Shrimp Sea Sampling Program

by

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Aim: To estimate the number (or weight) of fish by species discarded at sea and/or the species composition of the discards.

Strategy: The strategy to adopt in taking samples depends on the amount of cooperation the fishermen give and on the physical layout of the vessel. The best sampling coverage would consist of two bushels of mixed fish (which are being discarded) at each tow; and at least two bushels of each species discarded throughout the entire trip, the two samples not to be taken on the same day.

At each tow: a. If a tape recorder is used, the approximate number of fish discarded by species (tallied after verbally recording, say, the number of groups of 10 fish of a species discarded) should be recorded on the attached form, as well as the percents = volume of fish (by species) discarded/volume of shrimp kept (or number of bushels as recorded by the Captain). Both "numbers of fish" and "percents" are requested to check consistency. b. If a tape recorder is not used, estimating numbers by species is nearly impossible, so the percents must be visually estimated and recorded. The Captain will have information on the number of bushels of shrimp kept at each tow. In either case (a. or b.) at least one bushel basket of mixed fish being discarded should be weighed and measured for length composition whenever possible. (The fishermen may be willing to shovel the fish to be discarded into a corner of the vessel.) The information needed on the attached form should be filled out at every tow.

On each trip: In order to get length measurements for species which may constitute a small segment of the mixed sample at each tow, length samples (one bushel) should be taken for each species discarded at least twice during the trip according to the following rules:

1. Every species discarded should be sampled for length composition on at least two different tows (different days) during the trip,

2. For species whose length range varies from tow to tow (e.g. mackerel), sampling should be done so that every size-group is sampled for length composition during the trip.

3. Of the species which appear to have the same length range from tow to tow, those which constitute the bulk of the discards should be sampled for lengths on more tows than those comprising a small amount of the discards.

If the actual measuring is done on shore, proper freezing techniques should be followed. These procedures, along with proper measuring of the length of the fish, are given in the Manual for Sampling which each port sampler has.

Reminder:

All fish discarded should be recoded by species. A special request that this be done for skates has been made.

Definition of Terms on Sea Sampling Record

Departure Date: Record the date and time the vessel sailed.

Return Date: Record the date and time the vessel returned to port at the completion of the trip.

Vessel Name: Record the name of the vessel.

Species: All species taken at sea should be recorded whether or not some fish of that species were discarded.

Loran Bearing: Record the two loran bearings for each tow location.

No. fish and/or Wt. Discarded: Record the number of fish of each species discarded (and the weight, if possible) for each tow made while the sampler is on duty.

No. Bushels Kept: Record the number of marketable bushels of each species taken at each tow, regardless of whether the sampler was on duty. Operators usually keep a tally of this in the pilot house.

L.-Freq. Sample Taken: Was a length sample taken of this species at this tow-enter "yes" or "no".

Sea Sampling Summary Sheet

Departure Date________________

Return Date________________

Vessel Name________________

Total No. Tows Made on Trip____________

No. Tows Made While Sampler Was Off Duty____________

Sampler's Name____________

Species	Weight Landed	No. Bushels Landed	Any fish Discarded?	No. L.-Freq. Samples Taken	Notes

Sea Sampling Record

Departure Date ____________________

Return Date ____________________

Vessel Name ____________________

Total No. Tows Made on Trip __________

No. Tows Made While Sampler Was Off Duty __________

Sampler's Name ____________________

Day of Month	Tow Number	Loran Bearing	Tow Length		On Duty?	Species	No. fish and/or Wt. Discarded[1]	No. Bushels Kept	Marketable Nos. per Bu.	L.-Freq. Sample Taken?
			Hrs.	Min.						

1 Or percent = approximate number of bushels (or fish) discarded/number of bushels (or fish) of shrimp kept.

The basic formula used to estimate the number of fish of species discarded during a given time period, in a given area, etc. is:

$$\hat{N}_s = \frac{\hat{W}_s}{\bar{w}_s} = \frac{1}{\bar{w}_s} \frac{N_1}{n_1} \sum_{i=1}^{n_1} \frac{N_{i2}}{n_{i2}} \sum_{j=1}^{n_{i2}} \frac{N_{ij3}}{n_{ij3}} \sum_{k=1}^{n_{ij3}} w_{ijk} \qquad (1)$$

where $\hat{N}_s$ = estimated number of fish of species discarded,

$\hat{W}_s$ = estimated weight of fish of species discarded,

$\bar{w}_s$ = average weight of fish of species discarded, calculated from length samples taken,

N_1 = number of shrimp trips made during time period, or over area, etc.,

n_1 = number of trips ($n_1 = N_1$) during which sampling of discards occurred,

N_{i2} = number of tows made during trip i,

n_{i2} = number of tows on trip i during which sampling for discards occurred,

N_{ij3} = number of possible bushel basket samples on tow j of trip i,

n_{ij3} = number of bushel basket samples of mixed fish made on tow j of trip i,

w_{ijk} = weight of species discarded on tow j of trip i, calculated by $w_{ijk} = p_{ijk} * W_{ij}/p_{ij}$, where

p_{ijk} = fraction of total catch which is species s on tow j of trip i,

W_{ij} = weight of shrimp caught at tow j of trip i, and

p_{ij} = fraction of total catch at tow j of trip i which is shrimp.

Expression (1) can be written as

$$\hat{N}_s = \hat{B}/\bar{w}_s \qquad (2)$$

where $\hat{B} = \hat{N}_s * \bar{w}_s$ from (1), and $\hat{N}_s$ and $\bar{w}_s$ are as defined earlier. Then the variance of (1) can be estimated using the formula:

$$\begin{aligned}\mathrm{Var}(\hat{N}_s) \doteq \mathrm{Var}(\hat{B})/\bar{w}_s{}^2 + \mathrm{Var}(\bar{w}_s) * (\hat{B}/\bar{w}_s{}^2)^2 \\ - 2 * \mathrm{Cov}(\hat{B},\bar{w}_s)/\bar{w}_s * \hat{B}/\bar{w}_s{}^2 \end{aligned} \qquad (3)$$

The variance of $\hat{N}_s$ then will be under- or overestimated by using the first two terms of (3), depending on whether $\mathrm{Cov}(\hat{B},\bar{w}_s)$ is positive or negative. It will be assumed here that $\mathrm{Cov}(\hat{B},\bar{w}_s)$ is negligible.

If each trip is of the same duration in terms of number of tows, and if the sampler works for the same number of tows on each trip, then the variance of $\hat{B}$ can be simplified by assuming $N_{i2} = N_2$, $n_{i2} = n_2$, $Nij_3 = N_3$, etc. The variance of $\hat{B}$ can be estimated by:

$$\begin{aligned}\hat{\mathrm{Var}}(\hat{B}) = \frac{(N_1-n_1)}{N_1}\frac{\sum_{i=1}^{n_1}(\bar{w}_i-w)^2}{n_1(n_1-1)} + \frac{n_1(N_2-n_2)}{N_1 \quad N_2}\frac{\sum_{j=1}^{n_2}(\bar{w}_{ij}-\bar{w}_i)^2}{n_1n_2n_1(n_2-1)} \\ + \frac{n_1n_2(N_3-n_3)}{N_1N_2 \quad N_3}\frac{\sum_{k=1}^{n_3}(w_{ijk}-\bar{w}_{ij})^2}{n_1n_2n_3n_1n_2(n_3-1)}\end{aligned} \qquad (4)$$

The average weights (ie. $\bar{w}_i$, $\bar{w}_{ij}$) are stratified weights, and w is the weight stratified over all levels (trips, tows, samples).

If the N_i, n_i, N_{ij}, etc. vary considerably, then the formula for the variance is more complicated. The exact variance of $\hat{B}$ is

$$\mathrm{Var}(\hat{B}) = N_1^{\,2}\frac{\sigma_{Ti}^{\,2}}{n_1}\left(\frac{N_1-n_1}{N_1}\right) + \frac{N_1}{n_1}\sum_{i=1}^{n_1} N_{i2}^{\,2}\frac{\sigma_{Tij}^{\,2}}{n_{i2}}\left(\frac{N_{i2}-n_{i2}}{N_{i2}}\right)$$

$$+\frac{N_1}{n_1}\sum_{i=1}^{n_1}\frac{N_{i2}}{n_{i2}}\sum_{j=1}^{n_{i2}} N_{ij3}^{\,2}\frac{\sigma_{ij}^{\,2}}{n_{ij3}}\left(\frac{N_{ij3}-n_{ij3}}{N_{ij3}}\right) \qquad (5)$$

where $\sigma_{Ti}^{\,2} = 1/(N_1-1)\sum_{i=1}^{N_1}\left(T_i - \sum_{i=1}^{N_1} T_i/N_1\right)^2$ and

$$\sigma_{Tij}^{\,2} = 1/(N_{i2}-1)\sum_{j=1}^{N_{i2}}\left(T_{ij} - \sum_{j=1}^{N_{i2}} T_{ij}/N_{i2}\right)^2$$

and where T_i and T_{ij} are the totals of the first and second stages of sampling. The term $\sigma_{ij}^{\,2}$ is the usual within sample variance, ie. the tow to tow variance.

An unbiassed estimator of (5) is

$$\hat{\mathrm{Var}}(\hat{B}) = \hat{V}_1(\hat{B}) + \left(\frac{n_1}{N_1}\right)\sum_{i=1}^{n_1}\hat{V}_2(t_i) + \left(\frac{n_1}{N_1}\right)\sum_{i=1}^{n_1}\left(\frac{n_{i2}}{N_{i2}}\right)\sum_{j=1}^{n_{i2}}\hat{V}_3(t_{ij}) \qquad (6)$$

where $\hat{V}_1(\hat{B}) = \left(\frac{n_1}{N_1}\right)\left(\frac{N_1-n_1}{N_1}\right)\sum_{i=1}^{n_1} t_i^{\,2} + \left(\frac{n_1}{N_1}\left(\frac{n_1-1}{N_1-1}\right) - \left(\frac{n_1}{N_1}\right)^2\right)\sum_{\substack{j',k'=1\\k'\neq j'}}^{n_1} t_{k'}t_{j'}$ and

$$t_i = \frac{\dfrac{N_{i2}}{n_{i2}}\displaystyle\sum_{j=1}^{n_{i2}}\dfrac{N_{ij3}}{n_{ij3}}\sum_{k=1}^{n_{ij3}} w_{ijk}}{\left(n_1^{\,2}/N_1\right)}\;;$$

where $$\hat{V}_2(t_i) = \frac{n_{i2}}{N_{i2}}\left(\frac{N_{i2}-n_{i2}}{N_{i2}}\right)\sum_{j=1}^{n_{i2}} t_{ij}^2 + \left(\frac{n_{i2}}{N_{i2}}\left(\frac{n_{i2}-1}{N_{i2}-1}\right)-\left(\frac{n_{i2}}{N_{i2}}\right)^2\right)\sum_{\substack{k,m=1\\k\neq m}}^{n_{i2}} t_{ik}t_{im} \quad \text{and}$$

$$t_{ij} = \frac{\dfrac{N_{ij3}}{n_{ij3}}\sum_{k=1}^{n_{ij3}} w_{ijk}}{n_{ij3} * n_{i2}^2/N_{i2}} \quad ;$$

where $$\hat{V}_3(t_{ij}) = \frac{n_{ij3}}{N_{ij3}}\left(\frac{N_{ij3}-n_{ij3}}{N_{ij3}}\right)\sum_{k=1}^{n_{ij3}} w_{ijk}^2 + \left(\frac{n_{ij3}}{N_{ij3}}\left(\frac{n_{ij3}-1}{N_{ij3}-1}\right)-\left(\frac{n_{ij3}}{N_{ij3}}\right)^2\right)\sum_{\substack{k,m=1\\k\neq m}}^{n_{ij3}} w_{ijk}w_{ijm}.$$

Assuming a large sample size, standard Normal theory can be used to provide confidence intervals of all statistics.

Returning to (3), the variance of $\hat{N}_s$ can be estimated using the standard formulas for the variance of $\bar{w}_s$, and using (4).

References

Cochran, William G. Sampling Techniques. New York (1953), pp. 65-110.

Kendall, M. G. and A. Stuart. The Advanced Theory of Statistics, Vol. 3. London (1966), pp. 167-204.