Potential Interest of Two Time-Saving Methods for Measuring Activity and Catches of Small-Scale Fisheries

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ABSTRACT

During the intensive sampling program conducted in 1987 on the coastal fisheries of Martinique, two approximate methods were routinely used to measure numbers of fishing trips (indirect enquiry based on the knowledge of fishermen and local residents), and catches (visual estimation of weight and composition).

Their use saved a considerable amount of field time and, in many cases, made sampling possible whereas it would not have been so otherwise.

This paper deals with their description and validity, as indicated by parallel or simultaneous reliable measurements and focuses on the factors that may influence their validity and on the statistical consequences of their use.

INTRODUCTION

The collection of fishery data to compute landing statistics or to perform stock assessments can involve different sources, such as fishermen, merchants, and the processing sector. Most often these data are self-reported within a structured frame supervised by the administration, or by professional organizations.

However, field collection of raw data may become necessary, either because of the lack of an organized structure for self-reporting and processing of data (to estimate total production, for instance) or because more detailed data are required for a specified study, such as a comprehensive review of the fisheries.

Both the above were true in Martinique when a fishery research program was implemented in 1986 (Chevaillier *et al.*, 1991). Not only were the landings unknown with any reasonable degree of reliability, but the planned analyses needed additional data such as detailed catch compositions that had to be collected directly at landing sites .

In the field, work conditions are such that it is rarely possible to objectively measure all the parameters of interest. The field cost would either be prohibitive, even within an efficient sampling plan, or it would hinder the professional activity (*e.g.* catch, sale) of the fishermen to an unreasonable degree. The methods used are, therefore, most often approximate, taking into account, as far as possible, the many field constraints.

This paper deals with an evaluation of two such approximate methods, which were used in Martinique in 1987, to estimate fishing activity (number of trips) and individual catches.

The fishery research program implemented in 1986 in Martinique, aimed at an assessment of the status of the stocks exploited by the local fishermen and is described elsewhere (Chevaillier *et al.*, 1991). It involved the field collection of three main types of data:

- activity (number of trips)
- trip characteristics (effort, catch)
- detailed catch composition (species, lengths)

Objective and rigorous measurement of activity needs the continuous presence of an observer during a given period to count the trips either when the boats leave or come back. Most cases, especially when the activity is spread over time and among landing sites, involve high, and sometimes unaffordable field costs; various approximate methods have been used, whose cost and reliability are lower. One of these methods is studied here.

It is rarely possible to measure fishing effort components, and most often one has to rely on fishermen's declarations for quantities such as fishing depth, soaking or fishing time, etc. These problems will not be dealt with here.

In most cases (unless the fisherman allows it), the catch or its components cannot be weighed independently of their sale, which may take several hours, or occur elsewhere. A further complication is the fact that fish are often not sorted into species or categories. The weights then have to be estimated instead of being measured. A visual estimation method, used in Martinique, is studied here.

By definition, measuring a fish means handling it, and this operation cannot be performed by an approximate, cheaper, method. Sampling within the catches allows the reduction of costs but raises problems that are out of the scope of this paper (Chevaillier and Gobert, 1988).

1. MEASUREMENT OF FISHING ACTIVITY

The objective was to obtain estimates for the number of trips made with each fishing gear. Owing to the wide scattering of different types of fishing activity among sites, sampling was not restricted to the few more active sites, thus omitting an unknown and probably not negligible proportion of the total activity.

The basic principle of activity sampling was the following:

At the 25 more active sites (called "main sites"), the fishing activity was measured by directly counting the number of boats returning from fishing trips, within randomly drawn 4-hr periods of continuous presence of the field recorder. The most reliable method was therefore used to measure the highest activities.

In the 106 other sites (called "secondary sites"), the activity was indirectly measured through informal interviews of local fishermen or residents (called here "informants"), who were questioned about the number of trips and the gear used, of the particular site and day. These "indirect enquiries" can be considered as "backward" or "forward" depending on whether the informant is questioned about the past ("How many boats have already come back from fishing ?") or about the future ("How many boats are still at sea?"). In most cases, both types of questions were asked to obtain a measure of the total activity of the day.

The indirect enquiry method is of course subject to errors of various origins, the importance of which depend on several main factors.

1.1 Factors of Reliability

1.1.1 Site

In order to ensure good potential reporting conditions for the informants, the site must be defined functionally according to size, topography, level of activity, etc. in such a way the average informant should be able to remember easily the boats that left or came back and be able to check by observing the empty spaces on the beach.

Good examples of this factor are the long stretches of beach found on the north Caribbean coast of Martinique, where boats are scattered, and often somewhat hidden by vegetation or shelters. These beaches were split into several secondary sites, each to be monitored by a separate informant.

1.1.2 Activity

The potential error is related to the characteristics of the fishing itself. High numbers of trips are more difficult to report than low ones; the number of trips made are more likely to be underestimated than overestimated, and the gear types may be unknown by the informant. More specifically, recording bias is likely since the activity of specialized fishermen or fishermen catching large species is usually better remembered by the informants. This statement is particularly true for offshore pelagic fishing. Likewise, the less conspicuous fishing techniques, such as inshore trolling, or those methods used by non-professional fishermen are likely to be omitted or neglected by informants.

1.1.3 Period Covered by the Enquiry

At equal number of trips, it can be expected that the informant's memory is better for recent events. The trips observed several hours ago are more likely forgotten, and "backward" enquiries give more reliable data than "forward" ones, since they are based on an actual experience.

1.1.4 Informant

At a given site, the informant should ideally be a person who is most often present when the field recorder comes and who is familiar with the fishermen and their techniques. Actually, this situation seldomly occurs, and the field recorder cannot always chose his interlocutor. In some instances, the information may even be obviously wrong, beyond the limits of an "acceptable" error, or the recorder cannot find anybody to question, in a remote or uninhabited site. In these cases, the data are not included for further processing .

1.1.5 Field Recorder

The recorder's ability is a most important factor of reliability in this kind of data collection. The informants will most often give reliable information only if they feel confident with interrogator, whom they generally do not know, at least at the beginning of the study. The recorder should therefore be able to gain their confidence, explaining as many times as necessary the why and the how of the study, spending friendly time chatting or joking with people, etc.

Since the recorder seldomly has the choice of his informants, he should be very careful to check, as far as he can, the reliability of the data he collects, through comparison of data obtained from different persons or with reference to his own field experience of the site and its activity.

1.2 Results

1.2.1 Data Analysis

Since simultaneous activity measurements of activity were not possible while running the data collecting system, the errors were indirectly analyzed by comparing averages obtained in the main sites from direct observations with those obtained from indirect enquiries. These two kinds of data covered 4-hour periods ("backward": 6 to 10 am, and "forward": 2 to 6 pm), and 8-hour periods ("backward": 6 am to 2 pm, and "forward": 10 am to 6 pm).

Activity averages were computed separately for the two main fishing seasons to reduce sample variances. The 25 sites, 2 seasons, and 4 time periods yielded 188 pairs of averages, after elimination of one site where indirect enquiry was impossible and of some samples where independent problems occurred.

1.2.2 Analysis of Errors

The analysis, detailed elsewhere Gobert (1989a), leads to the following main conclusions:

- It was found that on the whole, direct and indirect averages are not very different: 67.0 % of the t-tests are not significant ($\alpha > 5$ %).
- Indirect enquiries underestimate the average activity in nearly 80% of all cases, and in 93.4 % of the cases showing significant differences.
- A recorder effect appears clearly when one compares the percentages of significant differences between direct and indirect averages obtained by

the recorder E (77.3 %) and of the four others (19.4 %), even though the features of the fishing activity he covered in his sector are quite different.

- The duration of the period covered by the indirect enquiry is also important. About 30% of the difference shift from "not significative" ($\alpha > 10$ %) to "very highly significative" ($\alpha < 1$ %) when the duration shifts from 4 to 8 hours.
- Whether enquiries are "backward" or "forward" appears to make very little difference with the results. The absolute error in the estimate of total activity is approximately proportional to the number of trips: the error is thus multiplicative in nature.
- For estimates of the effort with different gear types, it was found that the error was least for the most conspicuous types of fishing. For example, estimates of offshore pelagic fishing yields showed the least proportion of significative differences (2.3%). The most important proportions are comprised between 21 and 28%, and occur for different situations:

  - Trap fishing — the most commonly practiced fishery; subject to high absolute errors
  - Beach seine and surface gillnet fishing — relatively large errors in the estimates; proportions of significative differences may be explained at least in part by the recorder effect, since these fisheries are most (if not exclusively) active in the sector covered by the unreliable recorder E
  - Inshore trolling — relatively inconspicuous due to short duration of trips, the use of small outboard engines, and generally low catches

1.2.3 Correction of Errors

Theobjective of the analysis was to assess the validity of using indirect enquiries as a field methodology, and to correct activity estimates obtained by this method in secondary sites.

Analysis shows that an approximate ratio correction model can be applied to secondary site averages. The ratio was computed from the 4-hour observation data collected at the main sites (Gobert, 1988) and is described by the following equation where for a given fishery for the i^{th} site, A_i is the estimator of real average activity, a_{Ii} the average activity measured by indirect inquiries, and R the correction ratio:

$$A_i = R\, a_{Ii}$$

$$var(a_i) = a_{Ii}^2\, var(R) + R^2\, var(a_{Ii})$$

The correction method is itself biased, since R, which is an average ratio integrating all the possible effects described above, is used instead of R_i, the real but unknown ratio corresponding to the actual conditions of data collection in site i. It is assumed that the overall bias will be small enough to be negligible when the average total activity is computed.

The average underestimation due to the indirect enquiry method varies between 0 (in two cases the ratio R is lower than 1, but not significantly) and 48 %, this latter value being for inshore trolling activity. However, most values are between 12 and 30%, the most active and productive fisheries, traps and offshore pelagic fishing, having values of 19% and 16.6%.

The application of the correction method causes only a moderate increase of variability in the activity estimates (coefficients of variation were multiplied by a factor most often comprised between 1.0 and 1.1), but this system cannot be applied to single site corrections, as mentioned above.

1.2.4 Cost and Feasibility

The cost difference between the two methods is obvious. Direct observation of activity needs the continuous presence of a recorder on the site whereas indirect enquiry needs only a short visit to each site, if possible at the most favourable time. For example, during the whole year of field work in Martinique, 7,700 hours were devoted to 1,925 periods of direct observations (on activity, but also on catch) in the 25 main sites, and about 860 hours were devoted to 3,170 individual indirect enquiries in the 101 secondary sites. It was found on the average,that only about 16 minutes (including driving time from site to site) was needed in each of the secondary sites to collect activity information covering a whole day.

However, it should be noted that, even though direct observations remain much more expensive than indirect enquiries, their cost can be reduced by a proper time stratification such as that made in Martinique. Also, other kinds of data (weight and composition of catches, and biological information) can be collected at the same time with no extra cost.

1.3 Discussion

Extrapolations of fishing activity at main sites to assess activity at secondary sites was unsatisfactory mainly because of the wide variation in the types of fishing conducted at these sites. The secondary sites are important, however, accounting for 38% of the total fishing effort recorded in Martinique, and should, therefore, be sampled. Measuring fishing activity by using the knowledge of fishermen or local residents proved to be the only feasible method of gathering data at a large number of fishing sites.

The indirect method is subject to different biases. According to the features of the fishing techniques considered, the under-estimation of trip numbers varied between 12 and 30% (up to 50% in the least favourable case). If adequate data are available (which may prove costly), the biased activity estimates can be corrected. The correction method is itself biased, but the impact of this second-order bias is probably minor when activities are summed or averaged over a number of sites.

It appears that many factors can affect the reliability of indirect enquiries, but the most important ones lie at the conception stage of the data collection system: functional definition of sites and, above all, selection and training of field recorders.

2. VISUAL ESTIMATION OF CATCH WEIGHT AND COMPOSITION

The second basic step for landings estimation is to compute average catches per trip, by species or species groups, fishing gear, time period, sector, etc.

When there are neither log-books, nor sales receipts, some measurement of individual catch weights is applied. This situation is often not possible with any degree of rigor without an undesirable perturbation of the fisherman's professional activity (landing, sale).

Visual estimation was therefore routinely used by the field recorders in the 25 main sites of Martinique where direct observations were conducted. Usually, the total weight of the catch (unless the whole sale could be observed) and of the rough catch composition were estimated by eye. For the latter 34 species groups had been defined.

Three main types of catches are landed in Martinique:

- demersal catches, usually highly multispecific (sometimes more than 30 species in individual gillnet or trammel catches), rarely exceeding a few tens of kilos, and never sorted
- coastal pelagic catches (plus flyingfish catches), most often monospecific, sometimes reaching 100 kg or more
- offshore pelagic catches, characterized by a few species of generally large size, and total weights ranging from 0 to several hundreds of kg

The field recorder usually had to perform three successive steps between the landing itself and the beginning of the sale:

- estimation of the total weight of the catch
- identification of the species groups present in the catch
- estimation of the weight proportions of the groups.

In some cases (particularly for the pelagic catches), group weights could first be estimated, the total weight being obtained by summation.

2.1 Factors of Reliability

2.1.1 Field Recorder

The subjectivity of any eye estimation is well-known: some persons may show tendencies to over-estimate or to under-estimate real values. For instance, error in proportions estimation can be related to real proportions (such as over-reporting dominant groups and under-reporting minor ones, or the opposite) but also to the "usual" composition of the catch (such as over-reporting target species or groups of the considered fishing gear).

2.1.2 Species Diversity of the Catch

Without any likely effect on the total weight estimation, species diversity has direct influence upon the process of estimating proportions of species in the catch. Highly multispecific catches are more subject to qualitative (omissions and wrong identifications of groups) and quantitative errors.

2.1.3 Type of Catch

The three catch types mentioned above raise different problems for visual estimation :

- Total weights are probably easier to estimate for demersal catches, usually landed in containers (buckets, baskets,...) the size and filling rate of which are used as guides by the recorders; on the other hand, their often high multispecificity makes proportions difficult to estimate.
- Total or group weights of offshore pelagic catches generally have to be guessed according to the number and size of the fish, which are often too big to be landed in containers.
- Proportions estimation is often irrelevant for coastal pelagic catches, but the fish is generally sold directly from the bottom of the boat: the absence of containers hinders total weight estimation

2.1.4 Catch Weight

The main effect of catch weight is related to their frequency distribution and to the use of containers: large catches are seldom seen, and the commonly used containers are of no help.

2.1.5 Landing Activity

A source of important errors is the simultaneous or grouped landing and/or sale of several boats. Errors and confusion can occur in these situations if the field recorder's work is not very rigorous and methodical, which is more easily said than done in real field conditions.

2.2 Result

2.2.1 Method of Analysis

From May to December 1987, length-frequency data were collected on a subsample of the 4-hr periods drawn for catch-and-effort estimation (see above). When all the fish of a species group or of a whole catch were measured, their weight could be estimated with a minor error from the corresponding length-weight relationships, and compared to the eye estimations independently obtained by the field recorder (who did not participate in biological sampling). 1,470 pairs of group weights, and 158 pairs of catch weights are thus available.

2.2.2 Analysis of Errors

The main results, pertaining to the three error components described above, and to the error as a whole, are summarized below:

- Total catch weight estimation: all the regressions between estimated and measured weights have slopes less than 1, but the interpretation, in terms of over or underestimation depends on the value of a. In all cases, a is positive, suggesting an overestimation of low weights and an underestimation of high ones, but the sampling variability of α actually precludes such a conclusion. Recorder and type-of-catch effects appear when regression slopes only are considered.
- Identification of groups: errors in reporting qualitative catch composition are quite frequent, much more so for the demersal multispecific catches (61% of the net catches contain at least one error) than for the pelagic catches (16%). Most often, for the demersal catches, the error is an omission, rather than an over-reporting and concerns 1 group only (in 69% of cases), which is among the least important in the catch (less than .5 Kg in 75 % of cases). Here too, the recorder effect is apparent, groups and species identification being obviously more difficult for one of them. For pelagic catches, about 25% of the errors come from confusion of two closely related groups, "tunas" and "bonitos".
- Proportions of groups: it appears that there is no important and significative error in individual group reporting, with the exception of the two above-mentioned pelagic groups. When related to the measured proportions, the absolute error shows no pattern for demersal catches (independence), and a negative trend for pelagic ones: on the average, recorders tend to reduce the range of real proportions of the pelagic catches, over-reporting low proportions and under-reporting high ones.
- Global error on group weights: the interpretation of regressions between estimated and measured weights is hindered by the same problem as for total catch weights; yet some conclusions can be drawn:

1. Pelagic weights are, as a whole (and with the possible exception of very low weights), subject to underestimation, with regression slopes being comprised between 0.69 and 0.81, according to the recorder.
2. For demersal catches, in most combinations of recorder and type of gear, the regression model suggests an overestimation of low weights and an under-estimation of high ones, the samples being approximately centered on the point of zero error. This interpretation is very sensitive to the value of a, which has a high sampling variability, owing to the dispersion of pairs. However, it can be assumed that the error on a computed average is likely to be small, since most weights are in the vicinity of the average zero-error point.

2.2.3 Correction of Errors

The correction model is appropriate for the case where the subsample of objective measurements is not randomly drawn within the original sample (Yates, 1960):

If x and X are the eye-estimated activities on the original sample and on the subsample, Y the measured activity on the subsample, b the slope of the regression of X on Y, n and N the sizes of the samples, and V_r the residual variance of the subsample regression of X on Y :

$$y = Y + (x - X) / b$$

$$var(y) = V_1 + V_2 + V_3 \text{ with:}$$

$$V_1 \approx (\underline{x} - \underline{X})\ \underline{var}(b) / b^4$$

$$V_2 \approx \underline{var}(x) / b^2$$

$$V_3 = (n-N)\ V_r(X) / b^2 nN$$

The correction model is not rigorously applicable here for various reasons; some approximations are necessary, and therefore only an order of magnitude of the variance can be obtained.

2.2.4 Cost and Feasibility

The advantage of the method is actually not to reduce costs, since this cost is due to the time spent on the site by the recorder, whatever method he uses, but to make possible in every case what would not have been so with other methods.

Visual estimation requires only that the recorder observe the whole catch during a minimum time, which can be as short as 30 seconds or one minute. This method is thus the least demanding of all catch data collection methods, most (if not all) the other ones requiring either some kind of self-reporting or the permission and time to handle the catch.

After exclusion of some 200 catch observations which the recorders themselves qualified as "not reliable," nearly 7,000 catches were observed (weight and group composition), most often visually, thus making possible a more detailed analysis of the fisheries, by gear, sector, time period, etc.

2.3 Discussion

As mentioned earlier, the visual estimation of catches kept the overall cost of data collection within reasonable limits. Given the practical difficulties of applying this approach, one could have expected much larger average errors.

The reliability of the method is influenced by several factors which act simultaneously, together with random error, leading to a wide dispersion of pairs, to a difficult interpretation of the results, and to some uncertainty about the error correction model.

Most of these problems could probably be overcome by more thorough and regular training of field recorders, in conditions as close as possible to the real field work. If this had been possible more than once in Martinique (at the beginning of the field phase), the magnitude of errors would certainly have been reduced.

CONCLUSION

The usefulness of fishery data collection by feasible and cheap indirect methods was obvious in the field program conducted in Martinique, where only very few samples could have been collected by direct methods and where enough data could be collected to allow the correction of induced biases in the indirect method.

More generally, their potential applicability in different situations is related to the answers to two main questions:

- What is the cost of their use, compared to that of other available methods, taking into account the multi-purpose nature of most data collection programs, i.e. the possible sharing of a common cost among several "sub-systems" simultaneously collecting different kinds of data?
- What statistical properties (precision, accuracy) are expected for the results, thus how much attention should be paid to the error correction model ? What nature and quantity of data should be collected to allow an "acceptable" bias correction and at what cost (remembering that, in any case, a rough estimation of the nature and magnitude of the biases should, at the very least, be obtained) ?

The reliability of these methods (and therefore the degree of necessity of a correction model) clearly proves to be tightly related to the selection and the training of field recorders.

The experience acquired during the field trials of these two methods in the conditions encountered in Martinique leads to the expectation that, in most situations, they could help by overcoming the problem of manpower shortage for artisanal fisheries studies or monitoring.

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