Comparison of Balances For Estimating The Weight of Pink Shrimp (Pandalus jordani) At Sea

Mark R. Saelens
Robert W. Hannah

September 21, 1988

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ABSTRACT

Five commercially available balances were compared for measuring mean weight of pink shrimp aboard fishing vessels at sea. The relative precision of the balances was determined using blind weighings of known weights under actual shrimping conditions. The data indicated that mean shrimp weight can be determined precisely at sea using a magnetically dampened triple beam balance that is readable to the nearest 1 gram.

INTRODUCTION

One of the few regulations used to manage the Oregon pink shrimp (*Pandalus jordani*) fishery is a size regulation. Vessels must deliver captured shrimp (landed shrimp) that have a minimum average weight, expressed as a maximum number of shrimp per pound. The maximum allowable count is 160 whole shrimp per pound. This count-per-pound (ct/lb) regulation is designed to achieve a balance between maximizing total yield and total spawning stock for the pink shrimp population and is the primary within-season management tool. Recently, questions have been raised as to the fisherman's ability to reliably estimate the count-per-pound of the catch prior to actually landing it.

The primary purpose of this study was to determine if the mean weight of commercially caught pink shrimp can be measured precisely aboard a fishing vessel at sea. We tested several types of balances under various weather and sea conditions to evaluate their effectiveness for determining the count-per-pound of shrimp caught at sea. We hope this information will help commercial fishermen select scales for use aboard their vessels.

METHODS

Autopsy, dietary, flatbed, triple beam and Garibaldi balances were selected for comparison (Table 1). The balances tested varied in their construction. The autopsy scale tested is a hanging style, dial reading spring balance, equipped with a hanging pan for holding items to be weighed. The scale we tested is made by Chatillon and had a 6,000 g capacity. The dietary scale is a toploading, dial reading spring balance made by Morris Scale Co. This scale is temperature compensated and has a capacity of 1,000 g. The flatbed scale is a heavy duty platform style scale with a capacity of 56,700 g (125 lb). This scale is calibrated in ounces and can be read to the nearest half ounce. It is also manufactured by Morris Scale Co. The triple beam scale tested is an Ohaus model 1610. This balance is magnetically dampened and has a capacity of 610 g. The Garibaldi balance was so-named because it was developed by a fisherman from Garibaldi. This is a simple rugged single-arm equilibrium balance.

Table 1. Balance type, capacity, basic resolution[1], and estimated sensitivity at sea for five balances evaluated at sea during February through May 1988.

Balance Description	Capacity	Scale Resolution	Sensitivity at sea
Autopsy scale - Chatillon	6,000 g	± 5 g	Unreadable
Dietary (Temp. Compensated)	1,000 g	± 1 g	± 5 g
Flatbed - Morris Scale Co.	56,700 g	± 7.1 g	± 7.1 g
Triple Beam - Ohaus 1610	610 g	± .05 g	± .25 g
Garibaldi	226.8	± .5 shrimp	± .5 shrimp

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[1] Scale resolution was defined as plus or minus one-half of the smallest readable increment on the scale. Sensitivity at sea was defined as plus or minus one-half of the smallest increment resulting from measurements at sea. For example, if the balance was calibrated in 1 gram increments but yielded measurements at sea to the nearest 10 grams, then resolution and sensitivity at sea were ± .5 g and ± 5 g respectively.

Operating the Garibaldi balance at sea is quite simple. The single arm is suspended from a point near its center. The balance is adjusted by hooking an 8 oz fishing lead on one end of the arm of the balance. A tin can large enough to hold at least 0.5 lb of shrimp is located on the other end of the arm (shrimp pan). An 8 oz weight is placed in the shrimp pan. When the positions of the pan and fishing lead are adjusted until the arm is horizontal and the pointer reads zero, the balance is ready to operate. To operate this balance at sea it is either hand held or hooked to a boom or similar fixed location, allowing the arm to swing free. The initializing weight is removed from the shrimp pan. Whole shrimp are counted into the shrimp pan until the pointer reaches the zero mark. The number of shrimp is multiplied by two to attain estimated ct/lb. The procedure may be duplicated using a 1.0 lb fishing lead to directly obtain a ct/lb estimate.

Each balance was tested at sea to determine if it was readable on a moving fishing vessel. Balances that were readable were tested against 10 randomly selected known weights to evaluate basic precision at sea. Each set of weights was weighed at least three times at sea. Known weights were verified using a very sensitive certified electronic Mettler balance under laboratory conditions. The true weights were not known by the scale tester. One exception to this procedure was the Garibaldi scale which is calibrated to measure one-half pound samples. This scale was tested by comparing 153 one-half pound samples from the Garibaldi scale to actual weights of the same samples measured on the Ohaus triple beam (also at sea). We assumed that the triple beam would be more precise than the Garibaldi balance. A true measure of the precision of the Garibaldi scale was thus obtained by combining the measured errors from the Garibaldi scale relative to the Ohaus triple beam at sea, with the measured error of the triple beam relative to the control weights.

The precision of each balance was measured by calculating a mean square error as follows:

$$MS = \sum_{i=1}^{N} \frac{(Y_i - Y)^2}{N} \quad \text{where}$$

Y_i = estimated weight at sea

Y = known weight

N = total number of measurements

Since we used different calibration weights when testing each scale, relative scale precision was measured using the coefficient of variation (CV). We next evaluated the CV as it applied to the number of shrimp per pound. A 99% confidence interval was constructed around a count of 160 whole shrimp per pound, the maximum count-per-pound of shrimp that can legally be landed in the Oregon commercial pink shrimp fishery. A t-value based upon infinite degrees of freedom was used to construct the interval. This approach was employed because count-per-pound is the inverse of mean shrimp weight from a sample of approximately 160 whole shrimp.

RESULTS AND DISCUSSION

The five balances were tested from February through May 1988 aboard the F/V SEA PRIDE of Warrenton, and the F/V MARANATHA and F/V FLORENCE MAY of Newport, Oregon. The comparative statistics for four of the balances are shown in Table 2. The autopsy scale proved to be unreadable at sea due to the constant motion of the vessel causing wild swings of over 100 g on the dial scale. The Ohaus triple beam proved to be the most precise, followed by the flatbed scale, the Garibaldi scale, and the dietary scale.

The Ohaus triple beam balance proved to be the best of the scales tested for use at sea for a variety of reasons. First, the scale has good sensitivity when used at sea (Table 1) due to a magnetic dampening mechanism and high basic resolution of the scale. Second, it proved to be the most precise for measurement at sea with a coefficient of variation (CV) of 0.499%. This corresponds to a 99% confidence interval of ± 2.06 shrimp per pound at 160 shrimp per pound. One drawback is that this scale works best in a windless environment. The triple beam costs around $200.

Table 2. Comparative statistics for four balances used to estimate count-per-pound of pink shrimp at sea, February through May 1988.

Balance	Mean of weights tested	Sample size	Mean Square error	Coefficient of variation	99% Confidence Interval[1] (equiv. ct/lb)
Ohaus 1610 Triple Beam	366.75 g	30	3.35 g	0.499%	160 ± 2.06
Morris Scale Co. Flatbed	693.63 g	30	51.50 g	1.035%	160 ± 4.27
Garibaldi Scale[2]	226.70 g	153	18.40 g	1.892%	160 ± 7.80
Garibaldi[3]	-		-	2.391%	160 ± 9.85
Dietary Scale	662.33 g	30	303.48 g	2.630%	160 ± 10.84

[1] Confidence interval constructed around 160 whole shrimp per pound, the minimum count-per-pound that can be legally landed.

[2] Relative to Ohaus triple beam, also employed at sea.

[3] Estimated precision relative to known weights (CV Ohaus + CV Garibaldi)

The flatbed scale was the second most precise scale tested resulting in a CV of 1.035%. This generated a 99% confidence interval of ± 4.27 shrimp per pound at 160 shrimp per pound. Most of the difference in precision between this scale and the Ohaus triple beam can probably be attributed to a basic lack of resolution. The flatbed scale can only be read to the nearest half ounce (a resolution of ± .25 oz or ± 7.1 g). The Ohaus can be read to ± .25 g at sea. The flatbed scale also is rather large and costs $400-$500.

The Garibaldi scale was the third most precise scale tested with a CV of 1.892% relative to the Ohaus triple beam at sea. Even incorporating the inherent variability of the triple beam relative to known weights (CV=0.499%)the Garibaldi scale is still the third most precise scale. The combined CV of 2.391% results in a 99% confidence interval of 160 ± 9.85 shrimp per pound.

For both the dietary and Garibaldi scales the basic resolution of ± 5 grams and ± 1 shrimp respectively increased the coefficients of variation and resulting confidence intervals. Vessel motion also adversely affected the dietary scale performance, as it was necessary to read the midpoint of the swing of the dial to get a reading.

In conclusion, the data indicate that precise estimates of count-per-pound can be obtained at sea, providing the right balance is used. Several factors make for a good scale for estimating pink shrimp count-per-pound at sea. First, the basic resolution of the scale should be high enough to not introduce unwanted variation in the weight. A scale that can weigh to the nearest gram is recommended. Second, a scale that is minimally influenced by vessel motion, such as the magnetically dampened Ohaus triple beam is recommended to obtain precise estimates of count-per-pound at sea.