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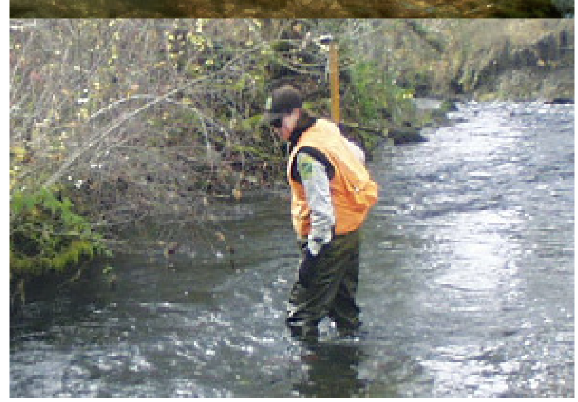

Smith River Steelhead and Coho Monitoring Verification Study, 2007

Report Number: OPSW-ODFW-2009-11

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Smith River Steelhead and Coho Monitoring Verification Study, 2007

Oregon Plan for Salmon and Watersheds

Monitoring Report No. OPSW-ODFW-2009-11

Ronald J. Constable, Jr. and Erik Suring
Western Oregon Rearing Project
Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, OR 97333

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EXECUTIVE SUMMARY

We used electrofishing and snorkel surveys to estimate juvenile salmonid abundance and compared their ability to monitor the status and trends of fish populations at the basin scale. From electrofishing we estimated population size, densities, and pool occupancies in the wadeable portions of the basin. Density and pool occupancies were estimated from all pools in electrofishing sites and pools within these sites that met snorkel size criteria. Population estimates were made from all habitat types and pools that met snorkel size criteria. From snorkel surveys we estimated the same metrics in both the wadeable and non-wadeable portions of the basin, but only in pools that met size criteria.

For sites where both surveys were conducted there was no detectable difference between electrofishing and snorkeling density estimates for coho. Snorkeling generated higher steelhead densities and electrofishing generated higher cutthroat densities. Coho and steelhead population estimates from electrofishing were not statistically different than coho and steelhead population estimates from snorkeling. Electrofishing population estimates were higher for cutthroat.

Electrofishing detected 39% of juvenile coho and 37% of juvenile steelhead rearing in wadeable habitats not sampled by snorkeling. Snorkeling detected 21% of juvenile coho and 17% of juvenile steelhead rearing in non-wadeable stream reaches not sampled by electrofishing.

Snorkelers sampled 3% (by length) of the steelhead rearing distribution in the study area. Electrofishers sampled 0.6% of the distribution. In pools that were sampled by both methods snorkelers counted 28% of the steelhead and 82% of the coho estimated by electrofishing, yet, by sampling a larger area, overall snorkeling produced similar density estimates for coho and higher density estimates for steelhead.

Results from 2007 indicate that either method alone is likely to underestimate actual population status. Previous studies evaluating snorkeling and electrofishing have shown undercounting of coho and steelhead. More accurate estimates require a combination of both methods, refined habitat measurements, and calibrated snorkel counts such as described by Hankin and Reeves (1988). Data from 2007 indicate that neither method is statistically different from the other for estimating population status of juvenile coho or steelhead.

Evaluation of these data show that juvenile coho densities for the two methods reflect increases and decreases in adult population estimates in the Smith River Basin. Coho densities from snorkeling tracked adult estimates better than densities from electrofishing. Steelhead density data did not track with adult estimates for all years. Steelhead densities from snorkeling tracked adult estimates better than densities from electrofishing. Steelhead densities may have a weaker correlation with adult numbers than coho because they are older fish when sampled and comprised of multiple cohorts.

Additional years of data will improve statistical power and trend evaluations, increasing our ability to compare the two methods. Results from all years of this study will provide information on the relationship of the data generated from the coast-wide monitoring of juvenile salmonids using a snorkeling protocol at large scales and actual population status.

INTRODUCTION

Monitoring the status of salmonids in Oregon coastal streams is an important component of the Oregon Department of Fish and Wildlife's (ODFW) 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. In 2002, ODFW expanded its monitoring program to include steelhead. Monitoring is occurring coast wide and relies on the Environmental Monitoring and Assessment Program (EMAP, Stevens and Olsen 1999) for site selection and to produce fish abundance metrics at large spatial scales. Juvenile monitoring is conducted using snorkel survey protocols.

The Smith River Steelhead and Coho Monitoring Verification Study is an effort to evaluate how well visual counts compare with removal estimates as a monitoring tool at the basin scale and to provide information on the relationship of monitoring data collected coast wide to actual populations. This report will summarize juvenile salmonid data collected by snorkeling and electrofishing in the Smith River basin during the summer of 2007 and provide a comparative analysis of several years' data of how the estimates from the two methods correspond to each other and to the spawning survey estimates of adult fish above Smith River Falls. Information on the relationship of coast wide snorkel counts on the basin scale to actual population status will be presented in a synthesis report covering all years of this study.

METHODS

The study area is in Northwestern Douglas County, Oregon (Figure 1), in the Smith River Basin above Smith River Falls, a small waterfall approximately 48 km from the confluence of the Smith and Umpqua Rivers. The study area is 525 km^2 with 89.6 km of mainstem (non-wadeable) streams, 303.7 km of tributary (wadeable) streams and 24.0 km of intermediate streams at the 1:100,000 map scale. Details of the study area are described in previous Oregon Plan annual reports (Jepsen and Rodgers 2004).

Environmental Monitoring and Assessment Program (EMAP) protocols (Diaz-Ramos et al. 1996) were used to randomly select 36 sites within the presumed rearing distribution of steelhead above Smith River Falls. To track the steelhead brood cycle, a four-year rotating panel design (revisiting a subset of sites every four years) is used since the majority of Oregon coastal steelhead are four years old when they return to spawn (reviewed in Busby et al. 1996). The EMAP site selection process provides the geographic coordinates (points) of each of the candidate sample sites.

For electrofishing, EMAP points are selected from the wadeable portion (length = 303.7 km of stream) of the study area. "Wadeable" is defined in this study as lower order streams that typically have active channel widths of less than 10 meters. Sampling begins slightly downstream of the EMAP point and continues upstream until the point is encompassed and a length of stream equal to approximately 20 active channel widths is sampled. All habitat units are sampled and block nets are used at the tail and head of

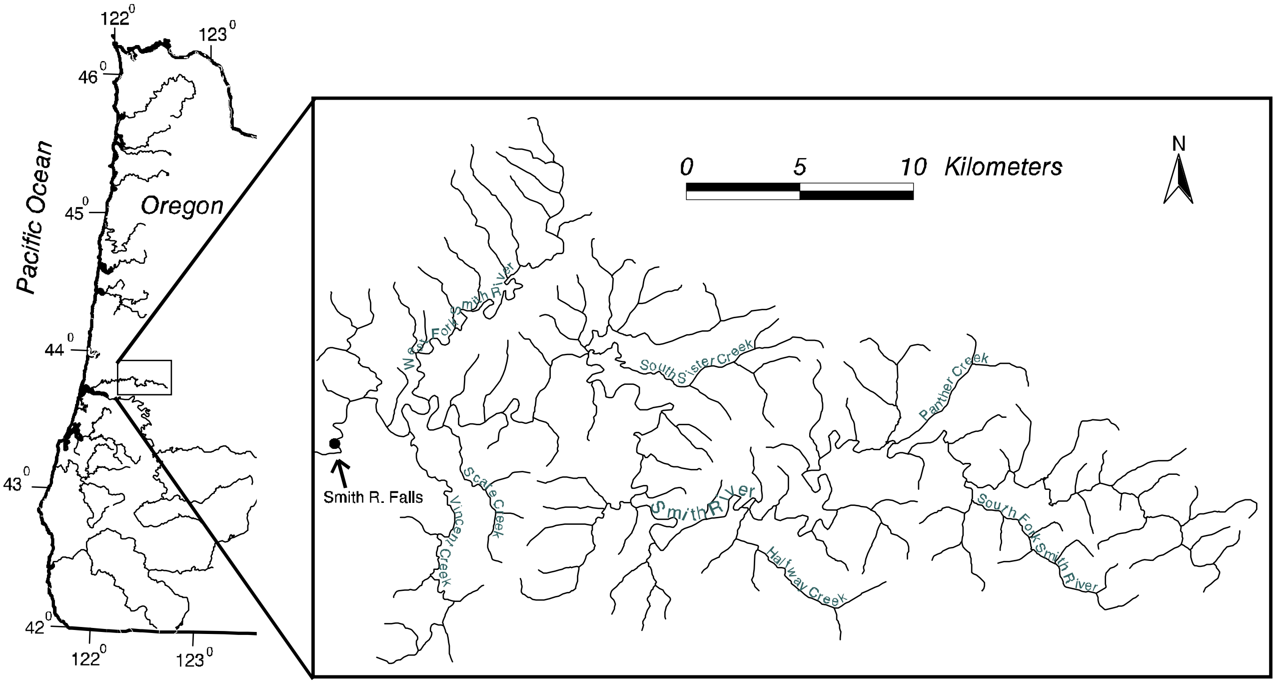

Figure 1. Location of the Smith River study area.

each unit so that estimates can be obtained on a habitat unit by habitat unit basis. Independent population estimates are made for juvenile coho, steelhead $\geq$ 90 mm, and cutthroat $\geq$ 90 mm. Because young of the year steelhead and cutthroat cannot be consistently distinguished in the field all trout >90mm are classified and estimated as 0+ age trout. A pass-removal estimate (Armour, et al. 1983) using a minimum of two passes is conducted in all units.

Snorkel surveys are conducted prior to electrofishing and encompass the same EMAP points. Snorkelers only survey pools with a maximum depth ≥40 cm and a minimum surface area of 6 square meters in a 1000 meter reach encompassing the EMAP point. Pools less than this size and fast-water habitat units (riffles, rapids, and glides) are not sampled. Snorkelers make a single pass through each pool and count juvenile coho, steelhead ≥ 90mm fork length, and cutthroat ≥90mm fork length. Trout less than 90mm in fork length are not counted but noted as either present or absent.

Additional snorkel surveys are conducted in the non-wadeable and intermediate portions of study area. Non-wadeable streams are generally 3rd to 5th order streams with active channels over 12 meters wide. Intermediate stream reaches are typically 3rd order streams with mixed wadeable and non-wadeable habitat units and active channel widths between 9 and 12 meters.

From electrofishing data we estimated the total populations of juvenile fish by summing the individual species and size class fish estimates for all habitat units sampled per site. The site sums were then divided by the sum of the lengths of all habitat units in the survey to obtain the number of each species per meter of stream channel. An estimate of the total population was calculated by multiplying the average number of species/meter for all sites by the total length of stream in the wadeable sampling frame. The 95% confidence interval around each species/size class population estimate was determined using the statistical analysis outlined by Stevens (2002). We also used this method to determine the portion of the population estimate found in pools that met snorkeling criteria and the portion found in habitat units that did not meet the criteria.

We used this method to estimate total populations from snorkeling data, summing individual species counts for all pools sampled per site to calculate the site sums. Population estimates were made for the wadeable and non-wadeable (sum = 113.5 km) portions of the basin and for the entire basin (417.3 km). Species per meter averages were weighted. Weights were determined by the portion (wadeable, intermediate, or non-wadeable) of the basin in which the surveys generating the averages took place. Weights were calculated by dividing the total length of the stream in each portion by the number of surveys in each portion.

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. For electrofishing, densities were calculated for all pools and for pools that met size criteria for snorkeling. For snorkeling, densities were calculated in wadeable and non-wadeable streams and for the entire basin, with average site densities given a weight dependant on its origin. 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. A full basin estimate of pool occupancy was obtained by averaging the site occupancy rates.

Abundance estimates for adult coho and steelhead were obtained from EMAP spawner surveys above 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).

RESULTS AND DISCUSSION

Electrofishing Surveys

In 2007, 36 sites were visited for electrofishing surveys (Figure 2). Five of these sites were completely dry and five sites were above fish passage barriers. Seven sites were in areas with pools too large to electrofish with the available resources (>50 meters long, >10 meters wide, and maximum depths exceeding 1 meter). These sites were unrepresentative of wadeable streams and were reclassified as either non-wadeable (3

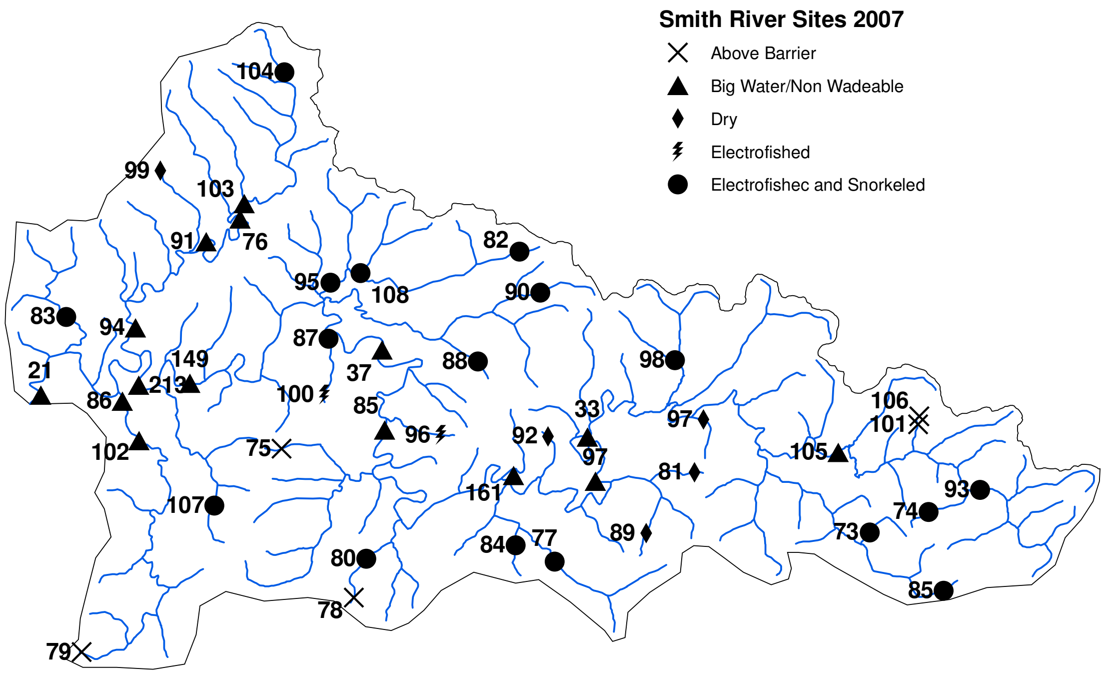

Figure 2. Location and status of survey sites in the Smith River basin, summer 2007. Numbers reference site numbers in Appendices 1 and 2. Non wadeable sites are not electrofished. Sites that were only electrofished contained no pools that met snorkel size criteria.

sites) or intermediate streams (4 sites). Four of these sites were electrofished but dropped from the analysis.

Nineteen sites, totaling 1689 meters of stream channel were electrofished and used in data analysis. Of this total 38 meters were dry channel. Four sites were dominated by pool habitat and 15 sites by riffle/rapid habitat. One site had no pools. The average wetted channel width ranged from 0.5-8.1 m and maximum water depth was 100 cm. Of the wetted sites, bedrock substrate dominated five sites, silt/sand 2 sites, and gravel/cobble/boulder 12 sites. Physical characteristics and removal estimates from electrofished sites are presented in Appendix 1. Habitat data from previous years are contained within the respective Oregon Plan annual reports and on the website: http://nrimp.dfw.state.or.us/crl/default.aspx?p=391.

0+ trout were widespread, occurring at 84% of the sites. Coho occurred at 74% of the sites, steelhead at 37%, and cutthroat at 68%. 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 $\geq$ 90 mm FL, and steelhead $\geq$ 90 mm FL.

Population estimates of the wadeable portion of the basin based on electrofishing surveys for 2007 are summarized in Table 1. To better compare electrofishing population estimates to snorkeling estimates we estimated the juvenile salmonid population in all habitats, in pools that met snorkeling size criteria, and in habitats that did not meet snorkeling protocols.

Table 1. Summer 2007 juvenile salmonid population estimates with 95% confidence intervals. The snorkel total includes pools from wadeable and non-wadeable streams. Electrofishing occurred only in wadeable streams but in all habitat types. The wadeable snorkel estimate and the electrofish snorkelable pools estimate are directly comparable.

	Snorkel			Electrofish		
Species	Total	Wadeable	Non-Wadeable	Total	Snorkelable Pools	Other Unit Types
Coho	92,568	73,285	19,282	140,845	86,078	54,767
	± 40,104	± 33,861	± 6,802	±54,697	±50,926	±22,151
Steelhead	2,392	1,992	400	3,536	2,221	1,314
	± 968	± 755	± 321	±2,347	±1,892	±1,113
Cutthroat	1,529	843	687	16,539	10,693	5,846
	± 443	± 390	± 244	±8,858	±6,241	±3,609
0+ Trout	n/a	n/a	n/a	42,855	14,754	28,101
				±19,361	±14,754	±11,551

These population estimates account only for fish in the wadeable reaches of the study area and underestimate actual population status. Rodgers (1992) found that electrofishing accounted for 67% of known summer populations of coho in pools in small streams. Data from Johnson et al (2005) found electrofishing underestimates steelhead and coho population status, as many of these fish rear in larger pools that cannot be adequately sampled. Steelhead distributions were patchy in the study area, with electrofishing finding only steelhead in 37% of the sites. In 2007 electrofishers handled only 23 juvenile steelhead ≥ 90mm in wadeable streams. Additional research is needed to determine how electrofishing estimates compare to known numbers of steelhead and coho.

Trends for these populations are shown in Figure 3. To examine trends we compared components of the same brood cycle for coho and steelhead. For coho, electrofishing population estimates were greater in 2003 than 2000 ($p=0.023$), there was no difference between 2001 and 2004 ($p=0.950$), and 2004 was greater than 2007 ($p=0.011$). Assuming a four year brood cycle for steelhead, electrofishing estimates were greater in 2000 than 2004 ($p=0.001$), and there was no detectable difference between 2003 and 2007 ($p=0.691$).

Snorkel Surveys

Forty-four sites were selected for snorkel surveys in 2007 (Figure 2). Of these, 10 sites were in the non-wadeable portions of the basin and five sites were in intermediate streams. For data analysis intermediate streams were considered non-wadeable, but given a separate weight. Data were lost for one of the surveys in a non-wadeable reach. Twenty nine sites were in the wadeable portions of the basin. Of these, five sites were completely dry, five were above fish passage barriers, and two did not contain pools that met size protocols for snorkel surveys. Seventeen sites were both snorkeled and

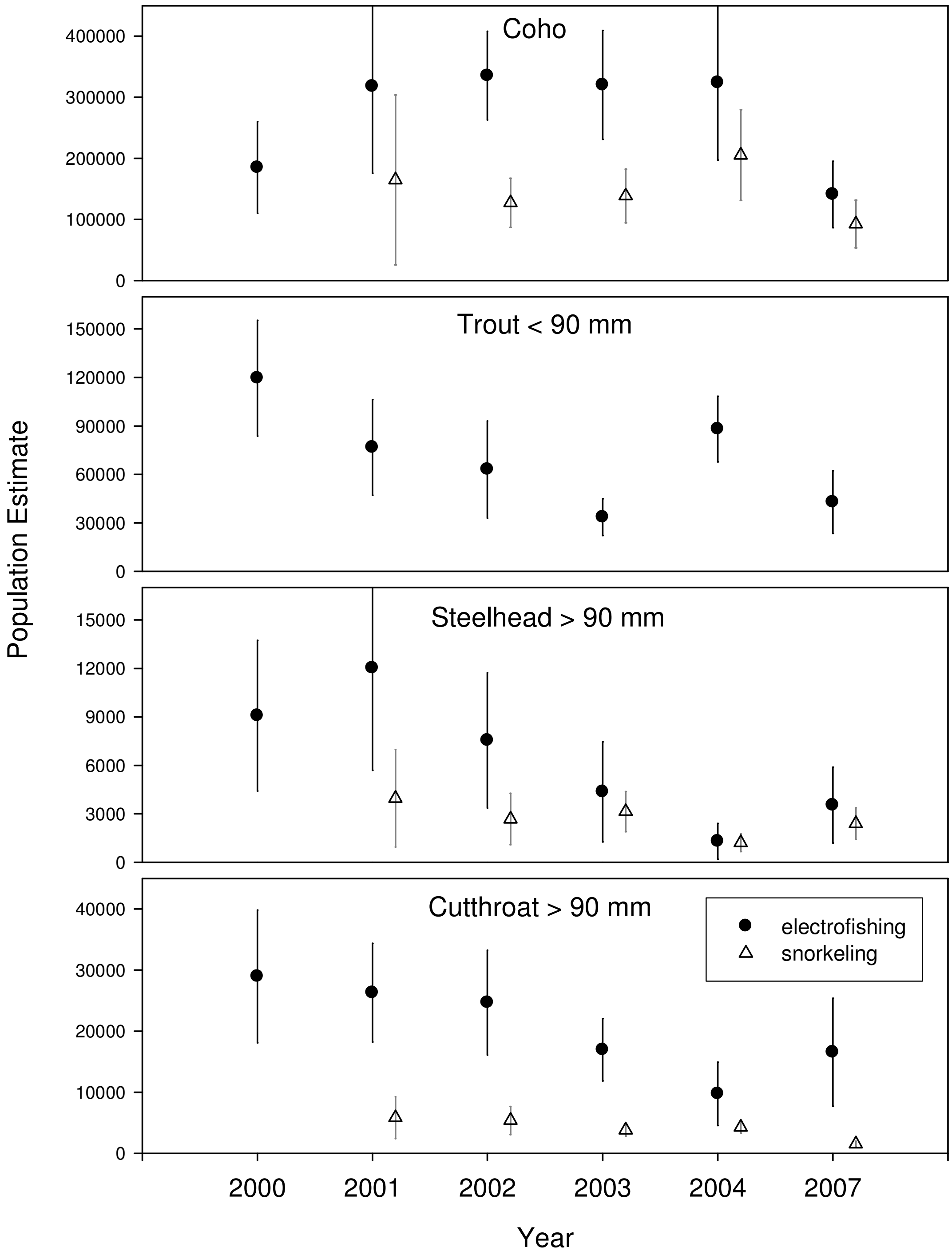

Figure 3. Electrofishing population estimates in wadeable streams and snorkeling population estimates in wadeable and non-wadeable streams, with 95% confidence interval. No sampling occurred in 2005 and 2006, not snorkeled in 2000.

Table 2 Snorkel survey estimates of average pool density (fish/m^2) of juvenile salmonids, and average percentage of pools per site with at least one fish in wadeable and non-wadeable stream reaches above Smith River Falls, summer 2007.

	All Sites (n=31)		Wadeable Sites (n=17)		Non-wadeable (n=14)	
Species	Density	Ave. Pool Occupancy	Density	Ave. Pool Occupancy	Density	Ave. Pool Occupancy
Coho	0.408 ± 0.014	74%	0.545 ± 0.021	79%	0.040 ± 0.0002	68%
Steelhead	0.028 ± <0.0002	18%	0.039 ± 0.001	24%	0.001 ± <0.0002	11%
Cutthroat	0.010 ± <0.0002	18%	0.013 ± 0.001	15%	0.001 ± <0.0002	22%

electrofished. Physical characteristics and pool count data from snorkel sites are presented in Appendix 2.

Coho were observed in 88% of wadeable stream sites and 93% of non-wadeable streams, although one non-wadeable site had only one coho. Steelhead were found in 82% of wadeable streams and 50% of non-wadeable streams. Cutthroat were found in 100% of non-wadeable streams and in 65% of wadeable streams. Steelhead and cutthroat were found only in small numbers at some sites. Fish densities were higher for all three species in the wadeable streams versus non-wadeable streams (Table 2). The pool occupancy metric indicated that coho were more dispersed than cutthroat or steelhead in wadeable and non-wadeable sites. Cutthroat and steelhead were equally dispersed in all sites, but steelhead were more dispersed in wadeable sites and cutthroat were more dispersed in non wadeable sites.

Population estimates based on snorkeling are summarized in Table 1. These population estimates are only from pools that met our size criteria and underestimate the actual population status. Prior studies have shown that snorkelers account for 40% of known summer coho population in small streams (Rodgers et al. 1992). Data from Johnson et al. (2005) indicate that coho and steelhead juveniles are typically undercounted when compared to removal estimates and Hillman et al. (1992) examine several variables that can be related to the undercounting of coho and steelhead juveniles by snorkelers. Little is known about how snorkel counts in larger, non-wadeable streams compare to known coho populations or how snorkel counts compare to known numbers of steelhead or cutthroat.

As a quality check and to detect potential differences between surveyors approximately 15% of the snorkel sites are resurveyed by supervisory staff. In 2007 four sites were resurveyed. Original surveyors counted 93% of the coho that resurveyors counted, 82% of the cutthroat, and 67% of the steelhead (Figure 4).

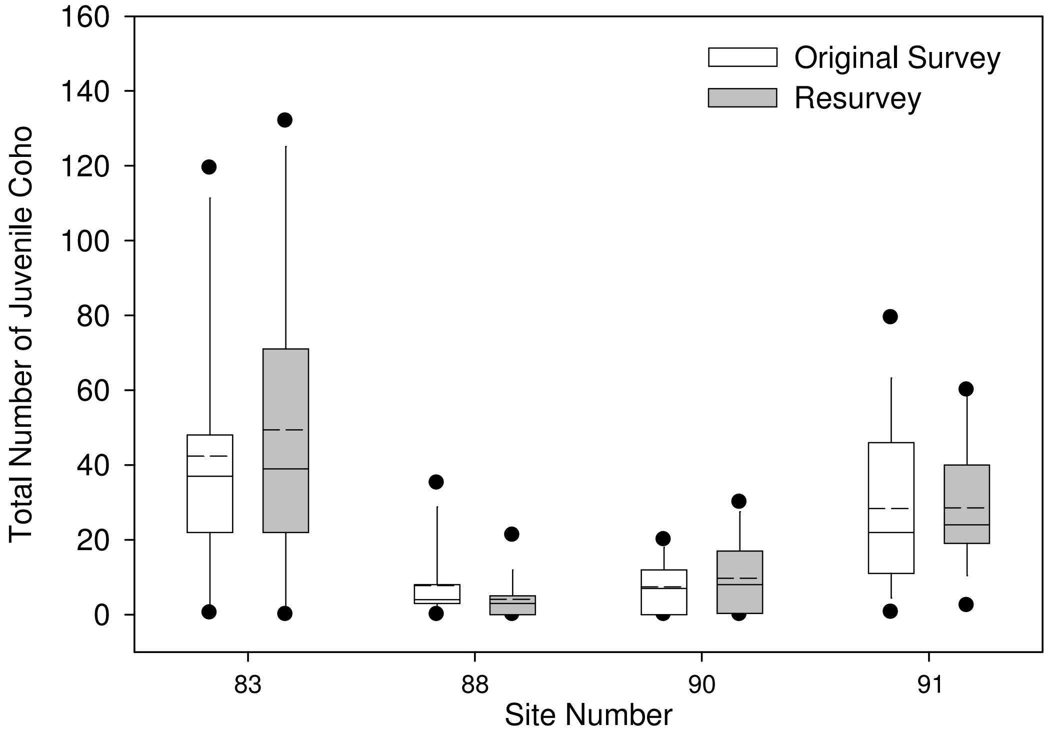

Figure 4. Comparison of coho counts in pools for sites that were resurveyed by snorkeling in Smith River tributaries, 2007. Boxes contain the pool estimates for mean number of fish (dashed line), median (solid line) and the 25th and 75th percentiles. Whiskers are the 10th and 90th percentiles, and symbols represent the 5th and 95th percentiles.

Electrofishing and Snorkel Survey Comparisons

In 2007 snorkelers visited 17,488 meters of stream in 17 sites in wadeable reaches of the study area. Of this, 8189 meters of pool habitat were sampled (372 pools), accounting for 2.4% of the length of the wadeable rearing distribution. Snorkelers covered 14,023 meters of stream in 14 sites in non-wadeable/intermediate reaches. Of this, 5704 meters of pool habitat were sampled (96 pools), accounting for 4.8% of the length of non-wadeable/intermediate rearing distribution in the study area. Snorkelers sampled only pools, but sampled 3% of the total length of rearing distribution in the study area, an area 5 times larger than the area sampled by electrofishers. Four weeks and a crew of two snorkelers were required to survey the 17 sites in wadeable streams, one week and a crew of three snorkelers were required to survey 7 of the 14 sites in non-wadeable/intermediate streams, and one week and a crew of five snorkelers were required to survey the remaining 7 sites in non-wadeable streams. 640 person-hours (crew size multiplied by time to complete the survey) were needed to complete the 31 snorkel sites.

Electrofishers surveyed 2,532 meters, or 0.8% of the rearing distribution in wadeable reaches (0.6% of the study area). Four weeks with a crew of 3 electrofishers and one week with a crew of 2 electrofishers were required to survey the 22 electrofishing sites. Of the 2,532 meters surveyed by electrofishers, 843 meters (four sites) were

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 for salmonids in Smith River tributaries, summer 2007. Snorkel data are from pools in wadeable streams that meet snorkeling size criteria. Electrofish data are from all electrofished pools and electrofished pools that also meet snorkeling size criteria.

	Snorkel			Electrofish			
Species	Average Density	Site Occupancy	Average Pool Occupancy	Density in snorkel pools	Density in all pools	Site Occupancy	Average Pool Occupancy
Coho	0.545 ± 0.021	88%	79%	0.571 ±0.050	0.388 ±0.011	74%	81%
Steelhead	0.039 ± 0.001	82%	24%	0.026 ± 0.001	0.01 ± <0.001	37%	25%
Cutthroat	0.013 ± <0.001	65%	15%	0.119 ±<0.001	0.056 ±0.003	68%	80%

unrepresentative of wadeable streams and were dropped from electrofishing analysis. Within the five week period electrofishers visited five sites that were dry and five sites that were above fish passage barriers. These ten sites were not visited by snorkelers. 520 person-hours were needed to complete the 22 electrofishing sites and to visit the 10 sites that were dry or above barriers.

For sites where both snorkel and electrofishing surveys were conducted in 2007, there was no detectable difference between snorkeling and electrofishing density estimates for coho (Table 3, $p = 0.347$). In 2001 and 2002 snorkelers estimated 41% and 78% of the coho density estimated by electrofishing. In 2003 and 2004 however, electrofishing density estimates for coho were 83% and 63% of that estimated by snorkeling. Consistent with past years, snorkel surveys estimated higher steelhead densities than electrofishing (p value < 0.001), and electrofishing produced higher cutthroat densities than snorkel surveys (p value < 0.001). In pools that were sampled by both methods and had adequate visibility for snorkeling, snorkelers counted 82% of the coho estimated by electrofishing and 28% of the steelhead.

In past reports electrofishing densities from pools used in comparison to snorkeling densities were generated from removal estimates in all electrofished pools, regardless of size. Since electrofishing surveys sample all pools regardless of depth and surface area and snorkel surveys sample only larger pools (pools ≥40cm in maximum depth and ≥6m^2 in surface area) there may be a negative bias in fish density estimates from electrofishing data. Analysis of the 2004 data showed that approximately half the electrofishing sites with average pool depths less than 40 cm had no coho (Jepsen 2005). In 2007 densities were lower for all three species when calculated from all electrofished pools compared to densities calculated from electrofished pools that meet snorkeling size requirements (Table 3). In 2007 we used electrofishing density estimates from pools that met snorkeling size protocols for comparisons with snorkeling density estimates. Data from past years will be reanalyzed to provide density estimates from electrofishing in all pools and in pools that meet snorkeling criteria.

In 2007 snorkel surveys produced a higher percent of sites that contained at least one fish for coho (electrofishing 84% of snorkel estimate) and steelhead (electrofishing 45% of snorkel estimate), but electrofishing produced a slightly higher percent of sites with at least one cutthroat (snorkeling 96% of electrofishing estimate). These results are consistent with data from past years.

Snorkeling and electrofishing produced similar percent pool occupancies for coho and steelhead in wadeable streams. Electrofishing produced higher (snorkeling 19% of electrofishing) percent pool occupancies for cutthroat. For all years except 2007, snorkel surveys yielded greater coho pool occupancy rates than electrofishing surveys. As with density estimates, pool occupancies in past reports are generated from all electrofishing pools and therefore may share the same negative bias.

Population estimates of juvenile fish for snorkeling and electrofishing protocols in 2007 are summarized in Table 1. There was no detectable difference between snorkeling and electrofishing total population estimates for coho ($p = 0.191$) or steelhead ($p = 0.812$) in 2007. Electrofishing surveys produced a much higher population estimate of cutthroat ($p = 0.003$).

Population estimate comparisons for all years are presented in Figure 3. In 2001 the coho population estimate produced from snorkeling was not statistically different than the estimate produced from electrofishing ($p = 0.131$). The 2001 steelhead population estimate from electrofishing was greater than the estimate from snorkeling ($p = 0.024$). In 2002 electrofishing produced higher population estimates for both coho ($p = <0.001$) and steelhead ($p = 0.033$). In 2003 electrofishing produced a higher coho estimate ($p = <0.001$), but there was no statistical difference between the steelhead estimates form electrofishing and snorkeling ($p = 0.472$). In 2004 there was no statistical difference for coho ($p = 0.112$) or steelhead estimates ($p = 0.902$).

Electrofishing techniques that estimate total fish counts are not feasible in non-wadeable and intermediate stream reaches, whereas several snorkelers can simultaneously sample a non-wadeable pool. Snorkeling, however, is not feasible in fast water habitat units and in pools that are less than 40 cm in maximum depth. Snorkeling protocols used in this study also do not estimate numbers of 0+ aged trout.

Density estimates were low from pools in non-wadeable reaches (Table 2), but these streams accounted for 21% of the coho population estimate, 17% of the steelhead estimate and 45% of the cutthroat estimate based on snorkeling data in 2007 (see Table 1).

Higher fish densities in the non-wadeable portion of the basin were found in the 7 sites located in the lower, non-wadeable, portions of higher order tributaries (specifically, the West Fork of the Smith River, Vincent Creek, and South Sister Creek) of the mainstem of the Smith. Average coho and steelhead density in these sites were 0.1148 fish/m^2 and 0.0020 fish/m^2, respectively. In the mainstem itself, densities for coho and steelhead were 0.0355 fish/m^2 and 0.0001 fish/m^2.

Electrofishing was able to detect juvenile salmonids rearing in fast water habitats (riffles and glides) and in pools ≤40cm in maximum depth. In 2007 these habitats accounted for 39% of the juvenile coho population, 37% of the juvenile steelhead population, 35% of the cutthroat population, and 68% of the 0+ trout population (Table 6).

Comparisons with Adult Data

To determine the relative effectiveness of either method as a basin-scale monitoring tool, we compared the juvenile data to trends in the estimated number of adult spawners returning to the Smith River basin above Smith River Falls (Figure 5). Snorkeling surveys show a close relationship between densities of juvenile coho and the adults that produced them (Figure 5; $R^2 = 0.930$, $p = 0.008$) while electrofishing showed less correlation between adult numbers and juvenile densities ($R^2 = 0.485$, $p = 0.125$). Relative to coho, snorkeling surveys for steelhead showed a weaker relationship between adults and juvenile densities ($R^2 = 0.726$, $p = 0.148$) due in part to smaller sample size. Electrofishing suggested very little relationship between adult numbers and juvenile densities for steelhead ($R^2 = 0.118$, $p = 0.657$).

When juvenile coho density data for the two methods are plotted against adult EMAP population estimates over several brood years (Figure 6), juvenile coho densities from snorkel surveys and electrofishing have tracked similarly in brood years 2000-2002. Snorkel surveys were not performed in the first year of the study (2000). In brood year 2003 and 2006 both snorkeling and electrofishing densities tracked the decline in adult coho numbers. For brood years 2003 and 2006 electrofishing densities declined more sharply than snorkeling densities.

Patterns for steelhead showed neither juvenile survey methods tracked changes in adult abundance between some brood years. Juvenile steelhead electrofishing estimates did not reflect the increase in adult estimates between brood years 2001-2002 and increased slightly in 2004 as adults in 2003 declined. Snorkel survey estimates increased between 2000 and 2001 as estimates of adults that produced them declined slightly.

Juvenile steelhead densities may have a weaker correlation with adult numbers than coho because they are older and the population is comprised of multiple cohorts. Unlike coho, when sampled in this study juvenile steelhead are >1 year old and may have been subjected to additional ecological bottlenecks such as competition and predation or winter floods and high summer temperatures. Scales analyzed by the Life Cycle Monitoring Project on the West Fork Smith River indicate that the age composition of smolts varies by year. Over four years 15-60% were 1+, 40-77% are 2+, and 0-8% were 3+ years old (Miller et al, 2008), increasing variability when attempting to relate a population of juvenile steelhead to the adults which produced them.

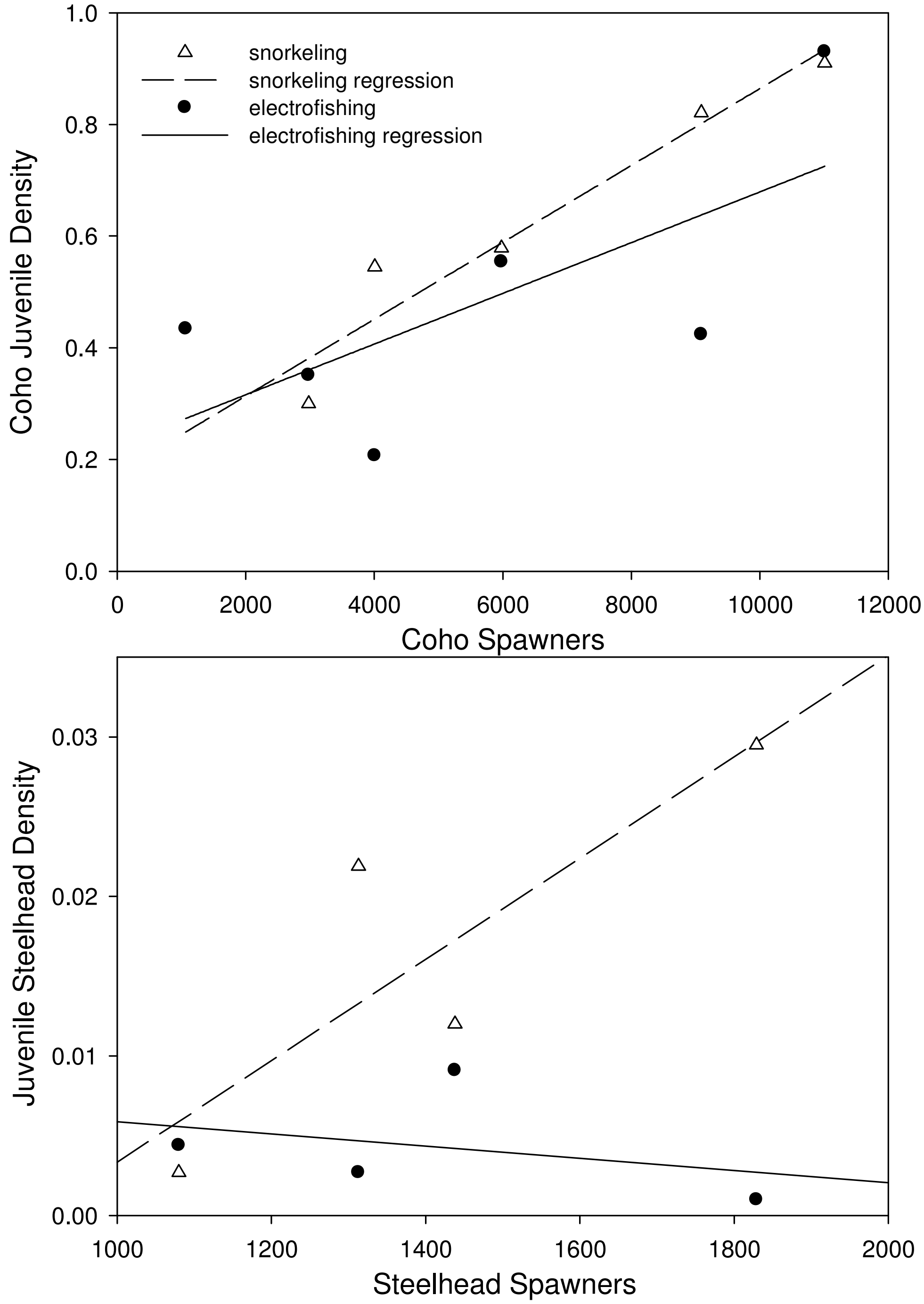

Figure 5. Relationship between the density of juvenile fish and the number of adults that produced them; coho in the top panel, steelhead in the bottom. Snorkeling regression is represented by the dashed line (for coho $R^2 = 0.930$, $p = 0.008$, for steelhead $R^2 = 0.726$, $p = 0.148$). Electrofishing regression is represented by the solid line (for coho $R^2 = 0.485$, $p = 0.125$, for steelhead $R^2 = 0.118$, $p = 0.657$).

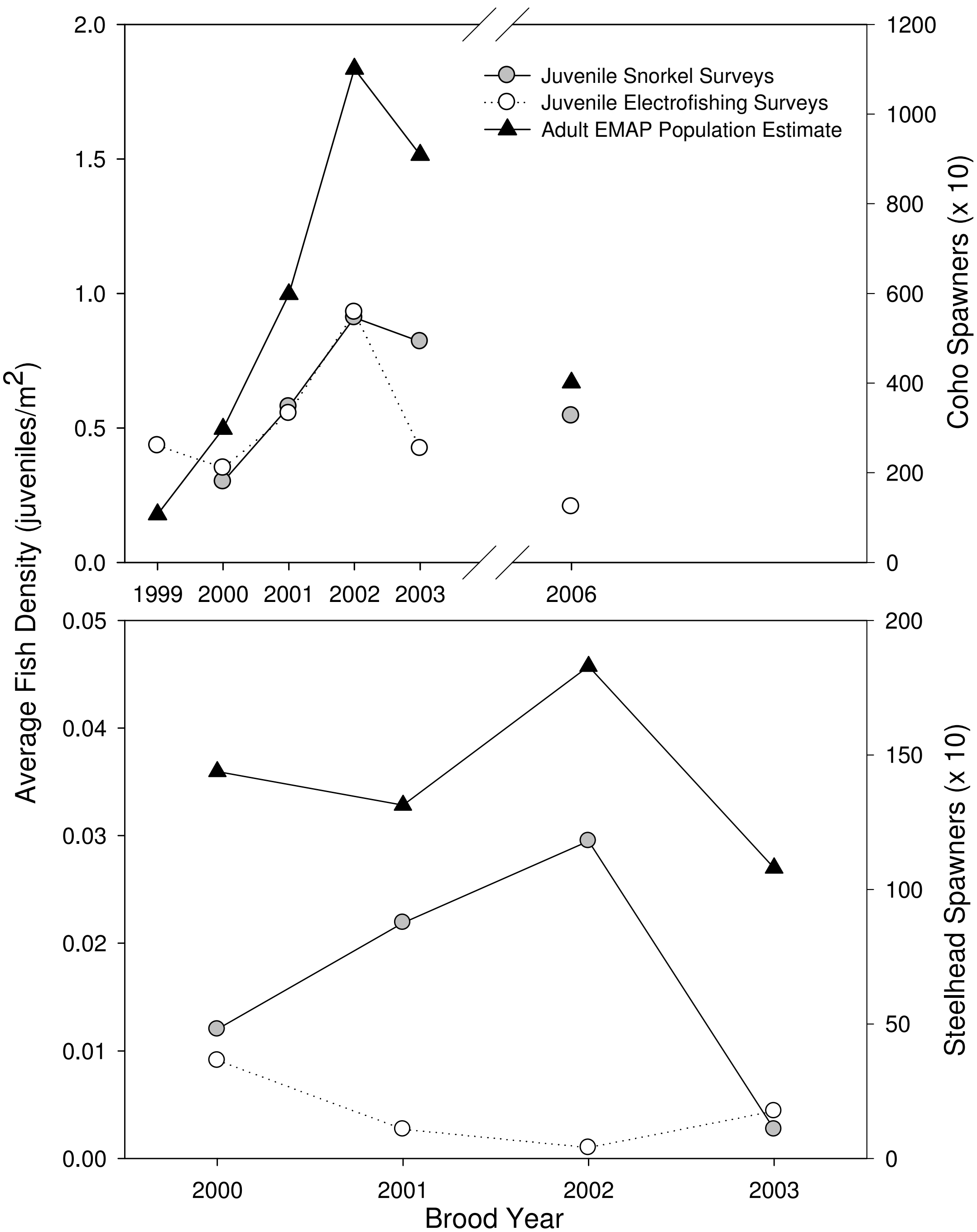

Figure 6. Comparison of juvenile fish densities for the two survey methods, related to estimates of adult spawner abundance for coho (top panel) and steelhead (bottom panel). Snorkel data are taken from pools in wadeable streams. Electrofishing data are from all units. Brood year refers to the year adult data were collected (juvenile fish spawned), corresponding to the subsequent year juvenile fish were surveyed. For brood year 1999 (juvenile survey year 2000) no snorkel surveys were conducted.

CONCLUSIONS

Both methods have advantages and disadvantages as juvenile salmonid monitoring tools at the basin scale. In 2007 electrofishing was able to detect 39% of the coho population and 37% steelhead populations rearing in habitats not sampleable under snorkeling protocols. Snorkeling was able to detect 21% of the coho population and 17% of the steelhead population rearing in habitats not sampleable by electrofishing protocols. In 2007 and 2004 the two methods produced statistically similar population estimates for coho and steelhead juveniles. In 2003 and in 2002 electrofishing produced higher population estimates for coho. In 2002 and 2001 electrofishing produced higher population estimates for steelhead. There was no statistical difference in the 2001 coho estimates or in the 2003 steelhead estimates.

In 2007 the two methods produced statistically similar density estimates for coho. Snorkeling produced higher density estimates for steelhead and electrofishing produced higher density estimates for cutthroat. Trends in juvenile coho and steelhead densities measured from snorkeling tracked better with adult trends than densities measured from electrofishing. In 2007 neither method was statistically more precise than the other at estimating juvenile salmonid trends or abundances.

In pool by pool comparisons from wadeable sites where both methods were used, snorkelers counted 82% of the coho and 28% of the steelhead estimated by electrofishing. Although less accurate than electrofishing, snorkelers sampled much longer segments of stream around each survey point and found coho and steelhead in 88% and 82% of the surveys, respectively where electrofishing found coho and steelhead in 74% and 37% of the surveys. Snorkeling produced steelhead density estimates that were higher than those from electrofishing and coho density estimates that were statistically similar to electrofishing. Other researchers (Rodgers et al.,1992 and Hankin and Reeves, 1998) have noted that, although less accurate than electrofishing, snorkeling methodologies sample a larger proportion of stream reaches which improves their ability to make population estimates. This could be especially important when juvenile fish densities are low or the population has a patchy distribution, as with steelhead in the Smith River Basin.

Data from the summer of 2007 suggest that neither snorkeling nor electrofishing alone can sample all habitat types and is likely to underestimate the population of juvenile fish on the basin scale. To produce more accurate population estimates sampling designs that use both methods and calibrate snorkelers with removal estimates should be used such as described by Hankin and Reeves (1988).

Data from previous years and 2008 will be synthesized into a report covering all years of this study to date. Some reanalysis of data is needed from past years so that density and pool occupancy rates can be more accurately compared. This analysis will also allow us to make conclusions about the ability of either method to accurately estimate trend. This analysis will be presented in the synthesis report.

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APPENDICES

Appendix 1. Site status, estimated number of juvenile salmonids (sthd=steelhead, cutt=cutthroat) per site, pool occupancies (percent of pools per site with at least one fish), and physical site characteristics in electrofished sites in the Smith River Basin above Smith River Falls, Summer 2007.

ELECTROFISHING									
Site	**Status**	**Coho**	**Sthd**	**Cutt**	**Trout ≤90mm FL**	**Length of Site in meters**	**Riffle/Rapid/ Glide Surface Area (m²)**	**Pool Surface Area (m²)**	**Percent Pool Occupancy: coho/sthd/cutt**
73	Electrofished/Snorkeled	47	0	4	1	67	14.1	28.8	100/0/50
74	Electrofished/Snorkeled	34	0	8	7	78.5	49.8	45.1	100/0/100
75	Above Barrier					0			
76	Reclassified-Big Water					n/a			
77	Electrofished/Snorkeled	171	1	7	11	143.4	111.3	414.1	100/25/100
78	Above Barrier					0			
79	Above Barrier					0			
80	Electrofished/Snorkeled	4	0	4	7	84.6	123.8	63.6	67/0/67
81	Dry					0			
82	Electrofished/Snorkeled	0	2	5	3	40.2	15.9	50.1	0/20/40
83	Electrofished/Snorkeled	200	0	1	117	153.6	355.9	344.7	75/0/25
84	Electrofished/Snorkeled	16	0	3	18	53.3	21.8	27.2	100/0/67
85	Electrofished/Snorkeled	0	0	0	1	43	22.7	0	0/0/0
86	Reclassified-Big Water	60	10	6	96	n/a			
87	Electrofished/Snorkeled	20	0	0	6	103.3	296.8	23.6	67/0/0
88	Electrofished/Snorkeled	3	0	0	0	63.7	113.5	23.4	50/0/0
89	Dry					0			
90	Electrofished/Snorkeled	84	0	4	9	103.6	146.7	115.0	100/0/25
91	Reclassified-Big Water	264	13	5	72	n/a			
92	Dry					0			
93	Electrofished/Snorkeled	180	5	18	2	148.6	67.4	665.1	100/50/100
94	Reclassified-Big Water					n/a			
95	Electrofished/Snorkeled	117	10	2	46	162.5	725.6	162.1	100/50/50
96	Electrofished	0	0	0	0	82.5	49.8	5.9	0/0/0
97	Dry					0			
98	Electrofished/Snorkeled	51	1	4	0	86	154.2	105.7	100/25/75
99	Dry					0			
100	Electrofished	0	0	0	7	48.2	37.2	0.8	0/0/0
101	Above Barrier					0			
102	Reclassified-Big Water	69	21	9	121	n/a			
103	Reclassified-Big Water	199	2	11	36	n/a			
104	Electrofished/Snorkeled	35	3	4	23	61.5	87.6	28.2	100/67/33
105	Reclassified-Big Water					n/a			
106	Above Barrier					0			
107	Electrofished/Snorkeled	0	0	16	8	52.3	20.7	59.0	0/0/100
108	Electrofished/Snorkeled	784	1	0	12	113.5	235.9	84.7	100/33/0

Appendix 2. Site status and summary of snorkel survey sites in the Smith River basin, 2007. Bolded site numbers are non-wadeable sites. Italicized site numbers are intermediate sites. Percent pool occupancy is the percentage of pools per site with at least one fish of the species.

SNORKELING						
Site	**Status**	**Number of Pools**	**Length of Site (m)**	**Pool Surface Area (m^2)**	**Hard counts of fish Coho/Sthd/Cutt**	**Percent Pool Occupancy Coho/Sthd/Cutt**
73	Electrofished/Snorkeled	10	1000	136	119/17/0	100/70/0
74	Electrofished/Snorkeled	8	1000	53	56/1/6	100/13/75
75	Above Barrier	n/a	n/a	n/a	n/a	n/a
76	Snorkeled	17	1022	7278	616/7/4	100/24/18
77	Electrofished/Snorkeled	40	1000	1917	508/8/8	98/18/10
78	Above Barrier	n/a	n/a	n/a	n/a	n/a
79	Above Barrier	n/a	n/a	n/a	n/a	n/a
80	Electrofished/Snorkeled	5	1000	133	0/0/0	0/0/0
81	Dry	n/a	n/a	n/a	n/a	n/a
82	Electrofished/Snorkeled	1	650	6	0/0/0	0/29/14
83	Electrofished/Snorkeled	27	1008	4149	1144/9/0	100/11/0
84	Electrofished/Snorkeled	1	1000	15	8/0/0	100/0/0
85	Electrofished/Snorkeled	11	1000	215	186/10/5	100/45/27
86	Snorkeled	25	1000	4880	348/3/13	100/8/28
87	Electrofished/Snorkeled	7	1000	339	396/17/1	100/71/14
88	Electrofished/Snorkeled	23	958	454	178/13/4	87/30/17
89	Dry	n/a	n/a	n/a	n/a	n/a
90	Electrofished/Snorkeled	24	950	423	178/2/3	92/17/8
91	Snorkeled	25	938	5589	710/13/15	96/32/32
92	Dry	n/a	n/a	n/a	n/a	n/a
93	Electrofished/Snorkeled	24	1000	3383	164/5/2	88/21/8
94	Snorkeled	16	1000	5007	142/5/7	81/25/31
95	Electrofished/Snorkeled	20	1022	3839	529/4/7	100/10/30
96	Electrofished	0	1000	0	0/0/0	0/0/0
97	Dry	n/a	n/a	n/a	n/a	n/a
98	Electrofished/Snorkeled	24	1000	656	308/2/4	96/13/21
99	Dry	n/a	n/a	n/a	n/a	n/a
100	Electrofished	0	1000	0	0/0/0	0/0/0
101	Above Barrier	n/a	n/a	n/a	n/a	n/a
102	Snorkeled	27	997	6333	587/40/31	93/48/30
103	Snorkeled	29	1009	9088	725/3/9	97/69/17
104	Electrofished/Snorkeled	15	1000	267	274/15/0	93/33/0
105	Snorkeled	12	1000	2616	68/0/2	100/0/8
106	Above Barrier	n/a	1000	n/a	n/a	n/a
107	Electrofished/Snorkeled	18	1000	133	5/6/6	28/17/22
108	Electrofished/Snorkeled	17	1000	754	52/2/1	65/6/6
21.07	Snorkeled	21	1000	29309	0/0/1	0/0/5
33.07	Snorkeled/data lost	n/a	1000	n/a	n/a	n/a
37.07	Snorkeled	14	1000	14001	29/0/4	57/0/21
85.07	Snorkeled	15	1000	10344	185/0/8	87/0/33
97.07	Snorkeled	11	1057	8614	31/0/2	55/0/18
149.07	Snorkeled	7	1000	15025	1/0/2	14/0/29
161.07	Snorkeled	17	1000	7540	18/0/2	41/0/12
213.07	Snorkeled	12	1000	30920	13/3/6	33/17/33