Collection of Fish Lengths for Stock Assessment in Developing Countries

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Abstract

A review of the data (handling) requirements for length-based stock assessment is presented, with emphasis on the relationship between the expected outputs and the key features of the samples required, and on biases and other sources of inaccuracy.

Introduction

In developing countries the nature of the information and calculations needed for fish stock assessment is variable, depending on the biology of the species concerned, place, time scale, and the purpose of the assessment. Those of us who work in developing countries have had it indelibly etched on our psyches that social and political factors also influence the type of management envisaged. This in turn will affect the type of analysis that is of interest and, hence, the information requirements of the assessment. In the final analysis, the data to be collected is determined by what is required and why; additionally, the feasibility of a particular assessment is in large measure determined by the available data.

Why Collect Length Data?

The major questions of fisheries assessment methods are concerned with the impact of fishing on fish populations. The population is being continuously sampled by the fishers but typically these catches form a biased sample of the fish population. In addition, the questions of how large the population is, and what the rate of removal of fish is, are difficult and not directly observable (Pope 1988). Both of these aspects give fisheries data collection its own character. Notwithstanding the fact that the data are likely to be biased some way, it is always sensible to make as much use as possible of statistics about the catch. The choice of the amount of data to be collected is dependent on: (a) how valuable the catch is; (b) how costly data collection is; (c) the value of the collected data to the assessment; and (d) the type of assessment method.

While the traditional measure of biological time has been age, another measure is size and usually, the simplest size to obtain is length. Length-based measures of stock assessment require data that are simple and relatively cheap to obtain, giving these methods some attractiveness in comparison to age-based methods. Of course, in addition to length being a nonlinear measure of time, the relationship is one that has to be estimated, introducing another source of uncertainty into the assessment process. Thus, it is probably true that there is "no best choice between an assessment method structured by age or size" (Rosenberg and Beddington 1988).

What Do We Hope to Get Out of Our Efforts?

Assessment results can be in the form of long-term management advice, short-term management advice, and/or simple assessment information, the latter being in the form of rough guides or broad averages (Rosenberg and Beddington 1988). One line of approach produces relatively coarse information which is appropriate for initial assessments or assessment of fisheries for which there is a sparse database. A middle path represents assessments conducted directly from the length composition of the stock, without translating the length scale into an age scale (Munro 1980; Rosenberg and Beddington 1988). The third approach describes assessment processes where this transition takes place, with the effect of uncertainty on the results of the assessment being considered.

What are the Major Factors to be Considered?

The factors which should be considered when designing a sampling program for length-based stock assessment are: (1) aggregation method; (2) length interval; (3) time span of study; and (4) uniformity of sampling frequency (Hoenig et al. 1987).

Statistical Considerations

ERRORS IN THE DATA

From a general standpoint, it is usual for statisticians to think of data errors in terms of:

1. bias, which is a systematic error in an estimate which no amount of replication can reduce (Pope 1988); and
2. variance, the variation about the true estimate which can be averaged out (Pope 1988).

To be realistic, this list should include the possibility of

3. silly mistakes.

The person designing the data collection must find ways of reducing these error sources as far as possible or, at least, to some acceptable level.

REDUCING BIAS

Bias occurs from a plethora of causes, for example, faults in the sampling design such as sampling the length distributions from only one type of fishing vessel, yet taking these distributions as being typical of the total landings, or through the processes illustrated in Figs. 1 and 2. Occasionally one may have little choice but to consider the bias unknown and probably not removable, but to ensure its consistency from year to year (Pope 1988). Building a time series of biased estimates may, in the long run, enable them to be calibrated from other information sources. The most sensible approach to reducing bias may be to stratify based on similar groups, such that it is simple to arrange random sampling within each group.

REDUCING VARIANCE

Variance occurs in assessment data from a number of causes including sampling error (Pope 1988). Those elements of a population which can be sampled will give an estimate which is either too large or too small. The extent of this deviation from the "true" population value will depend on the amount of variation in the population itself (as well as on the sample size). A simple increase in sampling intensity "does not provide a proportional increase of reliability of estimates" (Levi et al. 1987), and, together with the relationship between an increase in the sample size and the precision thus obtained, it quickly becomes very expensive to reduce the error range by any substantial amount (Pope 1988). While sampling variation can be reduced in a number of ways, the best approach is (again) to split the population into a number of more homogeneous strata. Variation therein should then be reduced and the overall estimate made by combining the results of each stratum.

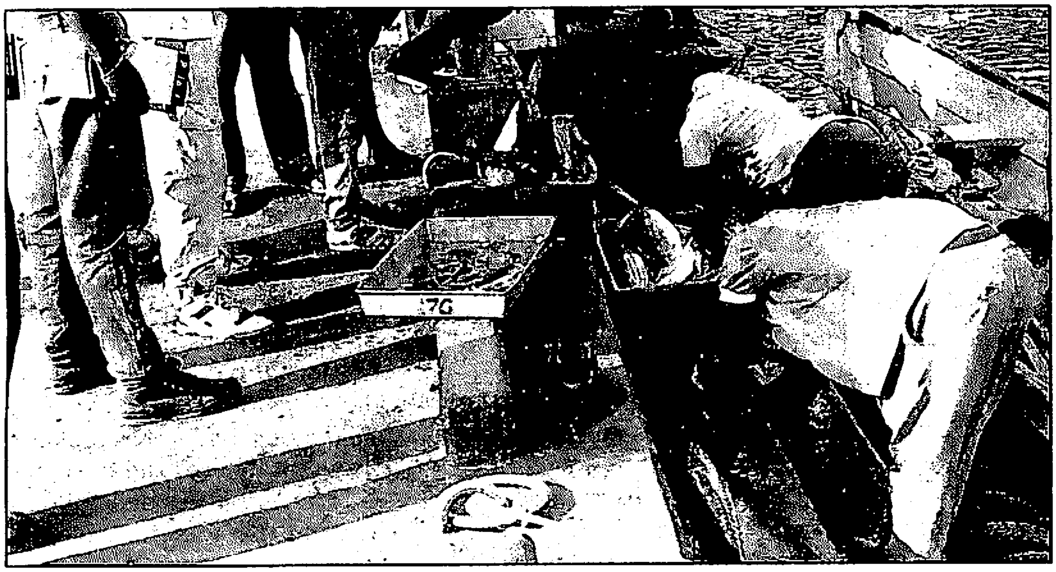

Fig. 1. ***Selling a catch in St. Vincent, West Indies; measuring fish at markets generates a number of biases which must be accounted for in assessments.***

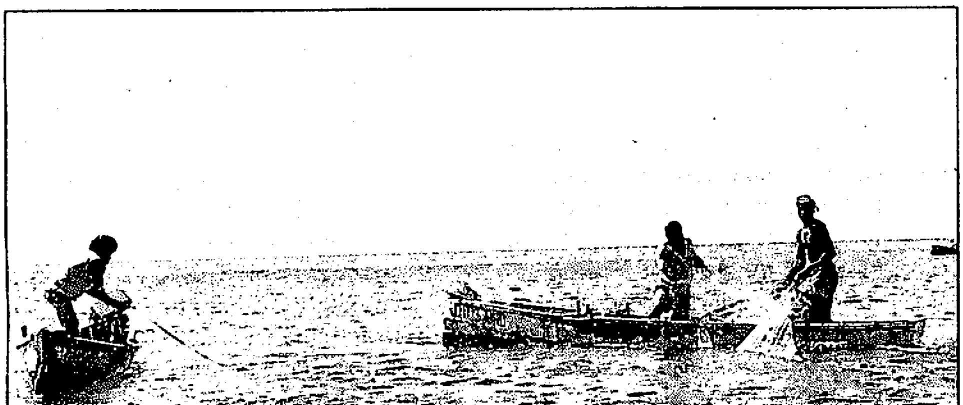

Fig. 2. ***Measuring fish at the point of capture will generally lead to less biases than market sampling, but gear selection must still be accounted for.***

DEALING WITH MISTAKES

Mistakes are human errors in execution other than those in the general sampling design. Unmeasured, mismeasured, unrecorded, or misrecorded data can cause errors in the data series and also cause a loss of credibility disproportionate to their actual effect on the results. As fishery data are so often collected in less than ideal conditions, mistakes of one kind or another are always likely. Carefully designing the sampling system and the use of available checking procedures can go a long way towards reducing mistakes. Cross-checking with other data, checking the range of values (a 150 cm queen angelfish? You must be joking!), and checking average levels of particular variables are ways of doing this. Pope (1988) has also pointed out that the attitude of the person collecting the data plays an important part in reducing mistakes. The projecting attitude that every last fish measured matters, often improves the performance of the data collectors.

Errors in Sampling

Isaac (1990) has noted a number of sampling or treatment biases that can occur when using length-based methods including: samples which are too small or too infrequent; systematic errors in length measurements, or nonrandom selection of the fish being measured; and errors in the method for grouping length measurements.

SAMPLING SIZE

Gulland (1987) has noted that the best sampling size in routine sampling may be around 50 fish; he has also pointed out that in the early stages of a study it may be desirable to let each sample stand by itself. Thus it may be better to have larger samples (e.g., 200) in which the modes in the distribution, if any, will be clearer.

CLASS INTERVAL

The width of the length class interval into which data will be grouped is also important (Wolff 1989). Isaac (1990) has shown that when the effect of individual variability in the growth parameters is combined with an increase in length class width, the bias in L and K derived by the length-based methods in use more commonly these days (ELEFAN I [Pauly and David 1981]; SLCA, Shepherd's Length Composition Analysis [Shepherd 1987]; and the Powell-Wetherall plot [Wetherall et al. 1987]), increased with the width of the length classes. Thus the smallest practical length interval should be used.

Sampling Design

In general then, there is a need to consider *all* aspects of the sampling program to avoid ill-defined situations which may lead to biased sampling related to the definition of the population, nature of the sampling procedures, and randomness of unit selection (Gobert 1992). The design must also ensure that the basic assumptions of the methods of analysis can be met by the data set to be collected. In addition, when assessments are being done at a regional level, there should be a standardization (or at least a harmonization) of methodologies used in each state to the extent that (say) the same types of length information are collected. For example, the decision should be made as to whether length measurements are to be standard, fork, or total lengths. Examples are fork length for species with obviously forked tails, total lengths for species with (approaching-) convex tails, carapace lengths for crustaceans, and lip thickness for conch.

General Guidelines

Great care must be taken in designing a sampling scheme which would require:

1. well-defined objectives about the data to collect and their future use: different kinds of length-frequency data may be necessary for different analyses; and
2. a good knowledge of the fishery, which can be qualitative such as from the field experience of extension officers, or quantitative coming from a prior or frame survey (Gobert 1992).

Hoenig et al. (1987) note some guidelines that apply generally to the collection of data for length-based stock assessment:

1. Collect and preserve raw length measurements if possible. If data must be collected as a histogram, use as narrow a length interval as possible. It is always possible to group data into longer length intervals at the time of data analysis.
2. When collecting data from the commercial catch, document the fishery, including, if possible, target species, number and type of gear, mesh size, fishing location, and quantity and description of any discards.
3. Variability among sampling units is almost always greater than variability within units, thus two boxes (baskets, or bags) examined from each of two vessels is generally better than four examined from one vessel.
4. Provide the person doing the sampling with simple, carefully selected, objective rules for choosing sampling units so that errors and biases are kept to a minimum. Sampling instructions should be simple and clear, and should be pretested before being employed in an actual sampling program.
5. Monitor sampling results regularly; if data are plotted after collection, one can modify the sampling plan in response to unexpected findings.

When the data are to be used specifically for modal progression analysis there are also a number of other guidelines to be considered (Hoenig et al. 1987):

1. Pool samples collected within a given time period to boost sample sizes.
2. For protracted spawners, keep the data summarized by short time intervals.
3. The bigger the maximum size, the more length intervals should be used to record the data.
4. The larger the maximum size the larger the sample should be.
5. Check for heterogeneity among different samples of schooling fish and fish which occur over a wide geographical area.
6. One or more preliminary samples should be taken to obtain a better idea of the likelihood of success of modal analysis.
7. Collect and examine samples from different areas separately, to guard against immigration or emigration of segments of the population changing the shape of the length distribution in a manner that may resemble modal progression due to growth and mortality (Shepherd et al. 1987).

In practical terms, most design considerations can be addressed if one follows the suggestions of Gulland and Rosenberg (1992), especially in the initial phase of data collection:

1. sampling should cover at least 14 months such that data are

obtained from the whole annual cycle with enough overlap to check on year-to-year differences;
2. unless the fishery is highly seasonal, sampling should be done in each month;
3. initially moderate samples (200 fish) are preferable in determining the length composition of the catches at a particular time and place;
4. samples should, as much as possible, be spread through the whole area of the fishery;
5. samples should be taken from across all types of gear that take significant catches of the species; and
6. there should be enough replication to establish the level of within-strata variance, and hence the level of precision likely to be achieved.

The level of sampling proposed initially could in due course be altered depending on, among other things, the observed variation between months, gears or areas. It should always be remembered that our information about the weight of fish in the landings as a whole will be improved by sampling from more vessels (even if fewer fish are weighed) than by increasing the size of the sample from any one vessel (Gulland and Rosenberg 1992). It may be a good idea when the sizes taken are not of the same order of magnitude (e.g., tuna taken by longlines) that they are kept apart until the final stage such that separate annual (subtotals are estimated for each gear and then added. If the differences are less pronounced, the different groups may be combined earlier, for example when calculating district totals for a given time period.

Finally, a data collection program should always be dynamic and hence, at regular intervals in the overall program, the sampling design should be reviewed, and answers sought for such questions as:

1. Is there a chance of bias in the design being used?
2. How big are the sampling errors?
3. What is the contribution of these errors to the final outputs of the stock assessment and to the various intermediate stages?
4. How does this contribution compare with that of other sources of error and uncertainty?
5. How might the sampling work be modified to reduce variance and as far as possible eliminate the risk of significant bias?
6. Should the proportion of the total resources allocated to data collection by the division be modified?

End Note

If the person who is ultimately in charge of the catch sampling, and who may be using the data for their own analysis, is not concerned with the actual work and especially, fails to show an appreciation of the difficulties and discomforts often involved, those actually collecting the data will be quick to detect this lack of concern and their performance will often reflect their perception of this attitude. To quote Pope (1988): "Every important data set should have someone to love and cherish it!"

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