

Evaluation of the Northwest Marine Technology Individual Fish Counter

by
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Introduction

With the advent of mass marking of salmonids, hatchery managers have the opportunity to obtain an accurate inventory of their fish during the marking process. This process often involves passing large numbers of fish through a marking trailer where they are manually fin clipped. The current standard practice of enumeration in manual fin clipping operations has been the “sample count” method. This is a method of estimating fish population from total weight based on individual weights of a small portion of the population. Studies have shown that even with care, these counts can be as much as $\pm 20\%$ inaccurate (Piper 1982)². In addition, weighing fish can cause undue stress and mortality. A device has been needed that would accurately count individual fish at the time of fin clipping. This technology would provide managers with a more accurate total count of the population at the time of marking, and later release. Northwest Marine Technology (NMT) has developed a new counting device called the Individual Fish Counter (IFC), and we tested the first prototype of this device.

Methods

The study was conducted on November 7th and 8th 2006, at the Puyallup Tribal Hatchery located on Diru Creek. The fish used were brood year 2005 winter run steelhead (*Oncorhynchus mykiss*). The fish had an average size of 65fpp or 6.9g. The size range of these fish was highly variable as approximately 10% of the population was > 30 fpp or < 150 fpp. This was considered an excellent example of a difficult counting situation utilizing a rearing group with highly variable fish sizes.

Two IFC counting sensors were mounted in the clipping table of a CWT (coded-wire tag) trailer. The plumbing from each sensor went directly to a trough area where the fish were collected and CWT using NMT Mark IV injectors. Prior to counting each group, five marbles were passed through the sensor to insure sensitivity settings were counting objects correctly. Taggers were instructed to apply CWTs in a standard prescribed method in an attempt to obtain an accurate machine count of the group previously counted by the sensor. Each test of the sensors consisted of a paired count with a CWT tagging machine. Fish were passed through the sensor until a total count of 500 was obtained on the IFC counting sensor. These same fish were then passed through a CWT process where they were tagged and counted by the CWT injector.

¹ Northwest Indian Fisheries Commission. 6730 Martin Way E. Olympia, WA 98516.

² Piper, R. G. 1982. *Fish Hatchery Management*. U.S. Government Printing Office, U.S. Dept of Interior Fish and Wildlife Service. Washington, D. C. 517p.

The two counts were compared using two different metrics:

1. The difference in counts between the two counters calculated as: (IFC sensor count – CWT count) and labeled DIFF.
2. The ratio of the counts calculated as: (sensor count / CWT count) and labeled RATIO.

DIFF measures the difference between the two counters in the number of fish counted over 500 sensor-counted fish. If DIFF is negative it indicates that the CWT count was larger than the sensor count.

RATIO compares the relative difference between the two total counts over 500 sensor-counted fish. If RATIO is less than 1.0 it indicates that the CWT count was greater than the sensor count.

If there are no differences between the two counts $DIFF = 0$ and $RATIO = 1.00$. Ten trials (replicates) were conducted for each sensor. If there are random differences between the two counts and no bias³ we expect the average (mean) DIFF to be 0 and average RATIO to be 1.00. A one sample t-test of the hypothesis $DIFF = 0$ or $RATIO = 1.0$ was used to test these hypotheses (two-tailed tests conducted).

If there is no bias between the two counts and the differences between the two counts are random, we expect that over a series of replicates one method would be greater than the other half the time (excluding ties where they are the same). A sign test was used to test the hypothesis that the frequencies of the signs of the differences between the two counts (positive or negative) were equal (i.e., the proportion of positives = proportion of negatives).

There was one replicate conducted for sensor #1 in which the sensor was recalibrated after the count had begun. This replicate (#8) was omitted from the data analysis.

In an additional test, three replicates of 1,600 fish total were hand counted through the sensors. These counts were conducted blindly in that the sensor count was unknown to the sampler conducting the physical count.

Results

Table 1 presents the results for the 10 replicate trials for each sensor. Figure 1 graphically compares the counts.

Summary statistics for DIFF and RATIO are presented in Tables 2 and 3, respectively. There is no indication of bias between the two counts. For sensor #1, the hypothesis that the mean $DIFF = 0$ cannot be rejected ($P = 0.813$) as well as the hypothesis that the mean $RATIO = 1.00$ ($P = 0.819$). Similarly for sensor #2, the hypothesis that the mean $DIFF = 0$ cannot be rejected ($P = 0.496$) as well as the hypothesis that the mean $RATIO = 1.00$ ($P = 0.493$).

³ No bias means that one count is not consistently less than, or consistently greater than, the other.

For sensor #1, there were 5 negative differences, 2 positive differences, and 2 ties. The hypothesis of equal frequencies of positive and negative differences (indicating no bias) could not be rejected by the sign test ($P = 0.453$). For sensor #2, there were 3 negative differences, 3 positive differences, and 4 ties. The hypothesis of equal frequencies of positive and negative differences (indicating no bias) could not be rejected by the sign test ($P = 1.000$).

Table 1. Results of the trials for the two counting methods.

Replicate Number	Sensor Station	Sensor Count	CWT Station	Count	Difference Sensor-CWT	Ratio Sensor/CWT
1	1	500	2	500	0	1.0000
2	1	500	2	501	-1	0.9980
3	1	500	2	501	-1	0.9980
4	1	500	2	501	-1	0.9980
5	1	500	2	497	3	1.0060
6	1	500	2	500	0	1.0000
7	1	500	2	499	1	1.0020
8 ^a	1	500	2	494	6	1.0121
9	1	500	2	501	-1	0.9980
10	1	500	2	501	-1	0.9980
1	2	500	1	500	0	1.0000
2	2	500	1	501	-1	0.9980
3	2	500	1	499	1	1.0020
4	2	500	1	500	0	1.0000
5	2	500	1	501	-1	0.9980
6	2	500	1	497	3	1.0060
7	2	500	1	501	-1	0.9980
8	2	500	1	498	2	1.0040
9	2	500	1	500	0	1.0000
10	2	500	1	500	0	1.0000
All Trials	1	5,000		4,995	5	1.0010
	2	5,000		4,997	3	1.0006
	Total	10,000		9,992	8	1.0008
Without Trial 8-1	1	4,500		4,501	-1	0.9998
	2	5,000		4,997	3	1.0006
	Total	9,500		9,498	2	1.0002

^a Possible sensor problem, sensor recalibrated after start of counting session.

There is no evidence that there is a significant difference between the sensors in mean DIFF or mean RATIO. Using a two sample t-test to compare the means for each sensor, the significance of the tests was 0.516 for DIFF and 0.518 for RATIO⁴. Combing the results from both sensors, the mean difference in the counts was 0.1053 fish per 500 sensor-counted fish with a mean

⁴ Two-tailed test with equal variances assumed.

RATIO of 1.0002 (a 0.02% difference). Over the 19 trials, the sensor count was greater than the CWT count 5 times (26.3%), the CWT count was greater than the sensor count 8 times (42.1%), and the counts were identical 6 times (31.6%).

Statistically, both methods give the same count for repeated trials of 500 fish. That is, we cannot reject the hypotheses that the mean DIFF is 0 and the mean RATIO is 1.0. In addition, there is no statistical evidence of a consistent difference (bias) between the two methods. Based on the combined results for the two sensors, one might expect a difference of 1 fish between the two methods for every 5,000 fish that are counted by sensor.

For the three replicates counts of 1,600 hand-counted fish through the sensors there were no variance noted for the three replicates. The hand counts and sensor counts were exactly the same.

Discussion

Scenarios were identified that could lead to inaccurate CWT machine counts of the groups. These potential errors would make the CWT count higher or lower than the actual count. Some possible miscount examples include: fish reluctant to leave plumbing connecting counter to the trough, fish leaving or entering the trough compartment, tagger not clearing trough of all of the fish, faulty CWT button pressing, machine activation, or fish being dropped without knowledge of tagger. These errors could account for the differences between the CWT counts and the sensor counts.

Based on the statistical results, and the complete agreement with hand counts, the IFC technology appears to be highly accurate means of counting individual fish.

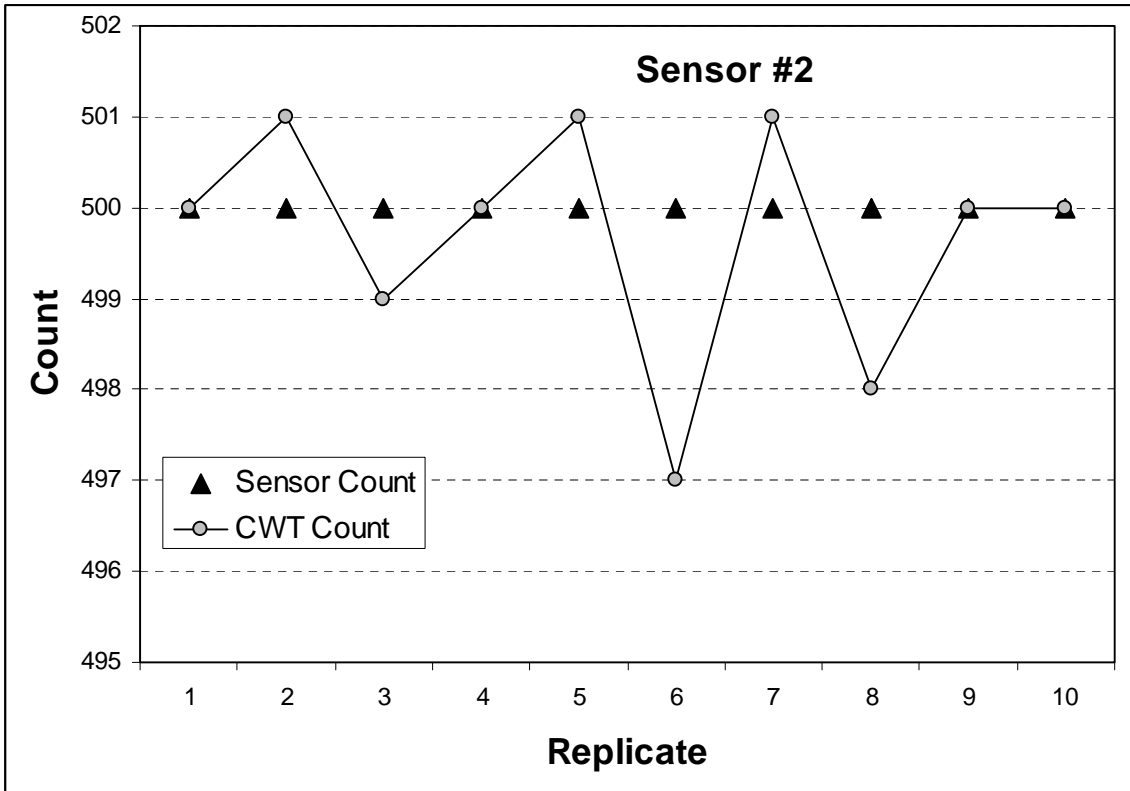
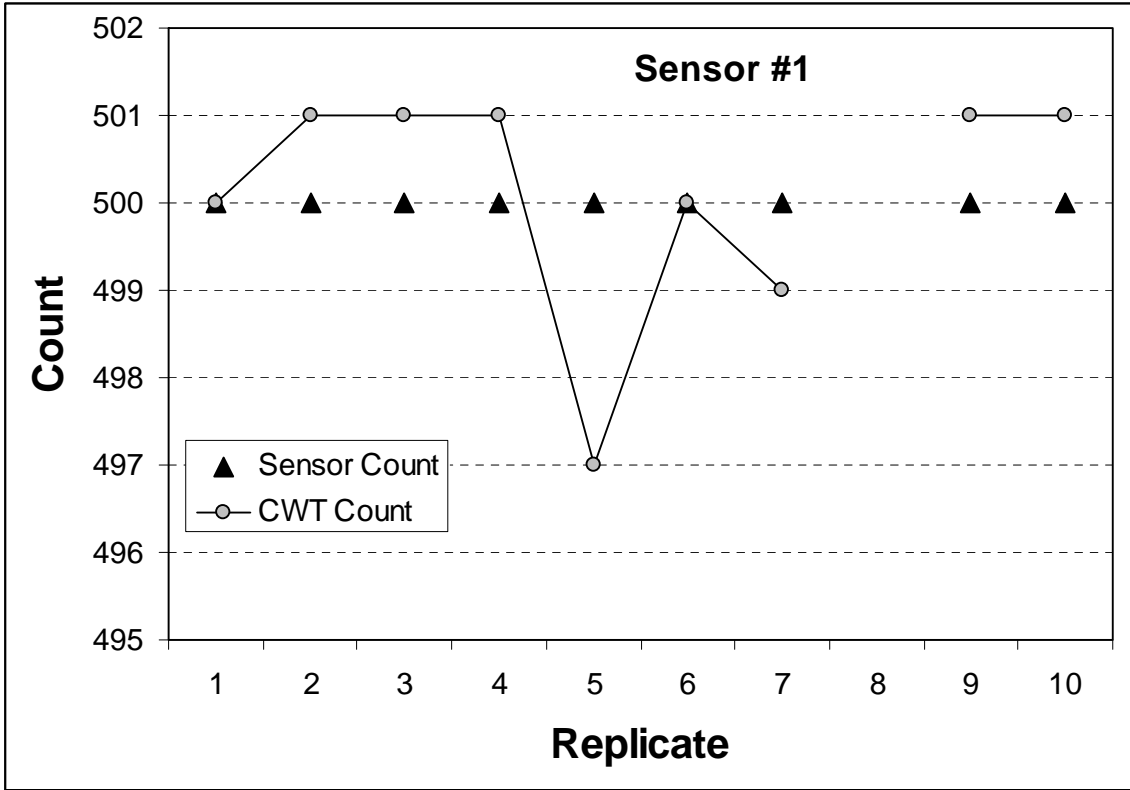


Figure 1. Comparison of sensor to CWT counts over 500 sensor-counted fish, by sensor.

Table 2. Summary statistics for DIFF, the sensor count – CWT count.

Sensor Number	Sample Size	Mean	Standard Error	Median	Minimum	Maximum	95% Confidence Interval
1	9	-0.1111	0.4547	-1.000	-1.000	3.000	-1.1598 - 0.9375
2	10	0.3000	0.4230	0.000	-1.000	3.000	-0.6568 - 1.2568

Table 3. Summary statistics for RATIO, the sensor count / CWT count.

Sensor Number	Sample Size	Mean	Standard Error	Median	Minimum	Maximum	95% Confidence Interval
1	9	0.9998	0.0009	0.9980	0.9980	1.0060	0.9977 - 1.0019
2	10	1.0006	0.0008	1.0000	0.9980	1.0060	0.9987 - 1.0025