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GEAR PERFORMANCE AND SAMPLE SIZE FOR  
SETTLING RED KING CRABS

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### Abstract

The counts of settling (young of the year) red king crabs are analyzed to determine whether a horizontally aligned collector works better than a vertically aligned collector. The overall mean number of crabs for vertical collectors is significantly ( $\alpha = 0.1$ ) larger than the overall mean for horizontal collectors. The variance estimates are small enough that only five vertical collectors need to be used in future sampling. The index for average number of crabs settling on vertical collectors in all sampled areas is 5.18 SE = 0.658).

## Introduction

Strings of collectors were placed in a systematic manner in three bays on Kodiak Island near the town of Kodiak. Each string of gear had 10 collectors with a set of five of each alignment type located at one end of the string. The horizontal collectors were attached to the line in such a manner that they were sitting on the bottom. The vertical collectors were suspended above the attachment line. The spacing between the attachment points for the collectors was 2 m.

This study analyzes the performance of the gear and addresses the estimation of variance versus sample size. An overall mean number of crabs for vertical collectors is computed.

## Methods

Only strings of collectors that were known or assumed to have fished properly are used in the hypothesis testing. Those collectors that were damaged or tangled were excluded. Some of the strings had diver observations that verified proper gear performance. Other strings are assumed to have fished properly if they came aboard the vessel without any tangles or damage.

The sample design is two-stage (Cochran 1977) with the strings as the primary units and the collectors as the subunits. Since the 10 collectors are a linear arrangement of observations, a variance estimate for the second stage was used that performs better under these conditions (Wolter 1984, 1985). Mean squared error was used for the variance at the first-stage.

Let

$$\begin{aligned}n &= \text{number of primary units sampled} \\m_i &= \text{number of subunits sampled in the } i^{\text{th}} \text{ primary unit} \\y_{ij} &= \text{value obtained for the } j^{\text{th}} \text{ subunit in the } i^{\text{th}} \text{ primary unit} \\ \bar{y}_i &= \sum_{j=1}^{m_i} \frac{y_{ij}}{m_i} = \text{sample mean per subunit in the } i^{\text{th}} \text{ primary unit} \\ s_1^2 &= \sum_{i=1}^n \frac{(\bar{y}_i - \bar{y})^2}{n-1} \\ s_{2i}^2 &= \sum_{j=2}^{m_i} \frac{(y_{ij} - y_{i,j-1})^2}{2(m_i - 1)}\end{aligned}$$

An unbiased estimate of the overall mean is provided with

$$\bar{y} = \sum_{i=1}^n \frac{\bar{y}_i}{n}$$

The variance of the overall mean is provided with

$$var(\bar{y}) = \frac{1}{n} s_1^2 + \frac{1}{n} \sum_{i=1}^n \frac{s_{2i}^2}{nm_i}$$

To determine if one type of gear fished better than the other, we tested whether the mean counts were significantly different for vertical versus horizontal alignment. The test was applied to each string individually and to the overall mean. In addition, a statistic for paired data was computed (Snedecor and Cochran 1967).

### Results and Discussion

Although we are interested in an overall test of gear performance; that for the total area sampled, the estimates for mean, variance and the t-statistic for each string of gear are provided in Table 1. These provide a picture of each string. The critical two-tailed t-value ( $\alpha = 0.05$ ,  $df = 8$ ) is 2.306 for strings with no missing or damaged collectors. The t-statistic is not significant for all strings, but a pattern does exist. All but four are negative, caused by the mean count for vertical collectors being larger than the horizontal. The test statistics do not take into account the two-stage sampling.

Table 1. — Pair-wise test of difference in collector mean number of crabs for the difference between vertical and horizontal.

t'	Horizontal			Vertical			t'	Horizontal			Vertical		
	$\bar{y}$	$s_2^2$	$m_i$	$\bar{y}$	$s_2^2$	$m_i$		$\bar{y}$	$s_2^2$	$m_i$	$\bar{y}$	$s_2^2$	$m_i$
-2.73	2.2	1.75	5	8.	20.875	5	-3.77	0.25	0.333	4	3.	2.25	5
-0.77	12.	7.75	5	16.2	140.125	5	-0.98	0.4	1.	5	1.	0.875	5
-1.41	3.2	7.875	5	5.2	2.25	5	-1.68	2.2	3.375	5	4.4	5.25	5
-2.50	1.	2.	2	3.75	0.833	4	0.26	12.5	112.5	2	10.4	45.75	5
-1.26	0.	0.	5	0.4	0.5	5	-1.61	2.6	5.25	5	6.8	28.75	5
-4.55	1.4	1.875	5	5.	1.25	5	-4.09	4.2	4.5	5	12.4	15.625	5
-1.31	0.25	0.333	4	1.5	3.333	4	1.06	4.4	7.375	5	3.	1.375	5
-0.27	2.6	7.875	5	3.	3.125	5	0.74	6.8	12.5	5	5.333	4.25	3
0.20	2.6	1.375	5	2.4	3.625	5	-1.34	1.8	2.125	5	3.	1.875	5
-7.41	0.4	0.375	5	6.6	3.125	5							

As a paired approach, with average vertical and horizontal counts paired for string, the test statistic is significant ( $t = 2.989$ ,  $df = 18$ ). Pairing is effective when the differences are the same sign and when the means are correlated. Again, the statistic does not take into account that two-stage sampling occurred.

The estimate for the overall mean ( $n = 19$ ) for horizontal collectors is 3.20 crabs and for vertical is 5.34 crabs.

When the variance estimator for two-stage sampling is used, the estimate of standard error for horizontal collectors is 0.940 and for vertical collectors is 1.013. The one-tailed t-statistic for the test of a larger mean for vertical collectors is 1.55, significant at the  $\alpha = 0.1$  level. We can conclude that vertical collectors collect more settling crabs than horizontal collectors. Even though the variance estimates include the second-stage variance, we still get a significant difference in the gear.

The largest part of the variance in the overall means is from the primary units (>84% for vertical). The increase from five to 10 collectors of a single alignment would not decrease the variance by a noticeable amount. Based on the assumption of the same average variance per collector, an increase from five to ten collectors could decrease the second-stage variance by 12-13% ( $1/2(5-1)$  versus  $2/2(10-1)$ ). A larger decrease in the variance would come about by increasing the number of strings sampled, because  $1/n$  affects the first variance component by  $1/n$  and the second component by  $1/n^2$ .

### Settling Index

All vertical collectors were used in estimating an overall mean and standard error. These included those with missing collectors or collectors abnormally arranged during the recovery effort. The overall mean is 5.18 crabs (SE = 0.658) for the vertical collectors.

To compare the index value to indices in future years, several requirements are necessary. The location of the strings needs to be the same and the vertical collectors need to be attached the same and be of the same design. In addition, the placement and recovery of the gear should remain temporally the same. Otherwise, the indices will not be comparable from year to year. With the number of strings the same, and the number on each string as five, then a significant change in mean count of at least 2.2 could be determined to be statistically significant. This assumes a similar two-stage variance in future years. If the variance is larger due to a larger mean, a value larger than 2.2 would need to exist.

With the basic assumption of indices in general, that the data is representative of the area sampled, this type of sample design and sampling intensity should be sensitive enough for tracking an index of mean settling counts.

### Conclusions

The vertical collectors held a significantly larger number of settling red king crabs when compared to the horizontal collectors. The observed variance is small enough to recommend using only the vertical collectors with five per string in future sampling.

### Literature Cited

- Cochran, W. G. 1977. Sampling techniques. John Wiley, New York.
- Snedecor, G. W., and W. G. Cochran. 1967. Statistical Methods. Iowa State University Press, Ames, Iowa.
- Wolter, K. M. 1984. An investigation of some estimators of variance for systematic sampling. Journal of the American Statistical Association. 79:781-790.
- Wolter, K. M. 1985. Introduction to variance estimation. Springer-Verlag, New York.

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