Comparison of three sampling methodologies to estimate abundance of juvenile Coho Salmon in two Russian River tributaries

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Introduction

We compared the effectiveness of snorkeling, electrofishing, and Passive Integrated Transponder (PIT) tag wanding in estimating juvenile Coho Salmon *Oncorhynchus kisutch* abundance in 250 m study reaches of Dutch Bill and Mill creeks, tributaries of the Russian River along the central coast of California (Figure 1). In 2016 and 2017, each reach was stocked in June with 500 age-0 PIT-tagged Coho Salmon as part of a long-term oversummer survival study. Reaches were bounded by stationary PIT-tag antennas at the upper and lower extents to account for movement in and out of the reaches (Figure 2). Abundance estimates generated using electrofishing data (multiple-pass depletions) were compared with those using snorkeling data (bounded count), and PIT-tag wanding data (Peterson). Although comparisons between snorkel surveys and electrofishing have been studied extensively, comparisons with PIT-tag wanding have been minimal. We were also interested in comparing maximum and average counts for two-pass snorkeling to determine which method best relates to electrofishing estimates and whether completing a second pass improves estimates. Equipment cost and crew time were compared for each method.

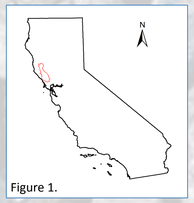


Figure 1.

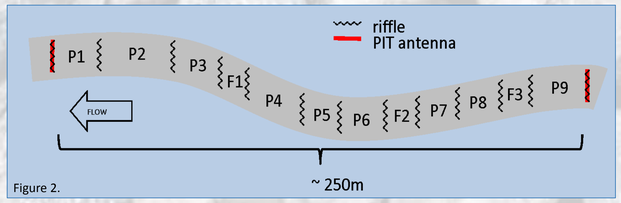


Figure 2.

Methods

Two-pass snorkel counts (Figure 3) were used to quantify the number of juvenile Coho Salmon within each reach. All pool and flatwater units were snorkeled by experienced divers. Bounded count abundance estimates were generated according to methods in Johnson et al. (2007).

Portable PIT-tag antennas (Figure 4), or "wands" (O'Donnell et al. 2010), were used to scan all pool and flatwater units and detect tagged fish; paired samples were conducted on consecutive days. Wanding abundance estimates were generated using a Peterson model in program MARK (White and Burnham 1999).

Multiple-pass electrofishing (Figure 5) was conducted in all pool and flatwater units, and a minimum of two passes was completed for each unit. Electrofishing abundance estimates were generated using a Cormack-Jolly-Seber (CJS) depletion model in program MARK (White and Burnham 1999).

Figure 3: Snorkel survey.

Figure 4: PIT-tag wanding.

Figure 5: Backpack electrofishing.

Because we did not know the "true" number of fish in each habitat unit, we compared estimates generated from wanding and snorkeling surveys to estimates generated using the well-established electrofishing depletion method. We used linear regression to evaluate whether abundance estimates generated using wanding and snorkeling data (alternate methods) were correlated with electrofishing depletion estimates. To quantify the level of agreement between electrofishing and alternate methods, we plotted the mean of the electrofishing estimate and the alternate method estimate (x-axis) against the difference between the electrofishing estimate and the alternate method estimate (y-axis) for each habitat unit (Bland-Altman 1986). Reach-scale abundance estimates were obtained by summing unit level estimates for each method.

Results

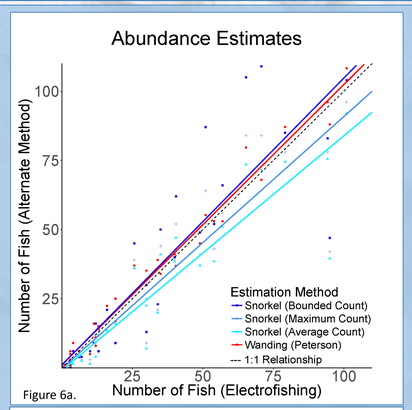


Figure 6a.

Table 1.

Estimation Method	Slope	Intercept	R-squared	P-Value
Snorkel (Bounded Count)	1.03	1.02	0.79	<0.001
Snorkel (Maximum Count)	0.91	0.26	0.83	<0.001
Snorkel (Average Count)	0.85	-0.91	0.85	<0.001
Wanding (Peterson)	1.01	1.13	0.98	<0.001

Snorkeling and wanding estimates were highly correlated with electrofishing estimates (Figure 6). The relationship between wanding and electrofishing estimates had the highest adjusted R^2 and was closest to a 1:1 ratio. Maximum counts and average counts were slightly more correlated with electrofishing estimates than bounded count estimates were with electrofishing estimates; however, the slope was closer to a 1:1 ratio for the relationship between bounded count and electrofishing estimates (Table 1).

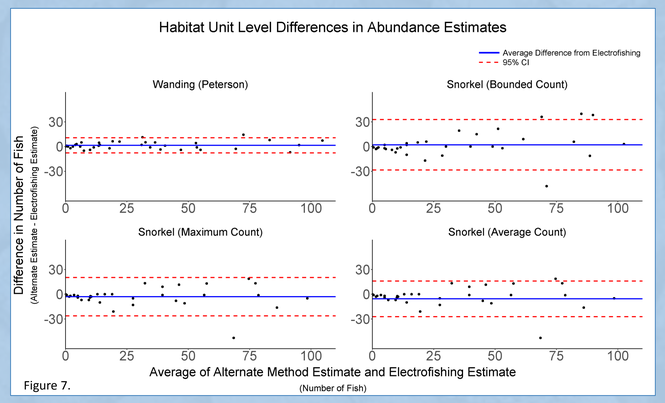


Figure 7.

Wanding abundance estimates had greater agreement with electrofishing estimates (±9 fish for 95% of units) than snorkel estimates (±22-±31) at the unit scale (Figure 7). On average, wanding and bounded count estimates were slightly higher than electrofishing estimates (+1.5 and +2.2 fish, respectively) while maximum and average counts were lower (-3.0 and -5.6 fish, respectively).

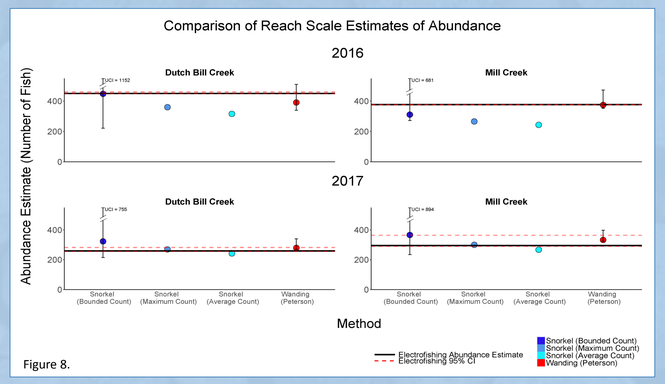
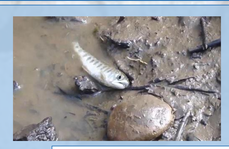


Figure 8.

Reach-scale estimates from wanding were very similar to those from electrofishing for all years and reaches (Figure 8). Estimates from snorkel counts showed more variability, with bounded count estimates performing better in 2016 and maximum count estimates performing better in 2017. Average count estimates always performed worse than bounded or maximum count estimates.

Discussion



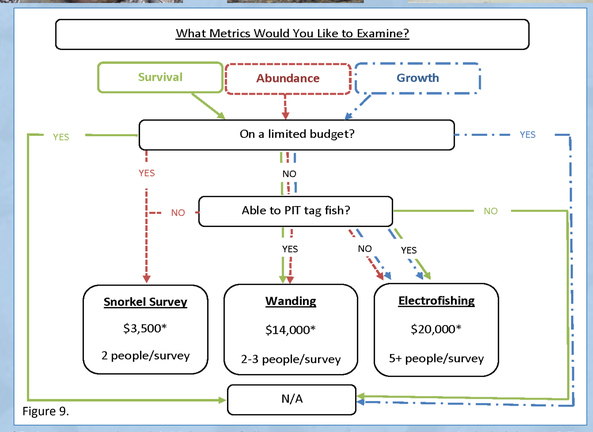


Figure 9.

*Estimated costs based initial costs of all necessary equipment; does not include labor or PIT tagging costs on studying two reaches a year, for two years.

- Snorkeling and wanding abundance estimates are both highly related to electrofishing estimates at the 250 m reach scale. At the unit scale, snorkel estimates have an expected accuracy ranging from ±22 to ±31 fish; therefore, methods should be considered carefully in the context of study objectives.
- Wanding appears to be an acceptable substitute for electrofishing; in this study, wanding estimates were within 9 fish of electrofishing estimates in 95% of units.
- In situations where electrofishing or wanding are impossible or impractical, snorkeling provides a viable alternative for estimating relative abundance on a broad scale.
- Based on our results, bounded counts and maximum counts were better than average counts for estimating abundance. Further studies may help highlight pros/cons between bounded and maximum counts.

Methods Considerations

- Two passes and experienced divers are essential for achieving accurate abundance estimates with snorkel surveys.
- When compared with electrofishing and wanding, snorkel surveys have less impact on fish, especially in low-flow conditions.
- Cost and effort associated with snorkeling is significantly lower than alternate survey methods; however, snorkeling does not yield survival and growth data (Figure 9).

Acknowledgements & References

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