1-1-1988

At-Sea Volumetric Measures and Monitoring Meat-Count Regulations: The Sea Scallop Fishery

William D. DuPaul
Virginia Institute of Marine Science

James E. Kirkley
Virginia Institute of Marine Science

Recommended Citation
DuPaul, W. D., & Kirkley, J. E. (1988) At-Sea Volumetric Measures and Monitoring Meat-Count Regulations: The Sea Scallop Fishery. Marine Resource Report No. 88-3. Virginia Institute of Marine Science, College of William and Mary. http://dx.doi.org/doi:10.21220/m2-vbac-pd96

AT-SEA VOLUMETRIC MEASURES AND MONITORING MEAT-COUNT REGULATIONS: THE SEA SCALLOP FISHERY

WILLIAM D. DUPAUL AND JAMES E. KIRKLEY*

Marine Resource Report No. 88-3

William DuPaul is Director of Marine Advisory Services, College of William and Mary, Virginia Institute of Marine Science, School of Marine Science. J. Kirkley is Assistant Professor, Virginia Institute of Marine Science, Gloucester Point, Virginia 23062.

Introduction:

Since 1982, the U.S. sea scallop fishery has been regulated by meat-count and shell-height regulations. Currently, firms which shuck at sea are restricted to meat counts of no more than 30 per pound with a 10-percent tolerance. Firms which shell stock cannot retain scallops with shells less than 3.5 inches in height. Problems of regulating the scallop fishery, by regulations which control the age of capture, have been discussed in Caddy and Walters (1972), Kirkley (1986), DuPaul and Kirkley (1987), Kirkley and DuPaul (1987), Smolowitz and Serchuk (1987), and Wilhelm (1987). However, the regulations continue to create problems for the industry.

A major problem, particularly for firms which shuck at sea, is that it is difficult to accurately determine meat counts at sea. In response, an at-sea volumetric sampling procedure has been suggested as one way to more accurately determine the meat count (Caddy and Walters 1972). Caddy and Walters proposed that a one-pound cylindrical sampler be used at sea to determine the volumetric equivalent of a specified meat count. Furthermore, they recognized that scallops held in the hold for a short time may take up water and increase in volume by the time they are landed. Caddy and Walters, though, failed to detect potential product loss over time in the hold.

More recently, a different volumetric measure has been proposed in which a sample is made at sea using a one-pound coffee can. The current volumetric measure requires that a can be filled with scallops and covered with a lid to mitigate the influence of air in the can. In order to be consistent with the current 30 meat count regulation, 10-percent tolerance limit, no more than 77 scallops could be packed into the can if there is no change in the weight or size of the product (on average, a filled can yields 2.346 pounds of scallops).

The volumetric approach, however, may suffer from several problems, particularly if fishermen work at the limit of the regulation. First, there is the problem of product change and length of on-board stowage identified in Caddy and Walters. Second, there is a problem of how many samples must be taken at sea to ensure that the at-sea count reflects the dockside count. Third, there is a problem of converting the at-sea count to an interpretable dockside count for the fishermen.

In this brief note, preliminary analyses of the three problems are presented. The analyses are based on a limited sample of 34 bags of scallops taken from 3 vessels. Thus, the sample and results are limited and should be evaluated with caution. In contrast to Caddy and Walters, however, there is need to consider product loss over time since mid-Atlantic scallop vessels typically have trips in excess of two weeks and bulk stow the scallop meats in stacks of three to four layers.

Sample collection:

Captains of the vessels were asked to take a one pound coffee can sample, fill a standard size scallop bag with the sample and other scallops, mark the bag by day of trip, and record the count and layer of stowage. The data are summarized in tables 1-3. Three dockside samples were taken and analyzed to determine the variability in weight, total can count, and meat-count per pound. The sample sizes for at-sea and dockside sampling were not statistically determined. Thus, the statistical validity of the following analyses cannot be ascertained.

Empirical Analysis:

Product Change Over Time

The analysis of product change over time was based on two types of models. The first model was a logit model in which the probability that the dockside count of the scallops in a coffee can would be greater than the at-sea count. A high probability that the dockside count exceeds the at-sea count implies product loss over the length of the trip. The second model was a conventional regression model in which the dockside count was examined as a function of the at-sea count, day of trip, the at-sea counts for different days, and dummy variables for counts consisting of meats with extreme variability in size.

In the logit model, a limited-dependent or binary dependent variable was set equal to one for observations in which all three dockside counts were greater than the at-sea count and zero otherwise. The model specified the dependent variable as a function of a constant term, day of trip, a dummy intercept for extreme mixing, and a dummy variable for days in which there was extreme mixing.

The model permits estimation of the probability that the three dockside counts will exceed the one at-sea count conditional on day of trip and level of mixing. The probability is estimated by the cumulative distribution function (CDF) for the logit distribution:

$$\text{Prob } (Y = 1) = \exp^{\beta X}/(1 + \exp^{\beta X})$$

where Y is the limited dependent variable, ß is a vector of estimated parameters, and X is a vector of explanatory variables.

The parameters are estimated by maximum likelihood procedures. However, the estimates are not presented in this brief note; they are available upon request. The estimated parameters were all statistically significant and the model correctly predicted 76-percent of the observations.

Instead of presenting the results, estimated probabilities that dockside counts will be higher than at-sea counts conditional on day of trip are presented (table 4). As shown, the probability that dockside counts will exceed at-sea counts increases as the product is held longer in stowage. That is, the dockside count of scallops caught early in a trip will likely be higher than the at-sea count of scallops caught later in a trip. As scallops are caught closer to the end of a trip, there is a lower probability that dockside counts will be higher than at-sea counts. (Note that the estimated probabilities are not indicative of whether or not dockside counts will be lower than at-sea counts; a different model is required to estimate these probabilities). Dockside counts are believed to reflect product changes due to shrinking, compression, and swelling due to soaking.

In addition, table 4 contains estimated probabilities that dockside counts will be higher than one at-sea count when there is extreme mixing of meat size. These results are inconsistent with expectations but reflect the observed counts. However, estimated probabilities subject to mixing are quite low; the maximum being .63. This suggests, though, that a volumetric measure at-sea may be inadequate for improving the at-sea measurement of meat count if there is extreme variability in meat size.

The regression model specified the average dockside count for three coffee cans as a function of the observed at-sea counts for the first, second, and third five-day segments of a trip, the day of the trip, and dummy variables for extreme mixing of the sizes of scallops. In comparision, Caddy and Walter's model specified the dockside drop in count per pound to be a function of the initital at-sea count.

The estimated equation was as follows:

$$\text{DOCKSIDE} = \underset{(4.36)}{31.92} + \underset{(4.49)}{.52}*\text{ATSEA (DAY I)} - \underset{(1.38)}{.083}*\text{ATSEA (DAY II)}$$

$$- \underset{(2.04)}{.18}*\text{ATSEA (DAY III)} + \underset{(2.06)}{.80}*\text{DUMDAY} + \underset{(.59)}{.30}*\text{DAY}$$

$$- \underset{(2.67)}{9.58}*\text{DUMMIX}$$

where DOCKSIDE is the mean dockside count of three coffee cans, ATSEA (DAY I) is the at-sea count over all days but reflects the first five days, ATSEA (DAY II) is the at-sea count for the second five days of the trip, ATSEA (DAY III) is the at-sea count for the third five days of the trip, DUMDAY is the product of a dummy variable when there is extreme mixing in scallop size and the day of the trip, DAY is the day of the trip, and DUMMIX is a dummy variable set equal to one (0 otherwise) when the sample consists of many different size scallops. Numbers in parentheses are the t-statistics.

Most of the parameters were statistically significant but the R^2 was only .57. Thus, the estimated model does not provide a high level of precision for establishing criteria for implementing at-sea counts consistent with the regulations. However, the estimated model does reflect general expectations about the relationship between at-sea and dockside counts.

For example, the at-sea count for scallops landed during the first five days tend to yield a greater count dockside after 15 to 16 days of a trip. The at-sea count for scallops landed during the second five days of trip does not appear to change at the end of a trip. The count for scallops landed during the last five days appears to decrease by the end of the 15 to 16 day trip. Last, there is a tendency for the dockside count to be lower than the at-sea count when there is extreme mixing in the size of scallops.

Measures at Sea and Docksize

The second issue of the necessary number of at-sea samples required to ensure consistency between at-sea and dockside measures cannot be analyzed with the available data. Instead, the equivalency of measures between one at-sea sample and three dockside samples is analyzed.

Similar to the analysis of product change, a logit model is specified in which the dependent variable is assigned the value one if the at-sea sample is within the mathematical range of the dockside count. It is otherwise assigned the value of zero. A high probability that the at-sea count equals the three dockside counts implies there is no change between the at-sea and dockside counts as a result of product changes due to compression, water loss, or water gain. Alternatively, a high probability that the two measures are equal implies that there is no need to adjust the at-sea volumetric measure for changes in product size due to shrinking or swelling.

The estimated model had significant parameters and correctly predicted 81-percent of the observed values. Table 5 presents the estimated probabilities that the two measures will be equal conditional on the day the scallops were harvested and bagged. In the two cases of some mixing and extreme mixing, the probability that the two measures will be equal increases for more recently harvested scallops. However, both probabilities are quite low. Thus, it is likely that at-sea volumetric measures will have to consider product size changes over time if the volumetric approach is to be useful for management purposes.

Conversion of At-sea Count to Dockside Count

As suggested in the first two analyses, implementation of the volumetric approach requires determining the change in product size over time and the number of counts or samples which must be taken at sea. However, implementation also requires a conversion of the at-sea coffee can counts to dockside meat-counts. As indicated by the analysis and the works of Caddy and Walters and Wilhelm (1987), scallop meats change size and weight over time depending on day of harvest and methods of on-baord processing and stowing.

To address the problem of converting at-sea counts to legal dockside counts of 30, a linear regression model was specified and estimated. The model specified dockside meat counts as a function of day of trip, dummy variables for extreme mixing, and at-sea count.

All estimated parameters were statistically significant, but the R^2 was only .52. Thus, the estimated model is inadequate for practical implementation of the at-sea volumetric measure. That is, the estimates of dockside meat counts based on the model are imprecise. Considerablymore data and analyses are required before a practical conversion of at-sea counts to dockside meat-counts per pound can be made. However, the model can be used to illustrate the need for different at-sea counts over time to maintain a constant dockside meat count.

Presented in table 6 are the estimated at-sea coffee can counts necessary to maintain a dockside count, based on one at-sea and three dockside coffee can samples, of 30 meats per pound. As indicated, the at-sea counts from the beginning of a trip should be lower than at-sea counts at the end of a trip to satisify the 30 meat count regulation.

For example, approximately 69 scallops per coffee can from the first day at sea are necessary to yield 30 meats per pound on day 16 (the day of off-loading). Eighty-seven meats on day 15 are required to yield 30 meats on the day of off-loading. The 87 count was a 37 meat count on day 15 but became a 30 meat count due to swelling and product gain. In contrast, the 60 at-sea count for the coffee was equivalent to 29 meats per pound on the first day but became a 30 meat count on the last day.

Summary and conclusions:

This brief note provided a preliminary analysis of three possible problems of using an at-sea volumetric measuring method. The results indicated that product changes over time and extreme variability in meat size may cause problems for using a volumetric measure. The results also indicated that one at-sea sample would not likely yield consistent dockside counts unless the dockside counts reflected the day of harvest. Last, the analysis demonstrated how different counts would be required for each day of a trip to ensure a meat count of 30 meats per pound at the end of a trip.

In conclusion, the volumetric measure will need considerable fine tuning to mitigate the possibility of landing small scallops. Unfortunately, the level of fine tuning required for accurate at-sea measurement may make the volumetric measure impractical. Considerable additional analyses are still required before the volumetric measures can be made practical enough for implementation.

Cited References

DuPaul, W.D. and J.E. Kirkley. (1987) Progress report No. 2: Industry, NMFS, and VIMS joint-sponsored sea scallop research. College of William and Mary, Virginia Institute of Marine Science, School of Marine Science, Gloucester Point, VA.

Kirkley, J.E. (1986) A preliminary comparative analysis of sea scallop harvest patterns between dredge and trawl vessels. College of William and Mary, Virginia Institute of Marine Science, School of Marine Science, Gloucester Point, VA.

Kirkley, J.E. and W.D. DuPaul. (1987) A partial analysis of the equity of meat-count and shell-height regulations in the sea scallop fishery. College of William and Mary, Virginia Institute of Marine Science, School of Marine Science, Gloucester Point, VA.

Smolowitz, R.J. and F.M. Serchuk. (1987) Current technical concerns with sea scallop management. NOAA Technical Memorandum, Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Northeast Fisheries Center, Woods Hole, Massachusetts.

Wilhelm, K.A. (1987) Weight change of scallop meats during fresh storage. National Marine Fisheries Service, Northeast Fisheries Center, Gloucester, MA.

Table 1. Volumetric summary from Carolina Baby, 8/28/87

Day of trip and bag number	Storage layer in hold[1]	On-board scallop count	On-dock sample count						On-dock sample meat-count per pound
			Can 1		Can 2		Can 3		
			Ct.	Wt.	Ct.	Wt.	Ct.	Wt.	
1	1	57	65		66		67		28.69
2	2	59	66		67		64		28.55
3	4	66	72		73		69		31.01
4	1	49	54		52		57		23.62
5	2	62	65		71		69		29.71
6	3	62	57		56		58		24.78
7	4	65	57		63		61		26.23
8	1	60	64		62		61		27.10
9	2	59	61		70		69		28.98
10	3	69	70		78		71		31.74
11	1	51	52		54		52		22.89
12	2	61	62		53		61		25.50
13	3	50	53		53		49		22.46
14	4	65	52		58		60		24.63
15		70	71		63		66		28.98

[1] Respresents the level of layer in the hold; 1 is the bottom and 4 is the top.

Table 2. Volumetric summary from Carolina Breeze, 9/18/87

Day of trip and bag number	Storage layer in hold[1]	On-board scallop count	On-dock sample count						On-dock sample meat-count per pound
			Can 1		Can 2		Can 3		
			Ct.	Wt.	Ct.	Wt.	Ct.	Wt.	
1	1	43	54	2.57*	50	2.54	51	2.53	22.11
2	4	55	55	2.56	64	2.48	58	2.57	25.36
3	2	59	63	2.54	60	2.54	65	2.53	26.86
4	2	57	65	2.53	67	2.54	72	2.53	29.27
5	1	70	69	2.54	64	2.55	67	2.51	28.69
6		62							
7	4	45							
8		53							
9	2	58	57	2.49	55	2.49	56	2.50	24.53
10	1	63	55	2.52	55	2.50	54	2.53	23.70
11	4	57	61	2.50	63	2.48	74	2.51	28.86
12	4	78	59	2.52	67	2.51	66	2.52	27.75
13	1	74							
14	4	58	57	2.53	62	2.53	50	2.52	24.32
15	4	68	49	2.50	54	2.47	54	2.50	22.95

[1] Respresents the level of layer in the hold; 1 is the bottom and 4 is the top.

* Includes weight of can and plastic top; weight is .21 pounds.

Table 1. Volumetric summary from Carolina Baby, 8/28/87

Day of trip and bag number	Storage layer in hold[1]	On-board scallop count	On-dock sample count: Can 1		On-dock sample count: Can 2		On-dock sample count: Can 3		On-dock sample meat-count per pound
			Ct.	Wt.	Ct.	Wt.	Ct.	Wt.	
1	1	57	65		66		67		28.69
2	2	59	66		67		64		28.55
3	4	66	72		73		69		31.01
4	1	49	54		52		57		23.62
5	2	62	65		71		69		29.71
6	3	62	57		56		58		24.78
7	4	65	57		63		61		26.23
8	1	60	64		62		61		27.10
9	2	59	61		70		69		28.98
10	3	69	70		78		71		31.74
11	1	51	52		54		52		22.89
12	2	61	62		53		61		25.50
13	3	50	53		53		49		22.46
14	4	65	52		58		60		24.63
15		70	71		63		66		28.98

[1] Respresents the level of layer in the hold; 1 is the bottom and 4 is the top.

Table 2. Volumetric summary from Carolina Breeze, 9/18/87

Day of trip and bag number	Storage layer in hold[1]	On-board scallop count	On-dock sample count: Can 1 Ct.	Can 1 Wt.	Can 2 Ct.	Can 2 Wt.	Can 3 Ct.	Can 3 Wt.	On-dock sample meat-count per pound
1	1	43	54	2.57[2]	50	2.54	51	2.53	22.11
2	4	55	55	2.56	64	2.48	58	2.57	25.36
3	2	59	63	2.54	60	2.54	65	2.53	26.86
4	2	57	65	2.53	67	2.54	72	2.53	29.27
5	1	70	69	2.54	64	2.55	67	2.51	28.69
6		62							
7	4	45							
8		53							
9	2	58	57	2.49	55	2.49	56	2.50	24.53
10	1	63	55	2.52	55	2.50	54	2.53	23.70
11	4	57	61	2.50	63	2.48	74	2.51	28.86
12	4	78	59	2.52	67	2.51	66	2.52	27.75
13	1	74							
14	4	58	57	2.53	62	2.53	50	2.52	24.32
15	4	68	49	2.50	54	2.47	54	2.50	22.95

[1] Respresents the level of layer in the hold; 1 is the bottom and 4 is the top.

[2] Includes weight of can and plastic top; weight is .21 pounds.

Table 3. Volumetric summary from Carolina Breeze, 10/13/87

Day of trip and bag number	Storage layer in hold[1]	On-board scallop count	On-dock sample count: Can 1 Ct.	Can 1 Wt.	Can 2 Ct.	Can 2 Wt.	Can 3 Ct.	Can 3 Wt.	On-dock sample meat-count per pound
1	1	47	44	2.48[a]	53	2.49	54	2.54	21.95
2	2	67	60	2.50	53	2.49	59	2.51	25.04
3	1	47	45	2.48	53	2.51	52	2.51	21.83
4	4	70							
5	2	45	49	2.50	55	2.52	50	2.55	22.19
6									
7		69							
8									
9	3	60							
10	4	60	67	2.52	68	2.52	62	2.50	28.51
11	2	72	52	2.52	68	2.52	53	2.49	25.07
12	3	45							
13	3	72							
14	4	60	49	2.51	55	2.51	60	2.48	23.87
15		47	63	2.55	50	2.54	61	2.54	24.86
16		52							

[1] Respresents the level of layer in the hold; 1 is the bottom and 4 is the top.

[a] Includes weight of can and plastic top; weight is .21 pounds.

Note: This sample had extreme variability in the size of scallop meats.

Table 4. Estimated probabilities of dockside count exceeding at-sea count

Day of trip	minimum mixing of meat size	large mixing of meat size
1	.95	.17
2	.93	.19
3	.90	.22
4	.85	.25
5	.80	.27
6	.73	.31
7	.65	.34
8	.56	.37
9	.46	.41
10	.37	.44
11	.29	.48
12	.21	.52
13	.16	.56
14	.11	.59
15	.08	.63

Table 5. Estimated probabilities of dockside count equalling at-sea count

Day of trip	minimum mixing of meat size	large mixing of meat size
1	.03	.53
2	.04	.50
3	.05	.48
4	.06	.45
5	.08	.43
6	.10	.41
7	.12	.38
8	.15	.36
9	.18	.34
10	.22	.31
11	.26	.29
12	.31	.27
13	.36	.25
14	.42	.23
15	.48	.22

Table 6. Estimated required at-sea counts to yield dockside 30 meats per pound

Day of trip	At-sea coffee can count
1	69
2	70
3	72
4	73
5	64
6	76
7	77
8	78
9	80
10	81
11	82
12	83
13	85
14	86
15	87