1991	3-Feb-93	2,055	46,550	1,875	0	202	117	699
1992	1-Feb-94	3,641	4,266	5,529	0	102	26	738
1993	1-Feb-95	892	8,130	5,549	0	55	21	187
1994	12-Feb-96	985	6,302	33[a]	0	116	3[a]	7[a]
1995	3-Mar-97	1,053	42,887	13,609	0	25	14[a]	5[a]
1996	2-Mar-98	1,286	18,416	14,584	0	464	455	523
1997	1-Mar-99	909	3,251	3,413	228	247	169	839
1998	28-Feb 00	1,189	17,108	8,025	0	737	714	691
	Average	1,197	19,433	5,686	24,087[b]	191[b]	181[b]	460[b]

[a]No marked fish recaptured. Number shown is total fish captured and not expanded for trap efficiency.
[b]Average only includes years for which trap efficiency estimates are available.

Table 8. Weekly estimates of the number of juvenile salmonids migrating downstream from Upper Mainstem Lobster Creek, Feb 28 through June 4, 2000.

Week	Coho 1+	Coho Fry	Trout Fry	Chinook Fry	Trout 60-89mm	Steelhead ≥90mm	Cutthroat ≥90mm
Feb 28 – Mar 5	0	31	0	0	14	0	0
Mar 6-12	0	619	0	0	30	10	0
Mar 13-19	0	132	0	0	43	10	0
Mar 20-26	9	56	0	0	88	22	0
Mar 27 – Apr 2	9	114	0	0	185	90	106
Apr 3-9	9	346	0	0	82	52	0
Apr 10-16	26	182	0	0	80	100	99
Apr 17-23	49	708	560	0	58	39	5
Apr 24-30	47	1148	3007	0	40	28.	52
May 1-7	73	1434	8273	0	36	53	41
May 8-14	108	672	2016	0	137	72	260
May 15-21	20	176	2126	0	4	18	10
May 22-28	17	148	3376	0	4	0	67
May 29 – Jun 4	10	45	648	0	0	0	5
Total	377	5,811	20,006	0	801	494	645

Table 9. The estimated number of juvenile salmonids migrating downstream each spring in Upper Mainstem Lobster Creek. 1988-1999.

Brood Year	Trap Start Date	Coho 1+	Coho Fry	Trout Fry	Chinook Fry	Trout 60-89mm	Steelhead >90mm	Cutthroat >90mm
1986	9-Mar-88	1,337	4,311	4,100	1[a]	3[a]	2[a]	21[a]
1987	1-Mar-89	832	1,570	1,370	1[a]	1	0	22
1988	5-Feb-90	974	5,419	1,218	0	5[a]	14	55
1989	4-Feb-91	3,455	6,702	449	0	14	36	319
1990	4-Feb-92	4,171	2,430	9[a]	0	76	284	762
1991	3-Feb-93	2,666	21,077	1,138	0	87	209	382
1992	1-Feb-94	8,909	8,628	21[a]	0	61	101	579
1993	1-Feb-95	5,797	1,759	12[a]	0	0	10[a]	606
1994	12-Feb-96	428	0	0	0	1[a]	2[a]	73
1995	3-Mar-97	214	1,266	6,561	0	0	6[a]	7[a]
1996	2-Mar-98	2,913	3,915	1,406	0	584	484	1,391
1997	1-Mar-99	1,481	353	9,135	0	196	147	398
1998	28-Feb-00	377	5,811	20,006	0	801	494	645
	Average	2,581	4,865	4,538[b]	0[b]	182[b]	197[b]	476[b]

[a]No marked fish recaptured. Number shown is total fish captured and not expanded for trap efficiency.
[b]Average only includes years for which trap efficiency estimates are available.

Table 10. The overwinter survival of juvenile coho salmon in East Fork Lobster and Upper Mainstem Lobster Creek. Survival was calculated by dividing the number of downstream migrating 1+ coho salmon captured in brood year + 2 by the summer population of juvenile coho in brood year +1.

Brood Year	E.F. Lobster Cr.	U.M. Lobster Cr.
1987	23.5%	7.8%
1988	25.9%	15.2%
1989	11.0%	19.0%
1990	26.4%	54.6%
1991	26.6%	30.2%
1992	23.0%	38.7%
1993	13.9%	37.4%
1994	12.2%	4.4%
1995	28.0%	22.8%
1996	11.6%	N/A
1997	18.7%	21.6%
1998	50.4%	22.3%
Average	20.1%	25.2%

Spawning Adult Surveys

From November 1, 1999 through January 18, 2000, we conducted periodic spawning ground surveys in each of the two study streams. A single observer walking the entire salmon-bearing length of each study stream counted the number of redds, live, and dead adult salmon and/or steelhead observed. Area-under-the-curve extrapolation techniques (Biedler and Nickelson 1980; Neilson and Geen 1981; Solazzi 1984) were used to estimate the total number of spawning coho salmon from the survey data.

Counts of live adult coho spawners during the 1999-00 spawning season are shown in Table 11. Based on area-under-the-curve adjusted estimates, a total of 22 and 39 adult coho salmon were estimated to have spawned in East Fork and Upper Mainstem Lobster Creek, respectively. Both of these estimates were below the average number of spawners observed in both streams (Table12).

Table 11. Spawning ground counts for live adult coho salmon in East Fork Lobster and Upper Mainstem Lobster Creek November, 1999 – January, 2000.

Date[*]	E.F. Lobster Cr.	U.M Lobster Cr.
1-Nov	0	0
10-Nov	1	0
17-Nov	1	4
24-Nov	3	2
1-Dec	0	2
8-Dec	1	7
20-Dec	2	12
30-Dec	3	6
6-Jan	6	3
18-Jan	1	0
26-Jan	3	1
4-Feb	0	0

Table 12. Estimated number of adult coho salmon spawning in East Fork Lobster and Upper Mainstem Lobster Creek, 1986-1999 brood years.

Brood Year	E.F. Lobster Cr.	U.M. Lobster Cr.
1986	159	31
1987	90	32
1988	302	22
1989	154	40
1990	32	9
1991	21	11
1992	272	284
1993	20	47
1994	30	25
1995	36	34
1996	25	23
1997	45	25
1998	6	1
1999	22	39
Average	87	45

References

Beidler, W.M., and T.E. Nickelson. 1980. An evaluation of the Oregon Department of Fish and Wildlife standard spawning fish survey system for coho salmon. Oregon Department of Fish and Wildlife, Information Report Series, Fisheries Number 80-9, Portland.

Chapman, D.G. 1951. Some properties of hypergeometric distribution with applications to zoological sample censuses. University of California Publications in Statistics 1:131-159.

Hankin, D.G. 1984. Multistage sampling designs in fisheries research: applications in small streams. Canadian Journal of Fisheries and Aquatic Sciences 41:1575-1591.

Hankin, D.G., and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834-844.

Neilson, J.D., and G.H. Geen. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. Transactions of the American Fisheries Society 110:554-556.

Rodgers, J.D., M.F. Solazzi, S.L. Johnson, and M.A. Buckman. 1992. Comparison of three techniques to estimate juvenile coho salmon populations in small streams. North American Journal of Fisheries Management 12:79-86.

Seber, G.A.F., and E.D. Le Cren. 1967. Estimating population parameters from catches large relative to the population. Journal of Animal Ecology 36:631-643.

Solazzi, M.F. 1984. Relationships between visual counts of coho, chinook, and chum salmon from spawning fish surveys and the actual number of fish present. Oregon Department of Fish and Wildlife, Information Report Series, Fisheries Number 84-7, Portland.

Solazzi, M.F., T.E. Nickelson, S.L. Johnson, and J.D. Rodgers. 2000. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. Canadian Journal of Fisheries and Aquatic Sciences. 57:906-914.