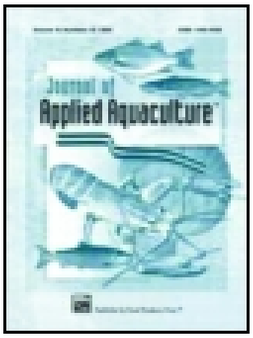

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Are standard protocols needed for performing weight counts?

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ABSTRACT
The most common way of counting fish is to use subsampling to determine the number of fish/lb. (weight count) and use weight measurements instead of counting individual fish. We compared differences in methods commonly used to determine weight counts. We found that none of the methods differed from each other and the mean weight counts remained close to the true weight count. Number of samples required to achieve accuracy depends on the individual performing the weight count and the size of fish. Efforts should be made to satisfy probability theory assumptions.

KEYWORDS
Weight count; enumeration; count; subsample

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Introduction

Enumeration of fish is an essential part of any aquaculture program. Discrete amounts of fish are moved for a variety of reasons, and different methods are employed to count those fish. Methods for counting fish can be separated into two categories: counting individual fish and counting by weight. Counting individual fish usually requires computerized methods to save time and labor. These methods are often not practical or cost-effective to use in a production environment. Drawing subsamples of fish out of a larger population and using the total number of fish per kilogram has been the standard for quite some time (Griffiths et al. 1941; Hewitt and Burrows 1948; Taft 1935). Hewitt and Burrows (1948) identified three separate concerns relating to the accuracy of these subsamples: percentage of population sampled, variation in size, and bias in the subsample. Bias in the subsample is what is focused on in this evaluation. Hewitt and Burrows found that fish will stratify by size, and subsamples can be overestimated. Subsequent to these early efforts to identify biases, hatchery personnel have often employed various methods and protocols to avoid biasing subsamples. A typical process for obtaining weight counts at state hatcheries are as follows: Fish will be crowded into a restricted space, an arbitrary number of fish will be dip netted from the main body and placed in a tared container. The fish are then

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weighed and counted, which gives the number of fish/unit of weight (weight count) (Piper et al. 1982). To determine the number of fish needed for transport, the appropriate weight is loaded into a truck using water displacement in a sight glass according to the determined weight count.

A wide variety of opinions exist about how to limit biases when netting fish out of the raceway. Techniques vary between hatcheries; some net fish haphazardly to achieve randomness, while some employ specific protocols that call for moving the net in the cardinal directions, sampling the entire water column, very small or large nets, not dumping fish when too many have been netted out, and netting fish from the top or bottom of the raceway. Some use three subsamples to determine the true weight count, while others require up to ten subsamples. Our goal was to determine how different techniques affected accuracy in determining the true weight count of a group of fish.

Methods

This evaluation was done at the New Mexico Department of Game and Fish's hatchery in Glenwood, NM, with triploid Rainbow Trout (*Onchorynchus mykiss)*. To obtain a population for which the true weight count was known, we crowded an entire raceway of fish and haphazardly removed 500 fish. We measured the length of each fish to describe the range of sizes used and obtained the total weight of the 500 fish. These fish were crowded to one end of a raceway until they began to fight against the crowding screen. We used seven different methods to obtain weight count estimates using this population of 500 fish:

(1) We pulled the net from the backscreen directly to the crowd screen through the middle of the water column.
(2) We pulled the net down one side, pulled across the raceway to the opposite side, then back attempting to capture fish from the entire water column.
(3) We pulled a large net, dumped a random amount of fish out of the net, then weighed and counted the remainder.
(4) We pulled the net only across the top 30 cm of water, close to the crowding screen.
(5) We pulled the net only along the bottom of the raceway, close to the crowding screen.
(6) We used a small number of fish to determine the weight count (<1.8 kg).
(7) We used a large number of fish to determine the weight count (>4.5 kg).

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For each trial we put the netted fish into a tared bucket and determined weight with a digital crane scale accurate to the nearest 0.05 kg. Excess water was shaken off the net prior to placing fish in the bucket. Weight was recorded after the scale stabilized. Individual fish were counted after the subsample weight was obtained. We performed six separate trials for methods 1–5 and ten trials for methods 6 and 7. We placed the fish back into the population after each trial, resulting in fish that had been handled multiple times. The order of trials performed was chosen at random in an attempt to detect any stratification or avoidance that may occur due to multiple handling events. At the end of the trials, the total weight handled was divided by the total number of fish handled to obtain a true weight count. Trials were compared using a one-way ANOVA in program r.

Results

The total weight of 500 fish used for sampling was 76.69 kg. This made the true weight count 6.52 fish per kg. The minimum and maximum lengths of fish used were 134 and 319 mm respectively. The mean length was 244 mm (SD = 26.40, SEM = 1.18). We found no significant differences among weight count methods (Figure 1) based on ANOVA results (F = 1.089; df = 6, 48; P = 0.384). Methods 6 and 7 had the most variation in weight counts, followed closely by method 3. Mean weight counts remained similar among all methods (Table 1).

Discussion

Strict protocols involving weight counts are typically an effort to decrease bias and achieve accurate results. Protocols may increase time and labor and are difficult to implement across a wide variety of facilities. With a base effort at providing equal probability of capture (e.g., crowding fish into a small space), seven different protocols did not result in significantly different weight counts. It is worth noting, however, that when outliers were removed according to Cook's distance, the variability of weight counts was larger for method 6 than for method 7 (Figure 1). Larger net sizes may yield less variable results. Our findings differ from Ewing et al. (1998) where larger fish were found closer to the crowding screen. The differences may be explained by the degree to which the fish were crowded. In Ewing et al.'s study the fish were crowded until fish fought against the crowding screen, and then the screen was backed off an unspecified distance. In our study the fish were crowded until they fought against the screen and left in that position.

Some hatchery personnel have insisted on a set net weight that depends on the size of fish being enumerated. We find a lack of patterns in our weight

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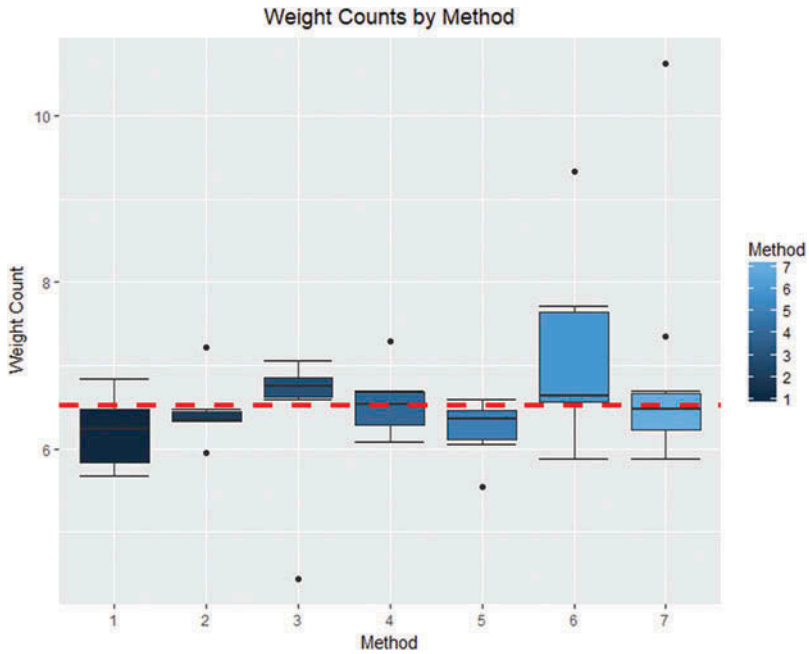

Figure 1. Boxplot of seven different methods of performing weight counts. The dashed line is the true population weight count of 6.52 fish/kg. Methods are listed by number. 1: We pulled the net from front to back (from the backscreen directly to the crowd screen). 2: We pulled the net down one side, pulled across the raceway to the opposite side, then up trying to capture fish from the entire water column. 3: We pulled a large net, dumped some fish out of the net, then weighed and counted the rest. 4: We pulled the net only across the top of the water. 5: We pulled the net only along the bottom of the raceway. 6: We sampled small nets haphazardly (<1.8 kg). 7: We sampled large nets haphazardly (>4.5 kg).

Table 1. Mean, variation, standard deviation, and standard error of the mean for each method. The true weight count for the population was 6.52 fish/kg.

Method	*n*	Mean	Var	*SD*	SEM
1	6	6.2091	0.2093	0.4574	0.1868
2	6	6.4404	0.1744	0.4176	0.1705
3	6	6.4112	0.9641	0.9819	0.4009
4	6	6.5663	0.1839	0.4279	0.1747
5	6	6.2296	0.1472	0.3836	0.1566
6	10	7.0848	1.1008	1.0004	0.3163
7	10	6.8556	1.9386	1.3923	0.4403

counts as they relate to the weights of individual nets (Figure 2). This was consistent with the findings of Ewing et al. (1994). Though an acceptable level of accuracy is generally subjective to the individual, we suggest that strict protocols are not necessary. For example, the difference between stocking 400 kg of fish at our true mean of 6.52 fish/kg and our highest sample mean of 7.08 fish/kg is 212 fish. This discrepancy may mean different things

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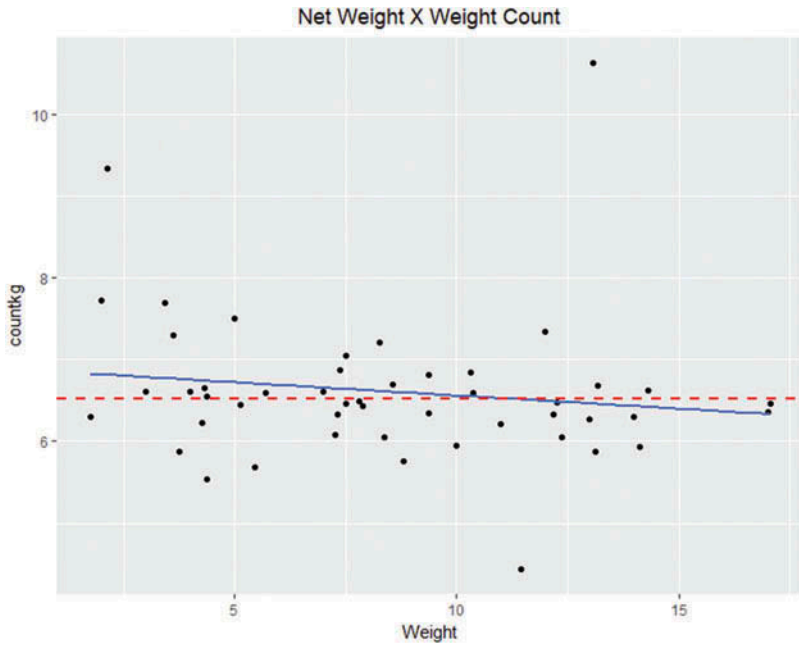

Figure 2. The dashed line indicates the true weight count of 6.52 fish/kg. A regression analysis of weight count by weight of each net was insignificant, indicated by the solid line. (F = 1.002; df = 1, 48; P = 0.3218, R^2 = 0.02).

to different industries. It may be a small drop in the bucket for a large Alaskan salmon facility, or it may decrease the profit margin or effectiveness of a small trout hatchery.

Hewitt and Burrows (1948) also listed the percentage of the population sampled as a key concern relating to accuracy. In our opinion, this is another point where different personnel have strong opinions. The central limit theorem might guide decisions to some extent, but under time and labor constraints there must be a limit to the number of samples taken. Various industries and situations might require various levels of confidence and accuracy. Private industries may require high levels of accuracy where profit margins are small. Small fish hatcheries might require accurate inventories to better estimate production. Large hatcheries might better absorb discrepancies in inventory. Ewing et al. (1994) recommended that seven to nine samples be taken to obtain accurate results. The authors determined that the number of samples, and not the percentage of population sampled, was most important. We recommend a statistical approach available in most statistical texts (Zar 1999) to determine sample size needed for a desired confidence level. Measures of variance needed for this approach can be obtained from previous weight counts. Levels of confidence and accuracy change with size of fish; required sample size will be greater if a greater level of precision is desired (Table 2). The desired level of precision can be

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Table 2. Required sample size for each level of confidence and accuracy desired.

Accuracy (#fish/kg)	Variance	Confidence interval	α	Required sample size
0.5	0.407	95%	0.05	27
0.5	0.407	99%	0.01	46
0.1	0.407	95%	0.05	287
0.1	0.407	99%	0.01	1000

informed by the size of fish. At a weight count of 7 fish/kg, a 4 kg error could result in ± 28 fish. At a weight count of 350 fish/kg, a 4 kg error would result in ± 1,400 fish. When manpower and time are restricted, the effort for accuracy and precision should increase with small fish.

The effort to limit error drives different approaches and innovations in fish counting, and using acoustics and video processing is an exciting new field emerging in the aquaculture world (Han et al. 2009, Zion 2012). These technologies have limited application in widespread use due to the expense of the technology. In the meantime, however, with a facility that relies on standard methods, strict protocols governing how subsamples are collected appear to be unnecessary.

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References

Ewing, R. D., M. A. Lewis, J. E. Sheahan, and S. K. Ewing. 1998. Evaluation of inventory procedures for hatchery fish. III. Nonrandom distributions of Chinook salmon in raceways. *The Progressive Fish Culturist* 60:159–166. doi:10.1577/1548-8640(1998)060<0159:EOIPFH>2.0.CO;2.

Ewing, R. D., T. R. Walters, M. A. Lewis, and J. E. Sheahan. 1994. Evaluation of inventory procedures for hatchery fish. I. Estimating weights of fish in raceways and transport trucks. *The Progressive Fish Culturist* 56:153–159. doi:10.1577/1548-8640(1994)056<0153:EOIPFH>2.3.CO;2.

Griffiths, F. P., W. Jarvis, A. B. Smith, and C. A. Lockwood. 1941. Measurement of fish for liberation by weighing. *Transactions of the American Fisheries Society* 70:275–281. doi:10.1577/1548-8659(1940)70[275:MOFFLB]2.0.CO;2.

Han, J., N. Honda, A. Asada, and K. Shibata. 2009. Automated acoustic method for counting and sizing farmed fish during transfer using DIDSON. *Fisheries Science* 75:1359–1367. doi:10.1007/s12562-009-0162-5.

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Hewitt, G. S., and R. E. Burrows. 1948. Improved method for enumerating hatchery fish populations. *The Progressive Fish Culturist* 10:23–27. doi:10.1577/1548-8640(1948)10[23:IMFEHF]2.0.CO;2.

Piper, R. G., I. B. McElwain, L. E. Orme, J. P. McCraren, L. G. Fowler, and J. R. Leonard. 1982. *Fish hatchery management*. Washington, DC: U.S. Fish and Wildlife Service.

Taft, A. C. 1935. Methods for counting small fish in hatcheries. *The Progressive Fish Culturist* 2:5–7. doi:10.1577/1548-8640(1935)22[5:MFCSFI]2.0.CO;2.

Zar, J. H. 1999. *Biostatistical analysis*. 4th ed. Upper Saddle River, NJ: Prentice-Hall.

Zion, B. 2012. The use of computer vision technologies in aquaculture—A review. *Computers and Electronics in Agriculture* 88:125–132. doi:10.1016/j.compag.2012.07.010.

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