THE OREGON PLAN *for Salmon and Watersheds*

Smith River Steelhead and Coho Monitoring Verification Study, 2004

Report Number: OPSW-ODFW-2005-6

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Executive Summary

- Two methods to survey juvenile salmonid abundance using two metrics were compared to evaluate their utility in monitoring the status and trends of fish populations at the basin scale

- For sites where both snorkel and electrofishing surveys were conducted in 2004, more coho were counted in pools by snorkeling than by electrofishing

- Approximately half of the electrofishing sites with mean pool depths < 40 cm had no coho, and of those with mean pool depths > 40 cm, coho densities were usually less than those of snorkeled pools of comparable depth

- Juvenile coho density data for the two methods reflect increases and decreases in adult population estimates in the Smith River basin over the last 5 years

- Both juvenile survey methods yielded coho pool occupancy percentages that track adult trends, with snorkel surveys finding a greater proportion of pools with fish than electrofishing surveys

- For steelhead, both juvenile survey methods produced density estimates that tracked overall trends in adult abundance, but did not track brood-cycle trends for all years. Snorkel surveys yielded higher densities than electrofishing in some years

- Percent pool occupancy of steelhead from snorkel surveys were higher than electrofishing surveys, but neither method appeared sensitive enough to track adult population trends

- A more comprehensive trend evaluation of the two juvenile survey methods will require additional year's data, which will improve trend detection, and provide increased statistical power to determine differences between the two methods

Introduction

Monitoring the status of salmonids in Oregon coastal streams is an important component of the Oregon Department of Fish and Wildlife's (ODFW's) contribution to the Oregon Plan for Salmon and Watersheds. Since 1998, ODFW has implemented a probabilistic sampling design (Stevens 2002) to monitor adult and juvenile coho in Oregon coastal streams, and in 2002, ODFW expanded its monitoring program to include juvenile steelhead. This monitoring is occurring coast-wide, and is designed to produce fish abundance metrics at large spatial scales. A complimentary effort is to document how well a particular monitoring procedure applied at a large spatial scale produces abundance data that conform to finer-scale abundance estimates of a given population. Previous calibration work by ODFW in the Smith River basin that compared visual counts of adult coho spawners in randomly selected stream reaches to rigorous mark-recapture estimates (Jacobs, 2002) suggested slight negative bias with random surveys. The objective of the present study is to evaluate juvenile fish survey methodology as a monitoring tool at the basin scale. This report will: 1) summarize juvenile salmonid data collected by two methods (snorkeling and electrofishing) at shared sites in the Smith River basin during the summer of 2004, and 2) provide a comparative analysis of several years data of how the two juvenile survey methods and the adult EMAP spawner surveys correspond to mark-recapture estimates of adult fish passing above Smith River Falls. Details of the study area (Figure 1) were described in previous Oregon Plan annual reports (Jepsen and Rodgers 2004). Details of methods and analyses specific to the present year are included below.

Methods

A full description of electrofishing and snorkeling survey methods is found in Jepsen and Rodgers (2004, Chapter 2). Environmental Monitoring and Assessment Program (EMAP) protocols (Diaz-Ramos et al. 1996) were used to randomly select 30-36 sites per year. To track individual brood years, a four-year rotating panel design (i.e. revisiting sites every four years) is used since the majority of Oregon coastal steelhead are four years old when they return to spawn. The EMAP site selection process provides the geographic coordinates (points) of each of the candidate sample sites.

For electrofishing, sampling begins at the EMAP sample point, and continues upstream on a habitat unit by habitat unit basis until a length of stream equal to approximately 20 active channel widths is sampled. Side channels entering the survey are not sampled. Independent population estimates are made of young-of-year trout (< 90 mm fork length), juvenile steelhead $\geq$ 90 mm, cutthroat $\geq$ 90 mm, and juvenile coho. Block nets are used at the tail and head of all fast water and pool units so that estimates can be obtained for each habitat unit.

A pass-removal estimate (Armour, et al. 1983) using a minimum of two passes is conducted in all units. Decisions on whether additional passes were necessary are based on the number of fish captured and the reduction in catch from one pass to the next. When 10 or fewer fish are caught on a pass, the next pass needs to have a 50% reduction or another pass is made. When more than 10 fish are captured, the next pass needs to be reduced by 67%. These rules apply independently to all species/size classes. In complex pools, fish captured during the pass-removal estimates are given a small notch in their upper caudal fin and released for a mark-recapture estimate (Armour, et al. 1983). Marked fish are distributed throughout the pool so that they can mix with the remaining unmarked fish. Marked fish are given a minimum of one hour to recover in the pool prior to recapture efforts. Recapture efforts continued until a minimum of 50% of the released marked fish are recovered.

Snorkel surveys were conducted at randomly chosen candidate sites prior to electrofishing surveys of the same reaches. In addition, snorkel surveys were conducted at nine randomly selected sites in the larger, non-wadeable (>60 km^2 basin area) mainstem portions of Smith River above Smith River Falls. We used two metrics to describe juvenile fish abundance in pools for coho, steelhead, and cutthroat trout. Fish densities (fish/m^2) for each pool were averaged for each site and species, and a basin-wide average density estimate for each species was obtained by averaging the site averages. Confidence intervals (95%) were determined with the procedure outlined in Stevens (2002). The average percent pool occupancy (percent of pools per site that contained fish) was obtained by dividing the number of pools that contained fish by the total number of pools at a site, then, an estimate of pool occupancy for the basin was obtained by averaging the site averages. For snorkel surveys, trout < 90 mm forklength (FL, based on visual estimation) were counted as a separate category from those identified as either steelhead or cutthroat.

From electrofishing data, we estimated the total population of juvenile fish (for each species) for wadeable streams above Smith River Falls by summing the individual species/size class fish counts for all habitat units sampled per site. The site count was then divided by the sum of the lengths of all habitat units in the survey (both wet and dry units) to obtain the number of fish per meter of stream channel. An estimate of the total population of fish was calculated by multiplying the average number of fish/meter for all electrofished sites by the total length of stream channels in the sampling universe (338.4 km). The 95% confidence interval around each species/size class population estimate was determined using the statistical analysis outlined by Stevens (2002). Abundance estimates for adult coho and steelhead were obtained from EMAP spawner surveys and mark-recapture efforts at Smith River Falls. Data and details of adult methods and adult calibration comparisons from previous years are found for coho in Jacobs (2002), and for steelhead in Jacobs et al. (2002).

Electrofishing versus Snorkel Survey Analysis

We analyzed within-year differences between the two juvenile fish survey methods by comparing the abundance measures for sites where both methods were used. In cases where abundance differences were pronounced, we examined attributes of the sites that potentially influenced fish counts. We also looked for a consistent pattern between the two survey methods by comparing data across the several years the study has been conducted. To determine the relative effectiveness of either method as a basin-scale monitoring tool, we graphically compared the multi-year juvenile data to trends in the estimated number of adult spawners returning to the Smith River basin above Smith River Falls.

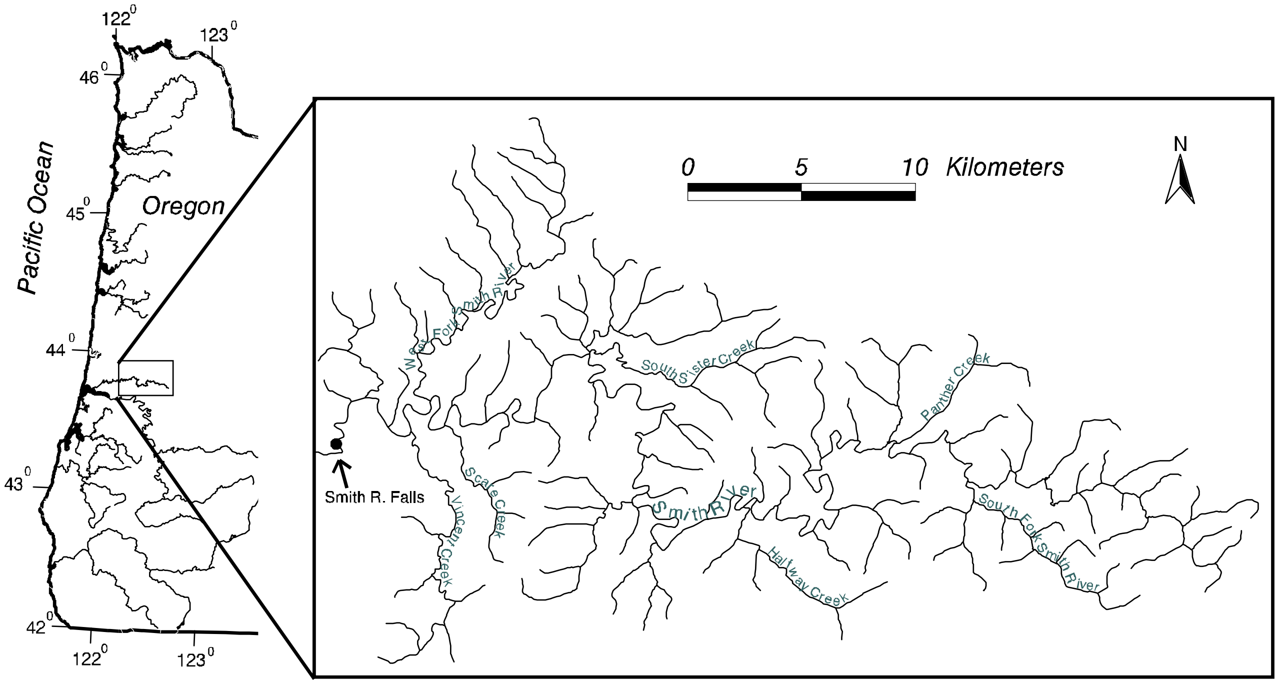

Figure 1. Location of the Smith River study area.

Results and Discussion

The physical characteristics of electrofished sites and fish count data from electrofished and snorkel surveys in 2004 are summarized in Appendices 1 and 2. Habitat data from previous years are contained within the respective Oregon Plan annual reports and on the website: http://oregonstate.edu/dept/pacrim/Availbleinfo.htm. Outputs from digital maps that summarize fish count data are available by request from the Western Oregon Rearing Project.

Electrofishing Surveys

In 2004, 36 wadeable sites were visited for electrofishing surveys, from which 3,366 meters of stream channel were surveyed (Figure 2). Of this total, 428 meters were dry channel. Five sites were completely dry, one site had no pools, and three sites were not surveyed due to dense brush in the creek, or pools too deep for efficient electrofishing. Eight sites had greater than 50% pool habitat by length, and 14 sites had greater than 50% riffle/rapid habitat by length. The average wetted channel width ranged from 0.9-9.9 m and maximum water depth was 200 cm. Of the wetted sites, bedrock substrate dominated eight sites, silt/sand 4 sites, and gravel/cobble/boulder 8 sites.

Juvenile coho were widespread, occurring at 71% of the sites, while steelhead, cutthroat and 0+ trout were found at 21%, 54%, and 93% of sites, respectively. As in previous years, population estimates indicated that juvenile coho were the most abundant salmonid in sampled reaches, followed in order by 0+ trout, cutthroat ≥ 90 mm FL, and steelhead ≥ 90 mm FL (Table 1). The proportion of trout ≥ 90 mm FL collected by electrofishing that were steelhead and cutthroat were 17.5% and 82.5%, respectively.

Annual basin-scale population estimates from electrofishing surveys for each species/size class are plotted in Figure 3. Between the brood cycle comparison of years 2000 and 2003 (same population element of a 3-year life cycle), population estimates were greater in 2000 than 2003 for coho (p=0.023), but there was no detectable difference in steelhead estimates (p=0.099). Between the brood cycle comparison of years 2001 and 2004 there were no differences in coho population estimates (p=0.950), but 2001 steelhead estimates were greater than those in year 2004 (p=0.001).

Table 1. Juvenile salmonid population estimates in 2004 for the Smith River basin above Smith River Falls, based on summer electrofishing surveys in wadeable streams.

Species	Population Estimate	95% CI	CI % of Estimate
Coho	323,928	126, 919	39
Steelhead ≥ 90 mm FL	1,292	1,099	85
Cutthroat ≥ 90 mm FL	9,719	5,179	53
0+ trout	88,065	20,265	23

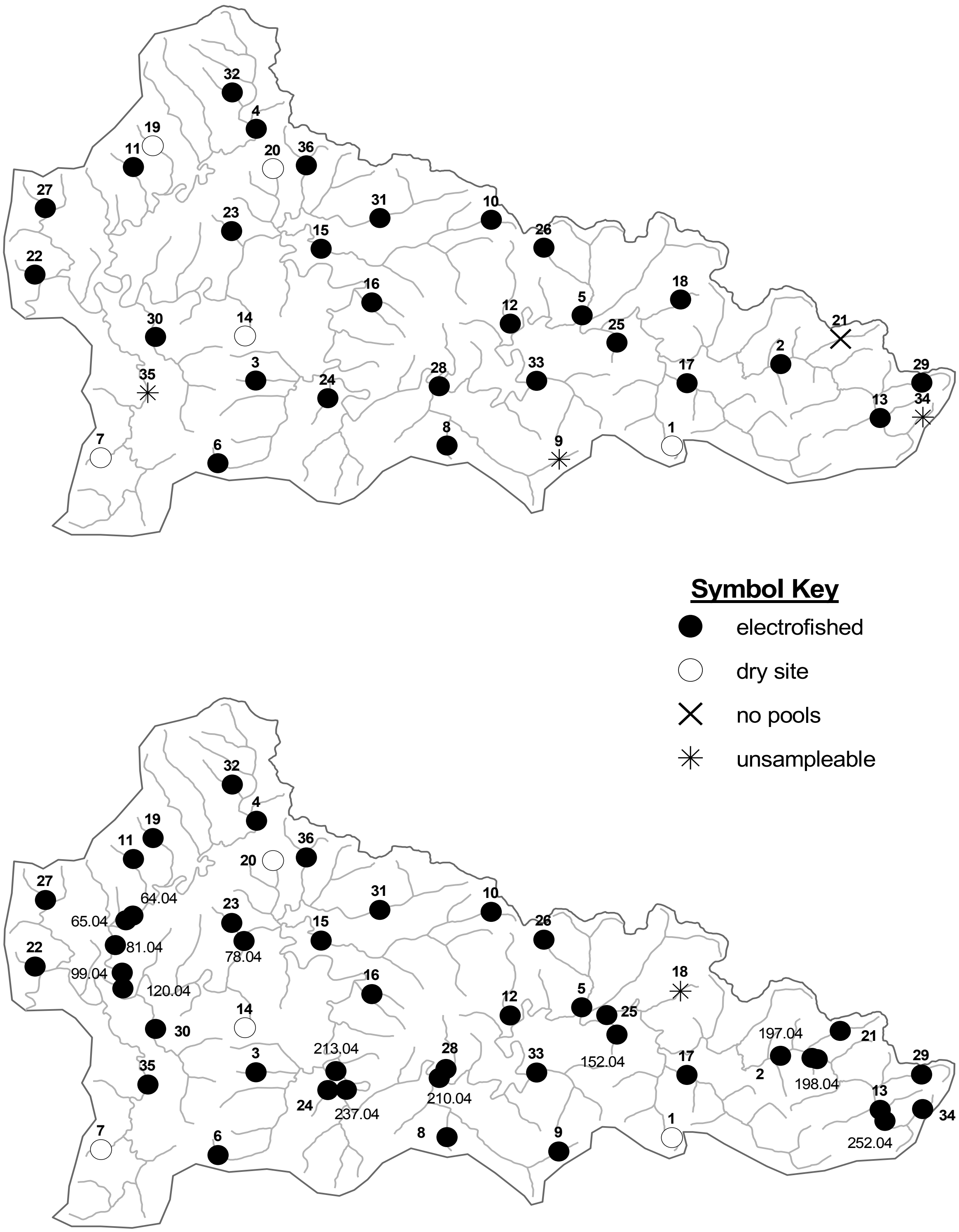

Figure 2. Location of sites electrofished (top panel) and snorkeled (bottom panel) for juvenile fish abundance in the Smith River basin, summer 2004. The numbers next to sample points are the site numbers for referencing data in Appendix 1 and 2. Non-bolded numbers for snorkel sites are for larger non-wadeable streams.

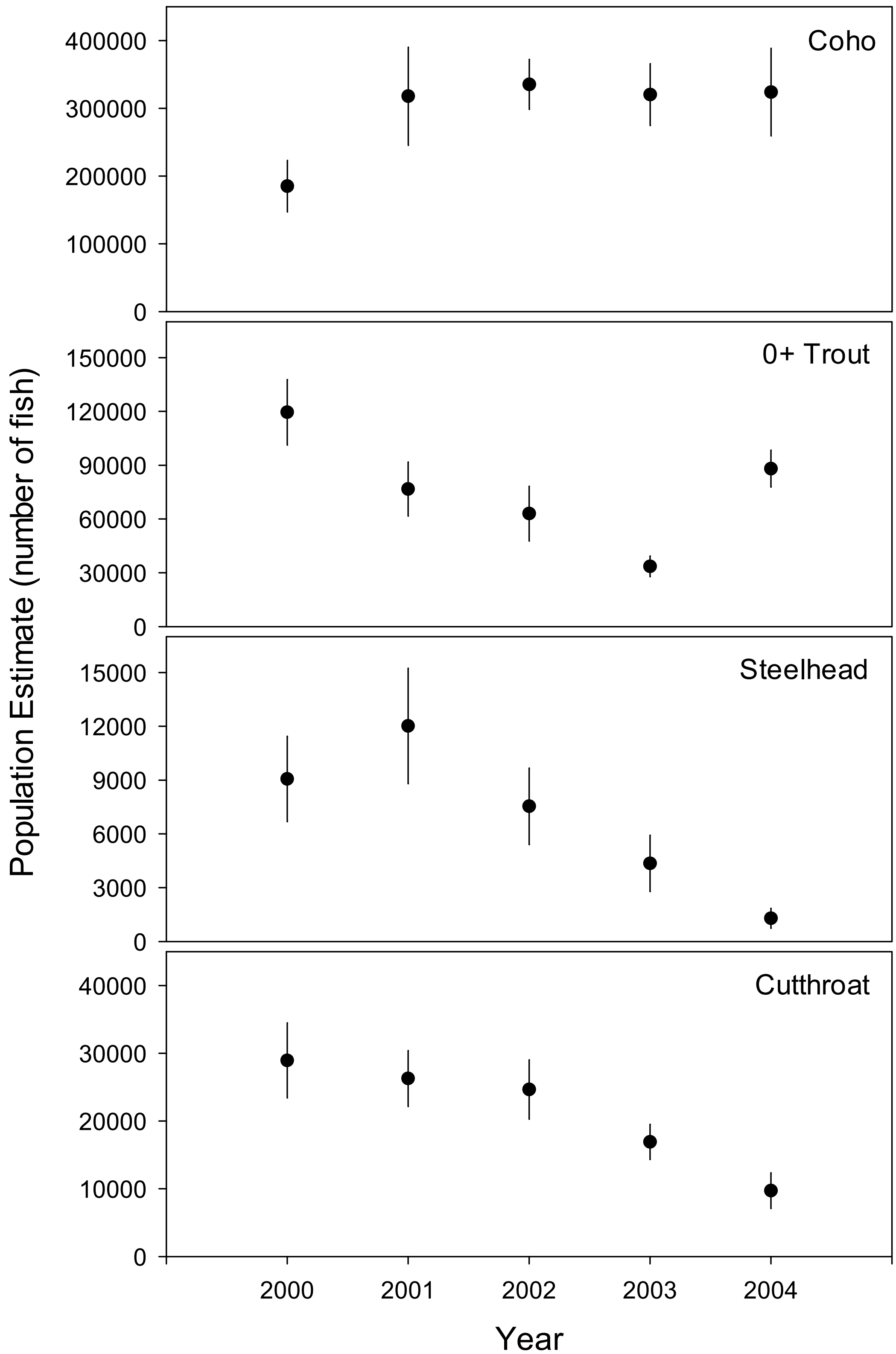

Figure 3. Estimated juvenile fish population (± standard error) in wadeable streams above Smith River Falls, based on electrofishing surveys.

Snorkel Surveys

Forty-nine sites were selected for snorkel surveys in 2004. Of these, five sites were either dry or had no pools that met the criteria for surface area and/or depth. One site was snorkeled where pools were too turbid for direct fish counts, so it was dropped from analysis. Of the 43 remaining snorkeled survey sites, 27 were also electrofishing sites, but one was dropped from the electrofishing dataset due to sampling issues. Four sites were not visited by the electrofishing crew, and 13 were in larger stream reaches outside the “wadeable” stream sampling universe for electrofishing surveys (Figure 2).

Of trout $\geq$ 90 mm that were classified by snorkelers as either cutthroat or steelhead, 73.4% were identified as cutthroat and 26.6% as steelhead. These proportions are slight overestimates for steelhead and slight underestimates for cutthroat relative to direct counts from electrofishing (above). Coho and cutthroat trout were observed in a high percentage of sites in both wadeable streams and non-wadeable streams (>87%), whereas steelhead trout were found in only 29% of wadeable streams but 92% of non-wadeable streams. Fish densities were higher for all three species in the wadeable streams vs non-wadeable streams (Table 2). The pool occupancy metric indicated that coho were more dispersed within sites than cutthroat or steelhead, that cutthroat were more dispersed within sites than steelhead, and that steelhead were more dispersed within non-wadeable streams than in wadeable streams (Table 2).

Table 2. Snorkel survey estimates of average pool density of juvenile salmonids, and average percentage of pools per site with at least one fish. Data obtained from wadeable and non-wadeable stream reaches above Smith River Falls, summer 2004.

Species	All snorkel sites (N=43)			Snorkel sites in wadeable streams (N=31)			Snorkel sites in non-wadeable streams (N=12)		
	Fish/m^2	95% CI	Pool Occupancy	Fish/m^2	95% CI	Pool Occupancy	Fish/m^2	95% CI	Pool Occupancy
Coho	0.623	0.193	69	0.821	0.222	69	0.128	0.070	71
Steelhead	0.003	0.002	11	0.003	0.003	4	0.002	0.001	26
Cutthroat	0.031	0.013	32	0.041	0.016	36	0.002	0.001	21

Electrofishing and Snorkel Survey Comparisons

For sites where both snorkel and electrofishing surveys were conducted in 2004, more coho were observed in pools by snorkeling than by electrofishing (Table 3; 63% of the snorkel estimate). Consistent with the pattern in density data were the percent of sites that contained at least one fish in pools, where snorkel surveys produced a higher percent of fish occurrence than electrofishing for all three species (Table 3).

Table 3. The average density of fish in pools, the percent of sites with at least one fish in pools, and average percent pool occupancy (percent of pools per site with at least one fish), for juvenile coho, steelhead ≥ 90 mm FL and cutthroat ≥ 90 mm FL. Data are from snorkeling and electrofishing surveys at sites sampled by both methods in Smith River tributaries, summer 2004.

	Snorkel				Electrofish			
Species	Density (Fish/m^2)	95% CI	Sites with at least one fish (%)	Pool Occupancy (%)	Density (Fish/m^2)	95% CI	Sites with at least one fish (%)	Pool Occupancy (%)
Coho	0.947	0.263	89	73	0.602	0.304	68	65
Steelhead	0.004	0.003	31	5	0.002	0.002	24	9
Cutthroat	0.038	0.017	96	36	0.029	0.017	64	37

Several factors may contribute to differences between the two survey methods. Consistent undercounting (or also over-counting in the case of snorkeling) by either method of the actual number of fish present would lead to differences in fish counts in pools. This study was not designed to provide a an assessment of the accuracy of the two methods, but prior research evaluating juvenile coho population estimation methods in small Oregon streams found that mark-recapture, removal, and snorkel techniques accounted for 85%, 67%, and 40%, respectively, of the known summer populations in pools (Rodgers et al. 1992). Higher fish densities influence snorkel counts more than other methods, as accurate visual counting is more difficult with larger numbers of fish (Heggenes et al. 1990); however, Rodgers et al. (1992) found no effect of fish density on the accuracy of snorkel or removal techniques. In the present study, counts by snorkelers were consistent, as resurveys at four randomly chosen sites (same pools) were similar to original pool counts for coho, with no tendency to over or undercount (Figure 4). There were no steelhead recorded at any of these sites from either the original survey or the resurvey.

Differences in pool dimensions potentially influence fish counts of a particular survey method. In other Oregon streams, removal methods were more accurate in smaller pools than larger pools, whereas snorkel counts were not influenced by pool surface area, nor did average pool depth influence the accuracy of either method (Rodgers et al. 1992). In the present study mean pool surface areas were comparable for pools sampled by the two methods (Figure 5), but mean maximum pool depths were greater for snorkeled surveys (snorkel protocol; lower limit 40 = cm depth) than electrofished surveys. Approximately half of the electrofishing sites with mean pool depths < 40 cm had no coho, and of those with mean pool depths > 40 cm, coho densities were usually less than those of snorkeled pools of comparable depth.

Discrepancies between the two methods could also occur if there were consistent differences in fish abundance between the ~1,000 m of stream per site surveyed by snorkelers and the 32-325 m of stream reaches surveyed by electrofishing. When survey effort for each method was standardized by dividing the total length of pool habitat units surveyed by the total survey length, a greater proportion of pool habitat per site was sampled by electrofishing than by snorkeling (Figure 6). Among snorkel sites, as the proportion of sampled pool habitat increased, there was trend of decreasing average coho density estimates (and less between-pool variability). The pattern of higher snorkel density estimates at sites that had < 20% snorkable pool habitat, and the greater relative representation of these surveys to the overall density estimate would account for some of the discrepancy in coho counts between the two methods.

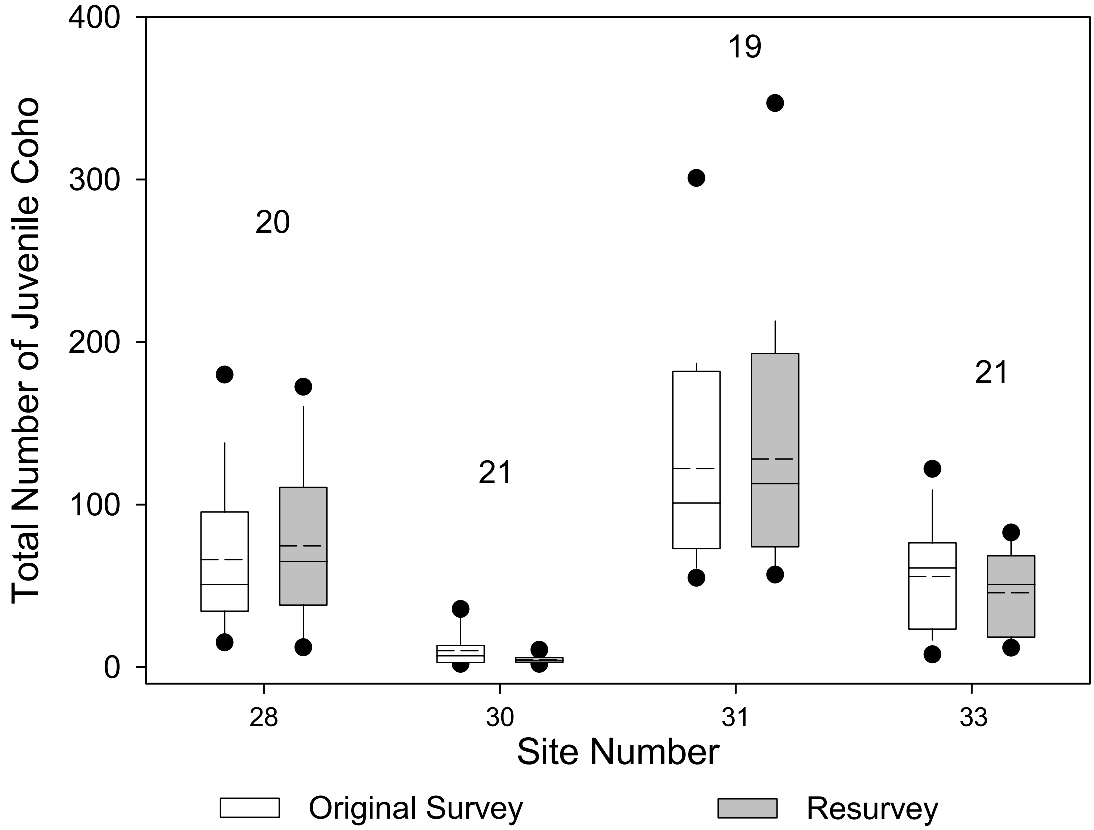

Figure 4. Comparison of juvenile fish counts in pools for sites that were resurveyed by snorkeling in Smith River tributaries, 2004. Boxes contain the pool estimates for mean number of fish (dashed line), median (solid line) and the 25th and 75th percentiles. Whiskers are the 10th and 90th percentiles, and symbols represent the 5th and 95th percentiles. Numbers above boxes are number of pools sampled.

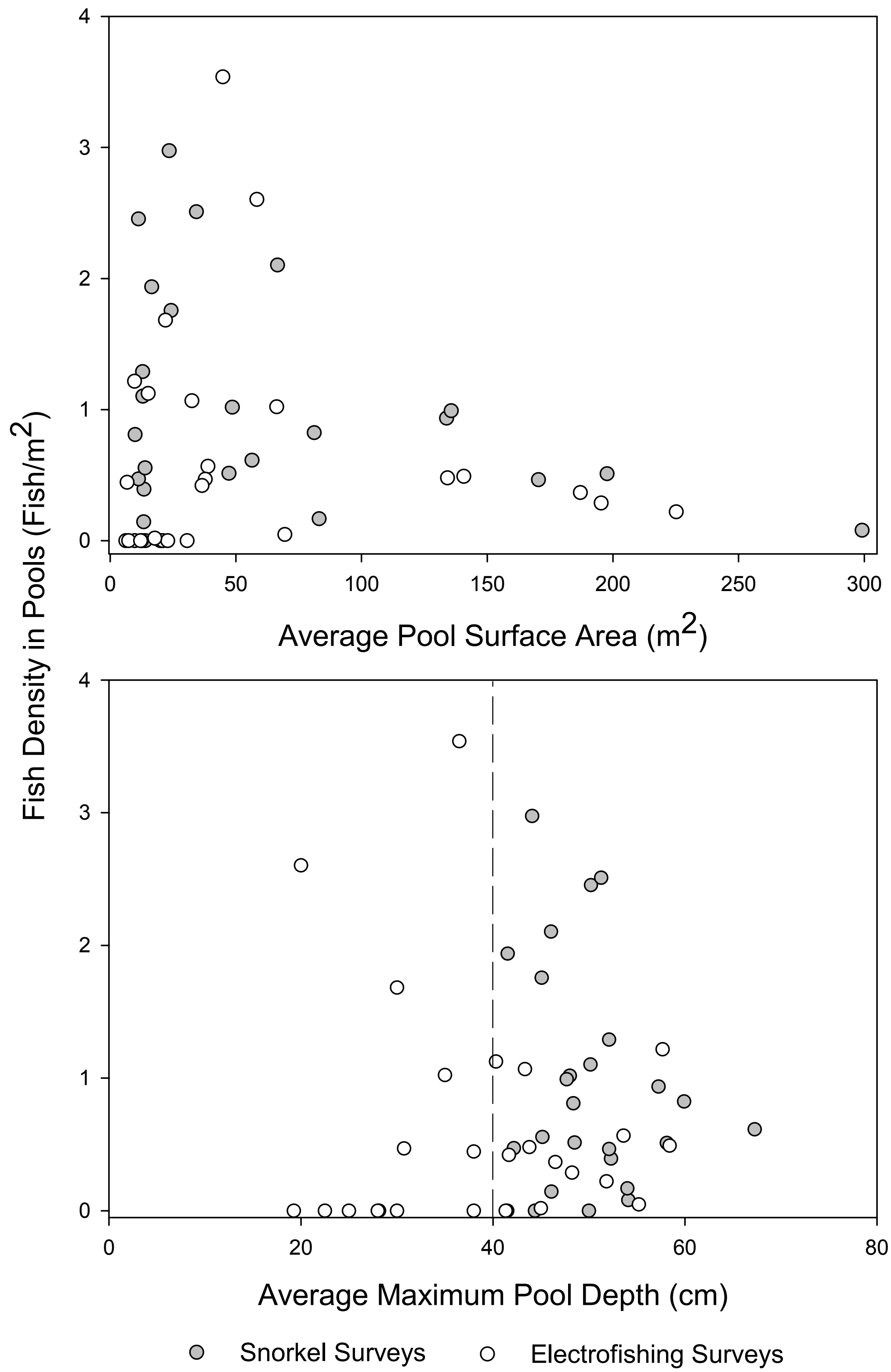

Figure 5. Relationship between juvenile coho densities in pools for two survey methods, and pool surface area (top panel) and maximum pool depth (bottom panel). Reference line at 40 cm depth is lower limit depth protocol for snorkel surveys.

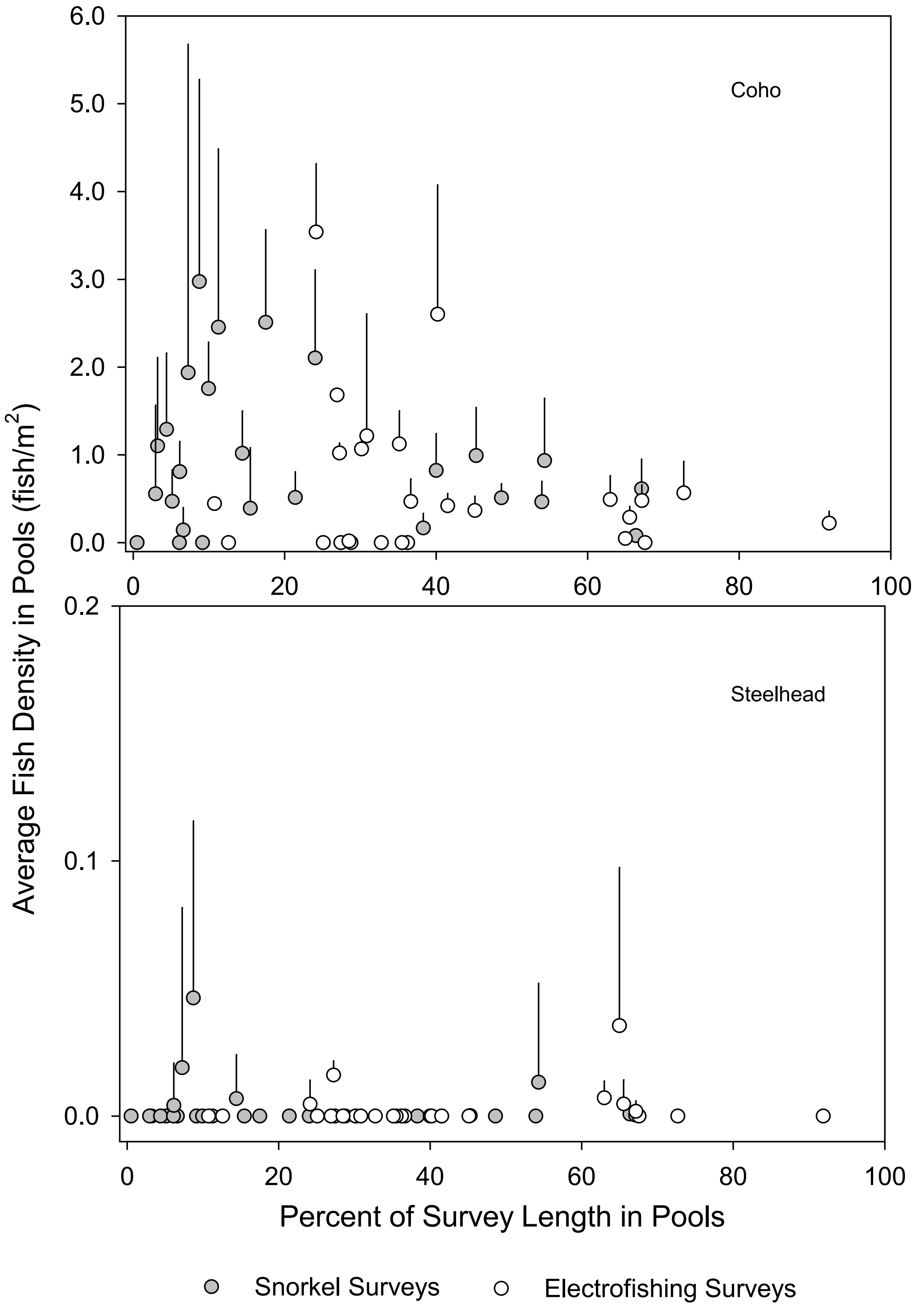

Figure 6. Relationship between sampling effort of two survey methods and juvenile fish density (+ SD's) in pools for coho (top panel) and steelhead (bottom panel). Symbols represent wadeable stream sites sampled by both snorkeling and electrofishing in the Smith River 2004.

Although snorkel surveys were the least accurate and most variable of the three methods in the Rodgers et al. (1992) study (due mostly to between-stream differences in accuracy), they and previous researchers (Hankin and Reeves 1988) noted that use of snorkel counts as a population estimation technique is improved by the ability to sample a larger proportion of stream reaches. The value of greater accuracy of mark-recapture and removal techniques as monitoring tools is diminished somewhat by the greater time needed to complete these surveys, thereby limiting their use for large-scale population estimates. In addition, electrofishing techniques that estimate total fish counts are not feasible in non-wadeable stream reaches, whereas several snorkelers can simultaneously sample a non-wadeable pool for a complete count. This is an important consideration for monitoring juvenile steelhead, where a portion of the summer rearing habitat is pools in larger streams. In the case of the Smith River basin however, snorkel density estimates were very low from pools in non-wadeable reaches over 4 years of sampling (range 0.0003-0.002 fish/m^2).

The comparative accuracy of the two juvenile fish survey methods in the present study can be evaluated in part, by how well the survey metrics reflect increases and decreases in adult mark-recapture estimates of the same brood. Although additional years of population estimate data will help refine testable trend analyses, graphical interpretation of existing adult and juvenile data provide a preliminary evaluation of the juvenile survey methods.

When juvenile coho density data for the two methods are plotted against adult population estimates in the Smith River basin over several brood years, juvenile coho densities from snorkel surveys have generally tracked better than electrofishing surveys the trends in population estimates derived from adult EMAP surveys and adult mark-recapture methods (Figure 7, top panel). The most notable exception was the decline in the juvenile electrofishing estimate in brood year 2002 as adult estimates continued to increase. Both juvenile methods recorded the apparent decrease in adult fish in brood year 2003. Patterns for steelhead showed neither juvenile survey methods tracked change in adult abundance between some brood years (Figure 7, bottom panel). Juvenile steelhead electrofishing estimates did not reflect the increase in adult estimates between brood years 2001-2002. Electrofishing density estimates from riffle and run habitats units (not presented here) coincided with those from pool habitats, showing decreases in juvenile densities from 2001 to 2004, and therefore not reflecting the increase in adult steelhead from 2001-2002. Snorkel survey estimates increased significantly between 2000 and 2001, even as estimates of adults that produced them declined slightly.

For all years, snorkel surveys yielded greater coho pool occupancy rates (average % of pools per site that had fish) than electrofishing surveys, but both methods produced pool occupancy rates that tracked changes in adult abundance. However, snorkel surveys were better than electrofishing surveys at tracking the increase of adult fish between brood years 2001 and 2002 (Figure 8, top panel). Pool occupancy results from electrofishing showed no increase between these coho brood years. Both juvenile survey methods tracked the decline in adult coho estimates between brood years 2002 and 2003. Both of the juvenile survey methods produced pool occupancy rates for steelhead that declined over the span of this study, whereas adult steelhead estimates were higher in brood year 2002 than in other years (Figure 8, bottom panel). It is not clear why an increase in adult spawners in 2002 did not result in a subsequent increase in the number of pools containing juvenile steelhead the following year. Juvenile steelhead densities recorded from snorkel surveys were high that year, indicating that juvenile steelhead were distributed in fewer pools but in higher numbers than in previous years.

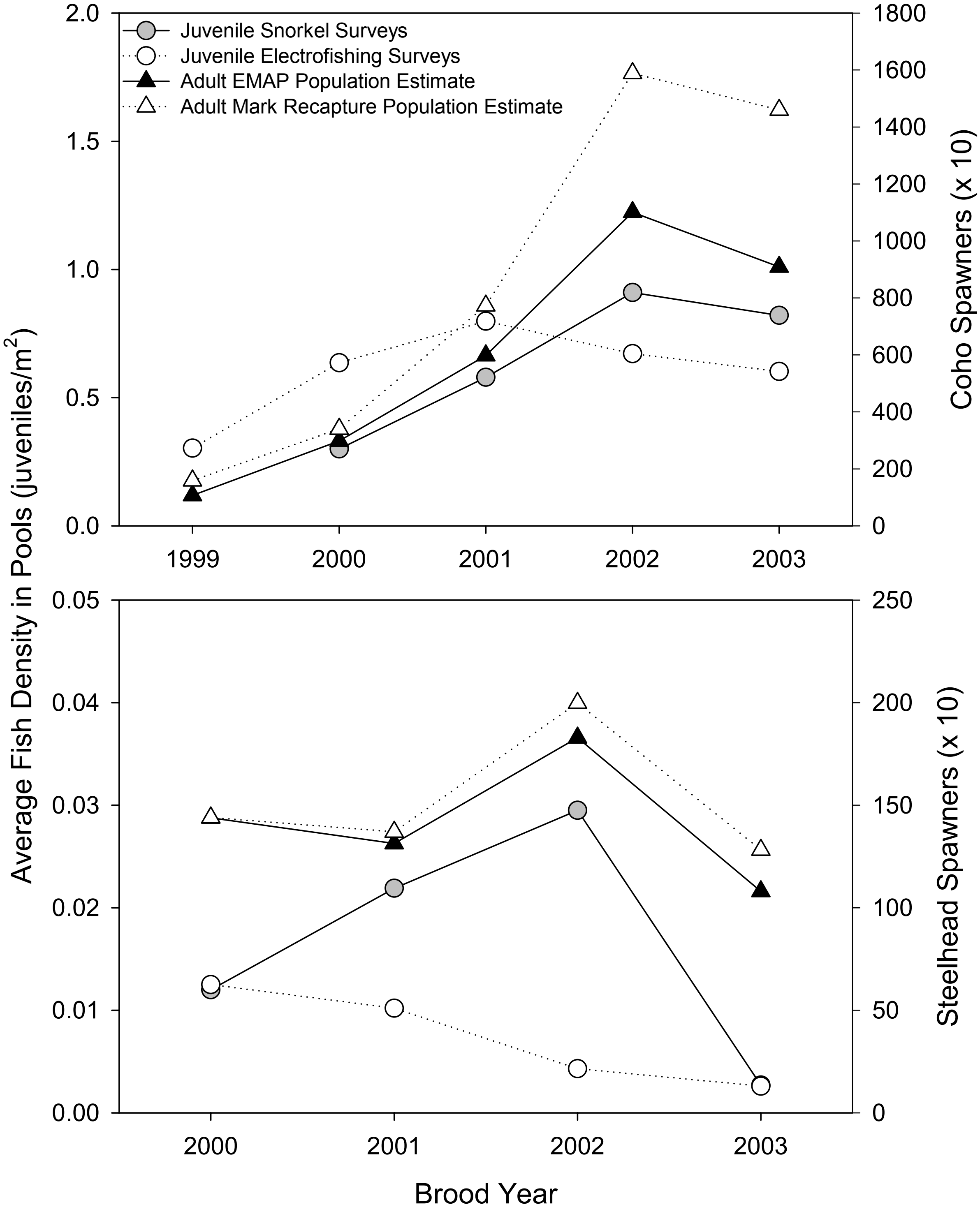

Figure 7. Comparison of juvenile fish densities in pools for two survey methods, related to estimates of adult spawner abundance for coho (top panel) and steelhead (bottom panel). Brood year refers to the year adult data were collected (juvenile fish spawned), corresponding to the subsequent year juvenile fish were surveyed. Data were collected from reaches above Smith River Falls. For brood year 1999 (juvenile survey year 2000) no snorkel surveys were conducted for steelhead.

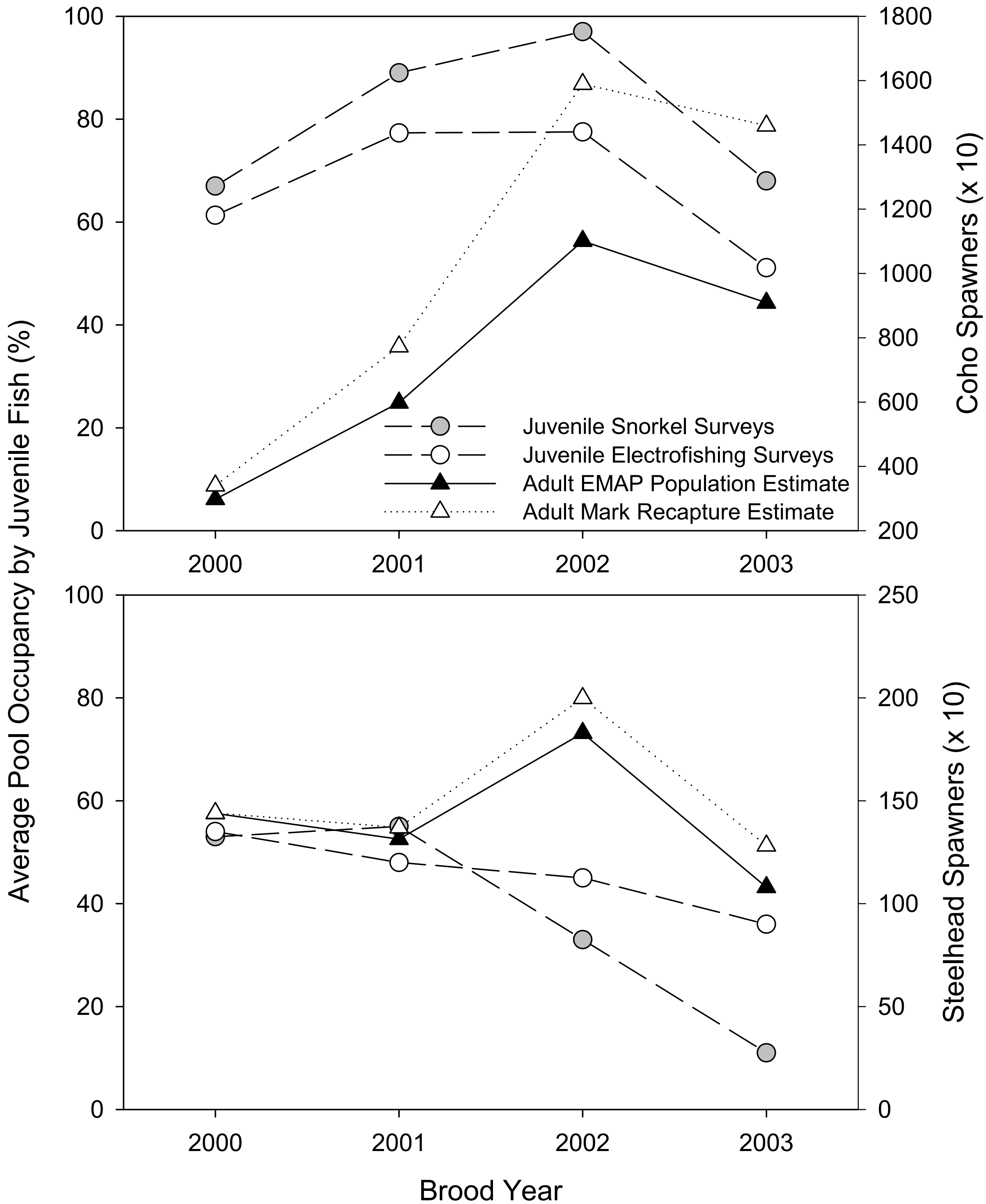

Figure 8. Comparison of pool occupancy rates of juvenile fish for two survey methods, related to estimates of adult spawner abundance for coho (top panel) and steelhead (bottom panel). Brood year refers to the year adult data were collected (juvenile fish spawned), corresponding to the subsequent year juvenile fish were surveyed. Data were collected from reaches above Smith River Falls. Pool occupancy metrics were not calculated for juvenile coho of brood year 1999 (juvenile survey year 2000).

References

Armour, C.L., K.P. Burnham, and W.S. Platts. 1983. Field methods and statistical analysis for monitoring small salmonid streams. U.S. Fish and Wildlife Service, Washington, D.C.

Dias-Ramos, S., D.L. Stevens, Jr., and A.R. Olsen. 1996. EMAP Statistical Methods Manual. Environmental Monitoring and Assessment Program, National Health and Environmental Effects Research Laboratory, Office of Research and Development, Corvallis, Oregon.

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.

Heggenes, J., Å. Brabrand, and S. J. Saltveit. 1990. Comparison of three methods for studies of stream habitat use by young brown trout and Atlantic salmon. Transactions of the American Fisheries Society 119:101-111

Jacobs, S. 2002. Calibration of estimates of coho spawner abundance in the Smith River, 2001. Monitoring Program Report Number OPSW-ODFW-2002-06, Oregon Department of Fish and Wildlife, Portland.

Jacobs, S., J. Firman, G. Susac, D. Stewart, and J. Weybright. 2002. Status of Oregon coastal stocks of anadromous salmonids, 2000-2001 and 2001-2002. Monitoring Program Report Number OPSW-ODFW-2002-3, Oregon Department of Fish and Wildlife, Portland.

Jepsen, D. B. and Rodgers, J. D. 2004. Abundance monitoring of juvenile salmonids in Oregon coastal streams, 2002-2003. Monitoring Program Report Number OPSW-ODFW-2003-1, Oregon Department of Fish and Wildlife, Portland.

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.

Stevens, D.L., Jr. 2002. Sampling design and statistical analysis methods for the integrated biological and physical monitoring of Oregon streams. Monitoring Program Report Number OPSW-ODFW-2002-7, Oregon Department of Fish and Wildlife, Portland.

Appendices

Appendix 1. Estimated number of juvenile salmonids and physical characteristics of sites sampled by electrofishing in the Smith River basin, 2004. Sthd- steelhead, Cutt= cutthroat.

	Number of Juvenile Fish																		Substrate Composition (%)			
Site	Coho	Sthd	Cutt	Trout ≤ 90 mm FL	Site Length (m)	Wetted Surface Area (m^2)	Average Wetted Width (m)	Max Depth (cm)	Dry Channel Length (m)	Glide Length (m)	Glide Surface Area (m^2)	N of Glides	Pool Length (m)	Pool Surface Area (m^2)	N of Pools	Riffle/ Rapid Length (m)	Riffle/ Rapid Surface Area (m^2)	N of Riffles/ Rapids	Silt/ Sand	Gravel	Cobble/ Boulder	Bedrock
1	-	-	-	-	40.0	0.0			40.0													
2	240	0	14	11	220.2	1450.6	6.0	64					202.3	1350.9	6	17.9	99.7	4	38.2	11.4	4.4	46.1
3	0	0	5	3	92.2	94.4	1.5	40	24.0				26.5	43.7	7	41.7	50.7	4	11.7	52.8	35.6	
4	415	7	21	75	191.4	961.7	4.8	80					120.5	703.3	5	70.9	258.4	6	44.7	33.7	4.6	17.1
5	95	0	1	2	78.7	226.4	2.5	70					57.2	194.3	5	21.5	32.1	4	65.3	33.7	1.0	
6	0	0	1	18	31.8	29.1	1.2	38					4.0	9.8	1	27.8	19.3	2	44.0	56.0	0.0	
7	-	-	-	-	40.0	0.0			40.0													
8	0	0	0	37	93.4	201.4	1.8	35					25.6	61.3	2	67.8	140.1	3	14.9	27.3	1.9	55.9
9	-	-	-	-	-	-																
10	0	0	1	7	52.7	61.3	1.0	30					35.6	49.6	4	17.1	11.6	3	43.3	48.9	7.8	
11	296	0	0	175	203.3	107.2	1.8	35	121.4				54.7	85.0	7	27.2	22.2	2	49.3	20.9	9.3	20.5
12	156	0	0	6	91.6	270.4	3.0	50					27.6	97.6	3	64.0	172.9	4	13.8	35.1	51.1	
13	110	0	2	11	114.9	382.4	3.4	34					42.1	151.3	4	72.8	231.1	3	18.1	9.5	2.4	70.1
14	-	-	-	-	40.0	0.0			40.0													
15	324	1	1	34	168.6	855.9	5.0	62					113.2	670.9	5	56.4	185.0	4	7.9	18.0	4.9	69.3
16	0	0	0	5	41.7	52.7	1.4	35					15.1	22.1	3	26.6	30.6	2	64.1	19.5	16.4	
17	249	0	0	15	150.3	687.7	4.5	58					67.8	374.1	2	82.5	313.5	2	9.9	20.8	22.9	46.5
18	1	0	0	2	64.4	15.6	0.9	20	48.3				16.1	15.6	3				8.2	54.9	1.9	35.0
19	-	-	-	-	-	0.0																
20	-	-	-	-	40.0	0.0			40.0													
21	33	0	0	2	76.1	150.3	2.1	0	6.0							70.1	150.3	2	26.0	10.0	5.0	59.0
22	0	0	16	65	118.4	160.1	1.7	45	33.0				29.7	83.9	4	55.7	76.2	3	35.8	15.6	26.3	19.7
23	0	0	13	56	68.2	113.3	1.9	50	15.0				24.2	68.6	3	29.0	44.7	3	33.6	56.9	9.5	
24	50	0	3	0	59.5	105.0	1.8	76					20.9	45.2	3	38.6	59.7	4	40.9	55.7	3.4	
25	33	0	0	9	49.3	41.6	1.4	101	14.0				15.2	29.0	3	20.1	12.6	2	10.9	54.8	30.4	3.9
26	1	0	0	6	57.6	64.5	1.3	45					16.4	35.5	2	41.2	28.9	3	36.4	60.8	2.7	
27	275	0	0	79	95.1	224.8	2.4	20					38.2	116.7	2	56.9	108.1	2	5.8	1.1	4.7	88.5

	Number of Juvenile Fish																		Substrate Composition (%)			
Site	Coho	Sthd	Cutt	Trout $\leq$ 90 mm FL	Site Length (m)	Wetted Surface Area (m^2)	Average Wetted Width (m)	Max Depth (cm)	Dry Channel Length (m)	Glide Length (m)	Glide Surface Area (m^2)	N of Glides	Pool Length (m)	Pool Surface Area (m^2)	N of Pools	Riffle/ Rapid Length (m)	Riffle/ Rapid Surface Area (m^2)	N of Riffles/ Rapids	Silt/ Sand	Gravel	Cobble/ Boulder	Bedrock
28	210	1	13	45	179.3	918.4	4.4	55		19.8	46.20	1	117.5	781.1	4	42.0	91.1	5	5.5	2.6	3.2	88.7
29	0	0	0	0	45.5	53.5	1.3	30					14.9	24.2	2	30.6	29.3	2	75.2	6.9	0.0	17.9
30	13	5	3	88	139.0	483.7	3.6	70	6.5				90.3	347.5	5	42.2	136.2	5	41.9	49.2	3.0	
31	765	1	0	49	149.6	487.9	4.0	45					36.1	179.3	4	113.5	308.6	4	7.2	10.4	8.1	74.2
32	18	0	0	5	40.1	50.6	1.4	38					4.3	6.7	1	35.8	43.9	1	62.7	18.0	8.7	10.7
33	244	2	1	22	123.4	321.8	3.0	45		40.6	113.68	1	33.6	132.4	2	49.2	75.7	3	10.4	35.1	16.4	38.2
34	-	-	-	-	-	-																
35	-	-	-	-	325.0	3217.5	9.9	200					325.0	3217.5	1				30.0	10.0	10.0	50.0
36	82	0	1	16	84.3	201.5	2.6	50					35.0	109.7	3	49.3	91.8	2	18.0	40.7	37.4	3.9

Appendix 2. Summary of snorkel survey sites in the Smith River basin, 2004. Bolded sites are non-wadeable sites in the mainstem Smith River.

	Percent of Pools with Fish				Average fish/m^2			
Site	**N of Pools Snorkeled For Pool Occupancy**	**Coho**	**Steelhead ≥90 mm**	**Cutthroat ≥90 mm**	**N of Pools Snorkeled for Density**	**Coho**	**Steelhead ≥90 mm**	**Cutthroat ≥90 mm**
2	19	89	11	32	18	0.0801	0.0008	0.0074
3	8	0	0	25	8	0.0000	0.0000	0.0521
4	28	100	39	50	27	0.9348	0.0133	0.0068
5	51	98	2	18	47	0.6139	0.0003	0.0042
6	33	33	0	58	31	0.3923	0.0000	0.0946
8	12	75	0	50	11	0.4709	0.0000	0.0770
9	7	0	0	29	6	0.0000	0.0000	0.1667
10	8	63	0	38	6	1.1022	0.0000	0.0286
11	13	100	0	23	13	1.7561	0.0000	0.0078
12	22	100	9	18	13	1.0180	0.0068	0.0088
13	16	94	0	63	16	0.5147	0.0000	0.0306
15	26	100	4	50	22	0.9912	0.0002	0.0068
16	2	0	0	0	1	0.0000	0.0000	0.0000
17	18	94	0	56	17	0.5109	0.0000	0.0075
19	4	100	0	50	4	0.6051	0.0000	0.0723
21	17	12	0	41	14	0.1139	0.0000	0.0355
22	11	45	9	100	11	1.9368	0.0189	0.2057
23	8	25	0	50	6	0.5556	0.0000	0.1455
24	30	90	0	20	24	2.4539	0.0000	0.0444
25	14	64	0	21	9	1.2897	0.0000	0.0509
26	11	45	0	45	11	0.1440	0.0000	0.0673
27	16	100	0	6	15	2.5091	0.0000	0.0016
28	23	100	0	52	20	0.4655	0.0000	0.0095
29	10	0	0	40	8	0.0000	0.0000	0.0538
30	27	89	0	30	22	0.1678	0.0000	0.0141
31	22	100	0	32	19	2.1030	0.0000	0.0035
32	16	100	6	31	16	0.8095	0.0042	0.0579
33	24	100	0	21	21	0.8234	0.0000	0.0047
34	6	17	0	0	6	0.0111	0.0000	0.0000
35	17	94	18	53	17	0.1183	0.0023	0.0029
36	12	100	42	8	11	2.9742	0.0463	0.0058
64.04	24	100	33	46	24	0.2010	0.0014	0.0058
65.04	22	100	32	41	22	0.2070	0.0014	0.0059
78.04	8	0	13	13	8	0.0000	0.0000	0.0000
81.04	28	100	25	11	28	0.3350	0.0013	0.0010
99.04	10	40	20	20	3	0.0008	0.0001	0.0010
120.04	2	0	50	0	0	-	-	-
152.04	16	94	50	19	16	0.0279	0.0019	0.0004
197.04	18	100	56	28	16	0.1051	0.0038	0.0035
198.04	34	100	29	3	32	0.1683	0.0042	0.0003
210.04	12	25	8	25	12	0.0010	0.0000	0.0018
213.04	22	32	18	32	22	0.0040	0.0005	0.0010
237.04	7	57	0	14	7	0.0012	0.0000	0.0001
252.04	16	100	31	0	16	0.4892	0.0095	0.0000