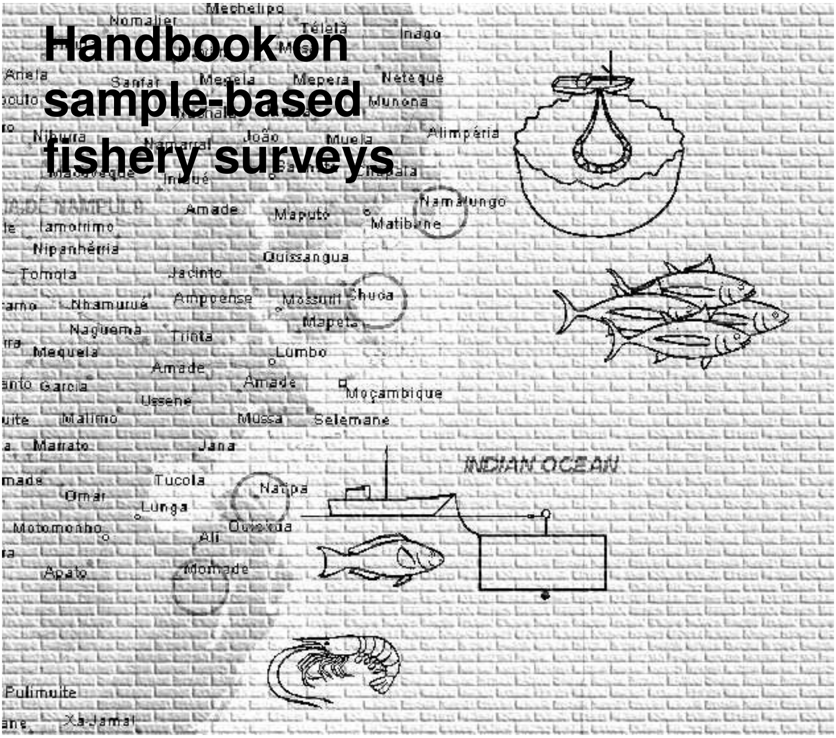
Handbook on sample-based fishery surveys



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1. Fishery statistics 2. Fishery surveys
3. Sampling 4. Training

Preface

Among the major tasks of the FAO is the promotion of improved approaches and techniques for the collection of data on agricultural statistics, including fisheries and forestry. The need for reliable and comprehensive statistics has never been more acutely felt than at present, when most countries are engaged in large-scale planning. Statistical programmes, however, require a great deal of effort and funds for their development and implementation and these are major constraints for many countries with limited human and financial resources. The merit of sampling approaches lies in providing a cost-effective and efficient method for the collection of data, thus accelerating the development of statistics urgently needed by fishery managers and planners.

Collection of basic data on catches, fishing effort and prices constitute a key factor in a wide variety of applications. Sample-based fishery surveys that are conducted on a regular basis are not an end in themselves but an important source of fishery information of wide utility and scope.

To help meet national needs for basic fishery data FAO has been assisting countries in upgrading their data collection, processing and reporting capabilities. Technical assistance at national and regional level is a significant component of the work programme of FAO’s technical units responsible for fishery statistical development and involves both normative and field programme activities. Outputs of normative activities include technical documents on statistical methodology and guidelines for data collection, while field programme activities involve project formulation and implementation, technical backstopping and organization of training courses and workshops.

The purpose of this publication is to summarize, in handbook form, experience gained over the recent years in fishery statistical development by the Fishery Information, Data and Statistics Unit (FIDI) of the FAO, and provide planners and users of fishery surveys with simple and step-by-step guidance for developing and implementing cost-effective and sustainable fishery surveys. The methodological and operational concepts discussed here apply equally to both marine and inland capture fisheries and are presented in a manner that is generic enough to make them adaptable in commonly used data collection systems.

Statistical aspects are presented in a descriptive rather than theoretical manner. Emphasis is placed on the understanding and interpretation of produced statistics and related indicators, rather than on the computations producing them. Readers interested in a more in-depth discussion on statistical and computing approaches, may make use of the list of references that is given at the end of the handbook.

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Contents

1. Introduction

In this section readers will be presented with some general aspects of sample-based fishery surveys with emphasis on:

(a) Basic fishery data.
(b) Justification for regular collection of basic fishery data.
(c) Scope and utility of basic fishery data.
(d) Need for fishery surveys to be cost-effective and sustainable.
(e) The key role of field and office staff for collecting, processing and disseminating basic fishery data and the resulting statistics.

1.1 Utility of basic fishery data

The definition of basic fishery data is rather empirical and based on the traditional method of setting-up general-purpose datasets that are subsequently used by a variety of application-specific systems.

In this handbook basic fishery data refer to catch, fishing effort, catch by species, first-sale prices (i.e. prices at landing), values, and fish size (in weight units).

It is axiomatic that a fishery statistical programme collecting basic fishery data should not be an end in itself. People involved in such programmes are sometimes challenged to provide a justification for regularly conducted (and thus costly) fishery surveys. From a long list of potential uses of basic fishery data, the following applications may be considered as representative:

1.1.1 Food Security

Food security is an over-riding concern for policy-makers, planners and administrators of natural living resources. In many communities, particularly in developing countries, fish is the major source of animal protein and people are dependent on fish as a food source.

Food balance sheets constitute a principal source of information for studies concerned with food security. Estimated total production of fish, combined with data on catch disposition, imports and exports, constitutes the basis for calculating per capita consumption of fish, which is subsequently used in the formulation of food balance sheets.

Basic data involved: Total catch, catch by species.

1.1.2 Fishing mortality

Effort is one of the variables used to estimate fishing mortality. Fishing mortality is a fundamental variable in stock assessment, representing the proportion of stock that is removed due to fishing. Effort is used in setting most fishing controls. Changes in total fishing effort may be an indication of stock status or fishing profitability.

Basic data involved: Fishing effort.

1.1.3 Fishing operations

Fishing operations indicators describe the composition of fishing fleets and fishing patterns and are the basis of most management decisions. They are important for monitoring compliance and in analyses involving fishing effort.

Basic data involved: Thematic maps of homeports and landing sites, numbers of fishing units by gear category, fishing effort by boat/gear category.

1.1.4 Gear selectivity

It is often useful to obtain data indicative of the species that are targeted by different boat/gear categories and/or fishing methods, together with other information relating to the size of the fish being caught. These datasets are used for a wide variety of in-time and in-space comparisons of gear selectivity indicators.

Basic data involved: Species composition, average weight of fish.

1.1.5 Abundance and exploitation

Catch-Per-Unit-Effort (CPUE) or catch rate is frequently the single most useful index for long-term monitoring of a fishery. It is often used as an index of stock abundance, where some relationship is assumed between the index and the stock size. It can also be used in monitoring economic efficiency. Catch rates by boat and gear categories, often combined with data on size at capture, permit a large number of analyses relating to gear selectivity and indices of exploitation.

Basic data involved: Catch by species, effort by boat/gear category.

1.1.6 Importance to national economy

For national and local policy-making and planning it is essential to describe the contribution of fisheries to the economy. Assessment of the economic contribution of fisheries needs to take into account several important variables and indicators, among which product prices and gross value of production.

Basic data involved: Total catch, catch by species, prices, values.

1.1.7 Fleet performance and profitability

Boat profitability is a vital micro-economic indicator of fishery performance since it provides a measure of economic sustainability of artisanal fleets. Prices at landing, combined with data on investment and operational costs can provide indices of fleet performance.

Basic data involved: Overall Catch-Per-Unit-Effort (CPUE), unit value (average price) of catch.

1.1.8 Socio-economic studies

Time series of fishing effort, catch and Catch-Per-Unit-Effort (CPUE) and prices are often used in socio-economic studies. Such data are indicative of declining or increasing trends of fisheries in districts and regions.

Basic data involved: Monthly data on catch, effort, CPUEs, prices and values.

1.2 Cost-effective fishery surveys

Regularly conducted fishery surveys are costly since they involve salaries and wages of field and office personnel, recurring field operations costs and other overhead and maintenance costs relating to office infrastructure and operations. In many developing countries these costs constitute a major constraint and it is thus important for fishery statistical programmes to be as effective as possible at lowest cost. Sample-based fishery surveys are cost-effective when:

(a) They are economical in data collection effort and produce reliable estimates.
(b) They make good use of existing human and financial resources involved in data collection and processing.
(c) They respond to users' needs in a timely and reliable manner.

1.3 Sustainable fishery surveys

Regularly conducted fishery surveys ought to be sustainable and supported by national staff on a continuing basis. A sample-based fishery survey is considered sustainable when:

(a) It has minimal or no dependence on external technical assistance.

(b) Its design is robust enough to permit its continuity when changes occur to the fisheries that are statistically monitored.
(c) Training of field and office staff is appropriate and regular so that data collection and processing/analysis are safeguarded against staff changes and turnover.

1.4 Role of field staff

The backbone of a fishery survey is the field team of data collectors and supervisors, as it is through these people that basic fishery data are collected and submitted to the fishery statistical units for further processing. The following points underline the important role of field staff involved in data collection:

1.4.1 Quality and utility of collected data

Quality and utility of produced statistics is a direct function of the effectiveness and timeliness of field operations involving data collectors and supervisors.

1.4.2 Training

Training of data collectors ought to take into consideration their capacity of carrying out their instructions.

1.4.3 Realistic survey design

A perfect survey design is worth very little if it cannot be interpreted into realistic work schedules and unambiguous and simple instructions for data collectors.

1.4.4 Mobility of data collectors and supervisors

Mobility of data collectors affects the quantity of collected data as well as their representativeness. Low mobility due to lack of transportation means reduces statistical coverage and increases the risks of biased data, since data collection is always conducted at the same few locations.

Mobility is also important for supervisory functions lack of which would leave data recorders on their own and without supervision and guidance.

1.4.5 Motivation

Data collectors and supervisors should be motivated for performing their work, and not only financially. They ought to have a precise idea as to the purpose and utility of their work and feel part of the statistics producers team.

1.4.6 Operational experience

Field staff should be given the opportunity to attend at workshops and training courses concerning operational aspects of data collection, since their operational experience would contribute positively in survey planning and revisions to survey design.

1.5 Role of office staff

It was stated earlier that the backbone of a fishery survey is the field team of data collectors and supervisors. However, without an appropriate statistical office infrastructure, primary data collected from the field are of little or no utility. The following points relating to the responsibilities and functions of office staff are worth considering:

1.5.1 Design and planning

Design and planning of fishery surveys, as well as co-ordination and monitoring of all of the field and office activities involved.

1.5.2 Monitoring

Organizing and reviewing primary data obtained from the field, including editing and data checking, and undertaking corrective actions where and when necessary.

1.5.3 Computer operations

Operating computer-based procedures for the effective storage of primary data, derivation of estimates and preparation of working documents, statistical bulletins and yearbooks.

1.5.4 Data dissemination

Dissemination of processed data and resulting fishery statistics for use by other national, regional and international user groups.

1.5.5 Essential points concerning office staff

(a) Sufficient and adequate computing capacity is essential for carrying out data processing, analysis and dissemination functions.
(b) Training in basic statistical analysis is essential for the preparation of statistical reports and the correct interpretation of statistical indicators and diagnostics.
(c) Robust and user-friendly computing tools and methods are essential for the routine processing, analysis and dissemination of fishery statistical data.

SUMMARY

In this introductory section readers have been introduced to:

(a) Importance and utility of basic fishery data such as catch, effort, prices and values and a list of commonly used applications that make use of such data.
(b) Need for sample-based fishery surveys to be cost-effective and sustainable and some criteria for evaluating them from these two standpoints.
(c) Key role of field staff in data collection operations and the also important role of office staff and equipment for the effective analysis and dissemination of fishery statistical data.

Readers that are in the process of implementing new fishery surveys for purposes of statistical monitoring may use this information to obtain a general idea of what is involved in terms of field and office infrastructure. Those that are already engaged in ongoing fisheries surveys may use this information as a checklist to ascertain their performance and identify their good or weak elements.

2. Concepts in estimating catch

In this section readers will be presented with a generic approach for estimating total catch from basic fishery data and within an estimating context of a geographical stratum, a reference period and a specific boat/gear category. Other secondary data such as catch by species, values and average fish size, will be estimated on the basis of the estimated total catch.

No complete enumeration (=census) approaches for determining total catch are discussed in this handbook. In most small-scale fisheries the amount of information regarding total landings, species composition, prices, etc., is so large that the use of census approaches is impractical and sampling techniques are almost invariably employed. Some exceptions occur in estimating total fishing effort and a detailed discussion on alternative approaches is given in Section 3.

2.1 A generic formula for estimating catch

The generic expression given below describes the relationship between *estimated* catch, *sample* CPUE and *estimated* effort.

Catch = CPUE x Effort

2.1.1 Catch (total)

Estimated total catch refers to all species taken together and is usually computed within the logical context of:

(a) A limited geographical area or stratum.
(b) A given reference period (i.e. a calendar month).

(c) A specific boat/gear category.

2.1.2 CPUE (sample, overall)

The sample Catch-Per-Unit-Effort (CPUE) is an *overall* average deriving from sampling and expressing how much fish (all species) is caught by a unit effort. Sampling context is the same as that for the estimated catch.

2.1.3 Effort

In this handbook and for statistical purposes only, estimated fishing effort is expressed uniformly in total number of boat-days within the same logical context used for total catch and overall CPUE.

In this section total fishing effort is assumed to be known. This will simplify the presentation of the generic approach for estimating total catch. Section 3 provides a detailed discussion on alternative approaches for estimating fishing effort.

2.2 Secondary estimates

2.2.1 Catch by species

Once the total catch has been estimated, species composition is computed by means of the following simple formula:

Species = **SP** x **Catch**

where:

(a) *Species catch* is the estimated catch for each species within the estimating context described earlier.

(b) *SP* is a fraction of the total catch corresponding to a species and is formulated from the proportion of a species found in the samples.
(c) *Catch* is the estimated total catch discussed earlier.

From catch by species and using the estimated effort, it is also possible to compute species-specific CPUEs.

2.2.2 Species value

Once the catch by species has been estimated, its value is computed by means of the following simple formula:

$$\text{Value} = \text{P} \times \text{Species}$$

where:

(a) *Species value* is calculated within the estimating context described earlier.
(b) *P* is the sample first-sale price of a landed species.
(c) *Species* is the estimated species catch discussed earlier.

2.2.3 Estimated total value of landings

It is computed within the estimating context by simply adding up all estimated values by species.

2.2.4 Average weight per species

In addition to catch by species and prices, sample surveys usually provide also data relating to fish size (in weight units) on a sub-sampling basis. When this information is available, it is possible to produce estimates of average fish size for certain species.

2.2.5 Numerical example

The following theoretical example uses the formulae given above and illustrates a stepwise process for deriving primary and secondary estimates.

For purposes of simplicity it involves only two species and the assumption that fishing effort is known.

A. Assumptions

(a) Estimating context: *Lake Volta, Area VII, February 2001, Gillnets*
(b) Estimated effort = 1,000 boat-days
(c) Sample overall CPUE = 10 kg/boat-day

Species 1

(d) Proportion of species 1 in samples: 60%
(e) Sample price of Species 1 = 5,000 Cedis/kg
(f) 1,000 fish found in sub-samples of 500 kg

Species 2

(g) Proportion of species 2 in samples: 40%
(h) Sample price of species 2 = 6,000 Cedis/kg
(i) 1,000 fish found in sub-samples of 800 kg

B. Estimations

Total catch

(j) Estimated total catch = 10,000 kg (from formula 2.1)

Species 1

(k) Catch of species 1 = 6,000 kg (from 2.2.1)
(l) CPUE=6 kg/boat-day (with an assumed effort of 1,000 boat-days)
(m) Value of species 1 = 30,000,000 Cedis (from 2.2.2)
(n) Average weight of Species 1 = 0.5 kg

Species 2

(o) Catch of species 2 = 4,000 kg (from 2.2.1)
(p) CPUE=4 kg/boat-day (with an assumed effort of 1,000 boat-days)
(q) Value of species 2 = 24,000,000 Cedis (from 2.2.2)
(r) Average weight of Species 2 = 0.8 kg

Total value

(s) Total value of landings = 54,000,000 Cedis

SUMMARY

At this point readers are familiar with the parameters involved in the estimation of total catch and other secondary basic fishery data. The following points have been emphasized:

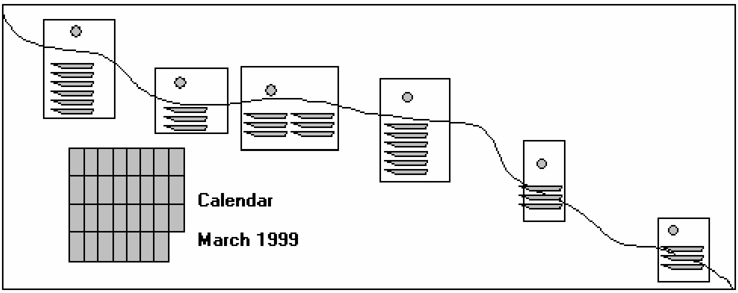
(a) All estimations are performed within a specific logical context of a stratum, a reference period and a boat/gear category.
(b) Within each context, estimates of total catch are derived from the sample overall CPUE and the estimated total effort.
(c) Catch by species is estimated on the basis of sample species proportions and the estimated total catch. Species values are estimated on the basis of sample prices and the estimated catch by species.
(d) Average weight per species is estimated on the basis of number of fish found in each species sample.
(e) Total values for landings are computed on the basis of estimated species values.

No mention has so far been made as to the mechanics for collecting the data required for formulating the above parameters. This is discussed in more detail in the coming sections that deal with the operational aspects of sample-based fishery surveys.

3. Concepts in estimating effort

In the example given earlier and in applying the generic approach for estimating total catch, it was assumed that the second fundamental parameter of the equation, the total fishing effort, was known. This is not the case in fishery surveys and, in fact, estimation of fishing effort is more of a task than that of estimating the overall CPUE. Below are some of the commonest scenarios for calculating fishing effort. Their applicability depends on local conditions as well as on the capacity of fisheries offices to conduct the required data collection operations.

3.1 Complete enumeration (census)



3.1.1 An illustrated example

The figure above illustrates the census approach for calculating fishing effort. Shaded fishing sites, boats and calendar days indicate that a complete enumeration is required in both space and time.

3.1.2 Type of survey

Complete enumeration of fishing effort implies that at the end of the reference period (i.e. a calendar month) the survey field teams have enumerated all fishing trips performed by all fishing units during that period.

3.1.3 Feasibility

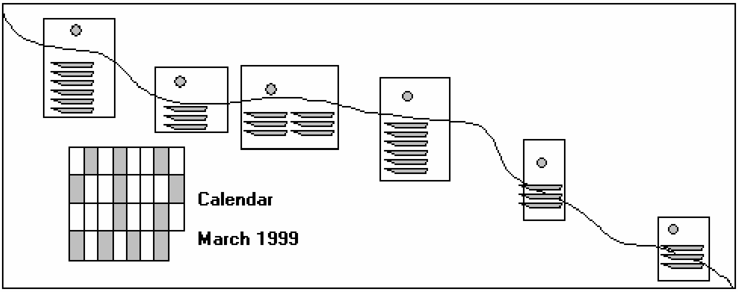
This approach is feasible when:

(a) Fishing units are concentrated on few locations.
(b) A mechanism is in place for obtaining exact records of all fishing units that are active (= fishing) on each and every day of the reference period (port authorities?, vessel operators?, sufficient number of recorders?, etc.).
(c) The census approach might be feasible for certain boat categories but impractical for others. In this case a “mixed” approach (census for some, sampling for others), would prove effective.

3.1.4 Evaluation of census approach

Concerning fishing effort, appropriately conducted census approaches are the most accurate as no sampling errors are involved.

3.2 Census in space, sampling in time



3.2.1 An illustrated example

In the figure above all elements that are related to space (fishing sites and boats) are shaded to indicate that they have been enumerated. Blank boxes in the calendar imply that recording was not performed on all days.

3.2.2 Type of approach

This approach is similar to that discussed earlier and almost as demanding in personnel, only that it is not conducted on a daily basis, thus achieving some reduction in data collection effort.

3.2.3 Estimation process

At the end of the month total fishing effort is estimated as:

$$\text{Effort} = \text{AverE} \times \text{A}$$

where:

(a) *AverE* is the average fishing effort in boat-days over the sample days.
(b) *A* is an extrapolating time factor expressing total number of days of fishing activities during the month.

3.2.4 Reliability of estimate

Reliability of the estimate for fishing effort depends on:

(a) The accuracy with which the mean effort AverE has been formulated.
(b) The correctness of the raising factor A.

3.2.5 Applicability

This approach is recommended when:

(a) The level of activity of fishing units is more or less regular during the month and AverE is robust enough to be considered as representative.
(b) The extrapolating factor A can be determined with a certain level of accuracy and by taking into account special conditions affecting *all fishing units*, such as bad weather, national and religious holidays, etc.

3.2.6 A numerical example

In January 2001 a complete enumeration of fishing effort at all locations was conducted on each of 10 pre-selected days excluding four Sundays (for which it was known that no fishing took place).

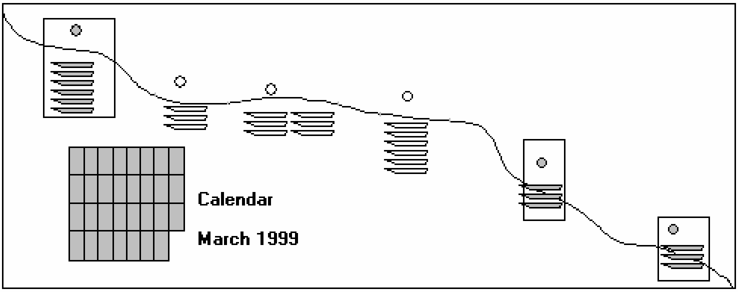
During the sampling period total fishing effort was found to be 10,000 boat-days. Thus AverE = 10,000/10 = 1,000 boat-days per calendar day.

The extrapolating factor A will be set as: 31 – 4 = 27 calendar days since no fishing took place on four Sundays.

Thus total fishing effort will be estimated as:

E = AverE x A = 1,000 x 27 = 27,000 boat-days.

3.3 Census in time, sampling in space



3.3.1 An illustrated example

This approach is illustrated in the figure above. Only few fishing sites are shaded as participating in the samples. On the other hand all days have been considered in sampling, as indicated in the shaded boxes in the calendar.

3.3.2 Type of approach

In this approach it is assumed that the fishing units are much dispersed over the statistical area and no mechanism exists for obtaining effort data from all homeports.

3.3.3 Staff time

It is also assumed that there is availability of staff time for daily collection of information from a number of sampling locations (for instance, data recorders resident at fishing sites).

3.3.4 Estimation process

At the end of the month total fishing effort is estimated as:

$$\text{Effort} = \text{AverF} \times \text{F}$$

where:

(c) *AverF* is the average fishing effort exerted by a single fishing unit during the month and is associated only to the sampling locations from which data have been collected.
(d) *F* is an extrapolating factor expressing the total number of fishing units that are *potentially operating* in the geographical stratum of the estimation context..

3.3.5 Reliability of estimate

The reliability of the estimate for fishing effort depends on:

(a) The accuracy with which the mean effort AverF has been formulated.
(b) The correctness of the raising factor F.

3.3.6 Applicability

This approach is recommended when:

(a) Monthly effort AverF of a single fishing unit operating from the sampled sites is also representative enough for the entire statistical area.
(b) The extrapolating factor F can be determined with a certain level of accuracy. This is usually obtained from a census that was once conducted at all sites and is conventionally called *frame survey*.

3.3.7 Evaluation of approach

In comparison to scenario 3.2 discussed earlier, this approach is less robust because of the raising factor F which is provided by a frame survey conducted, at best, on a yearly basis. Instead, the formerly examined time raising factor A is less “static” since it is formulated on a monthly basis.

3.3.8 A numerical example

A frame survey conducted in a statistical area in March 1998 reported the existence of F = 1,000 gillnet canoes operating from 20 homeports.

During January 2001 daily data collection operations took place in four pre-selected sites with the view of calculating total fishing effort related to 40 canoes operating from these sites.

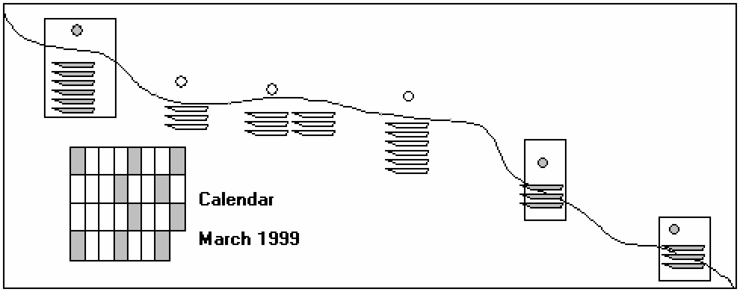
This was found to be 800 boat-days, meaning that the average effort of a single canoe during January 2001 was:

AverF = 800/40 = 20 boat-days.

Therefore, total fishing effort is estimated as:

E = AverF x F = 20 x 1,000 = 20,000 boat-days.

3.4 Sampling in space and in time



3.4.1 An illustrated example

This approach is illustrated by showing only the sites that participate in the sampling operations (shaded areas) and the sampling days (shaded boxes in the calendar).

3.4.2 Estimation

This is the commonest approach for estimating total fishing effort and is described by the following formula:

$$\text{Effort} = \text{BAC} \times \text{F} \times \text{A}$$

where:

(a) *BAC* is the *Boat Activity Coefficient*, expressing the probability that any boat (=fishing unit) will be active (=fishing) on any day during the month.

(b) *F* is an extrapolating factor expressing the total number of fishing units that are potentially operating in the geographical stratum of the estimation context (already discussed in 3.3).
(c) *A* is an extrapolating time factor expressing total number of days with fishing activities during the month (already discussed in 3.2).

3.4.3 A numerical example

The process of estimating total fishing effort from the above expression is best illustrated by a numerical example.

Assume that in the province of Fako in Cameroun and during April 2001 a fishing effort survey was conducted for *gillnets*. The last frame survey that was conducted in June 1999 had reported that in the province of Fako *there should be* 500 canoes of this boat/gear category, that is F=500.

A boat activity survey has revealed that in the province of Fako the probability of a gillnet canoe to be fishing on any given day during April 2001 was BAC=0.8 and that during April 2001 all days in the month ought to be considered without exception as days with fishing activities. In other words A=30 calendar days.

With this information available, fishing effort is computed as follows:

(a) If the probability of a single canoe to be active on any day is BAC=0.8, then BAC x F = 0.8 x 500 = 400 boats are expected to be active on any day.
(b) If 400 boats are expected to be active on any day then the expected boat-days over the month will be equal to: 400 x 30 = 12,000 boat-days, hence the estimated total fishing effort for the gillnetters in the province of Fako in April 2001.

3.4.4 Comparison to other approaches

(a) From the standpoint of survey cost this approach is the most economical since it requires that effort data are collected only from few locations and only during selected days.

(b) It is the least robust since it depends on the accuracy of three, rather than two, parameters, which are the Boat Activity Coefficient BAC, the total number of fishing units F and the time raising factor A.

SUMMARY

In this section the reader was presented with four different approaches that constitute alternative scenarios for the estimation of fishing effort. During the presentation the following points were underlined:

(a) When feasible the census approach is the most accurate in calculating total fishing effort (Approach 3.1)
(b) When sampling operations are unavoidable, the second best scenario is the one that uses sampling in time and census in space (Approach 3.2).
(c) Sampling in space and census in time (Approach 3.3) is inferior to (b) because of the need for accurate frame survey data.
(d) Approach 3.4 uses sampling operations in both space and time; it is the most economical in terms of data collection effort but it is also the least robust due to increased assumptions regarding the estimation parameters.

At this point the reader is familiar with the parameters and variables involved in the estimation of fishing effort and with the numerical approaches used in each case. No mention has so far been made as to the mechanics for collecting the data required for formulating the above effort parameters. This is discussed in more detail in the coming sections that deal with the operational aspects of sample-based fishery surveys.

4. General sampling considerations

In this section readers will be presented with some general aspects of sampling methods that place specific emphasis on the collection of basic fishery data. The following topics will be discussed:

(a) Reason for and objectives of sampling.
(b) The terms *accuracy* and *precision* used in sampling
(c) Reliability of estimates with varying sample size.
(d) *Safe* sample sizes for landing and effort surveys.
(e) Variability of data.
(f) Stratification and its impact on survey cost.
(g) Risks of biased estimates.
(h) The “boat” and “gear” statistical approaches.

4.1 Objectives of sampling

4.1.1 Operational shortcomings in census-based surveys

Census-based techniques are generally impractical in small-scale fisheries due to the large number of fishing operations that would have to be monitored over a reference period. The following example may help readers to obtain an idea of the logistics problems and costs involved in complete enumeration surveys in contrast to sample-based surveys.

4.1.2 Example of a census approach

Assume a fishery of moderate size comprising 1,000 fishing canoes. Assume also that on average each canoe goes out fishing 24 times during a month on a one-day-per-trip basis. This would mean that:

(a) There should be about 24,000 landings during the month and all landings would have to be recorded, each with its complete set of basic fishery data.

(b) There will be no need for a separate survey for fishing effort, since all trips will be recorded.
(c) Assuming that a single recording of a landing would take a minimum of ten minutes (experience shows that this is the case in many data collection systems), a total of 240,000 minutes, or a total of 4,000 hours will be needed.
(d) If a data collector works 8 hours per day for 25 days in a month, then collection of data would require: 4,000/8x25 = 20 data collectors, just to monitor this relatively small fishery.

To obtain a more complete picture of the costs involved, the following points should also be considered:

(e) Supervision costs.
(f) Data editing and checking for 24,000 landings per month.
(g) Data inputting for 24,000 landings per month.
(h) Data storage for 12 x 24,000 = 288,000 landings per year.

4.1.3 Merits of sampling

On the other hand a well-defined sampling scheme would most likely need only one or two recorders for data collection and only a fraction of the computer storage and processing resources, due to the much lower volume of incoming data.

4.1.4 Objectives of a sampling programme

It can thus be stated that the three objectives of a sampling programme are:

(a) Rather than completely enumerating a population of fishing operations, examine representative sub-sets of the population with the purpose of producing *estimates* of population parameters, such as CPUE, prices, etc.
(b) Significantly reduce operational costs.
(c) Significantly reduce computing requirements.

4.2 Accuracy and precision in sampling

In sampling procedures *accuracy* and *precision* are two different statistical indicators and it is perhaps worth clarifying their meaning at this point, as frequent reference will be made to these two terms in the coming sections.

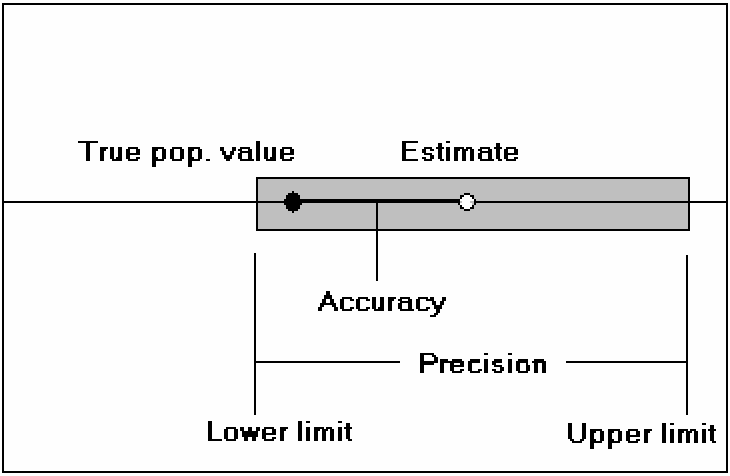
4.2.1 Accuracy in sampling

(a) It is usually expressed as a relative index in percentage form (i.e. between 0 and 100%).
(b) It indicates the *closeness* of a sample-based parameter estimator to the true population value.
(c) When expressed as a relative index, it is independent of the variability of the population. In other words, population parameters of high variability can still be estimated with good accuracy, which is in fact the primary issue in sampling.
(d) When sample size increases and samples are representative, sampling accuracy also increases. Its growth, very sharp in the region of small samples, becomes slower and steadier beyond a certain sample size.

4.2.2 Precision in sampling

(a) It is related to the variability of the samples used and measured, in reverse sense, by the *coefficient of variation* (CV), a relative index of variability that utilizes the sample variance and the sample mean.
(b) The CV index also determines the *confidence limits* of the estimates, that is the range of values that are expected to contain the true population values at a given probability.
(c) Estimates can be of high precision (that is with narrow confidence limits), but of low accuracy. This occurs when samples are not representative and the resulting estimates are systematically lower or higher than the true population value (cases of biased samples and estimates).

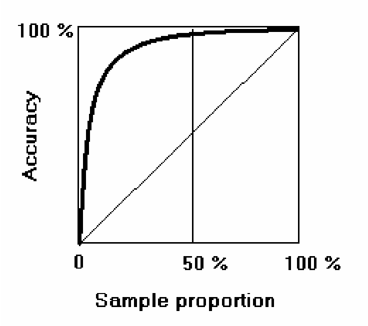
(d) When sample size increases the precision also increases as a result of decreasing variability. Its growth, very sharp in the region of small samples, becomes slower and steadier beyond a certain sample size.



4.2.3 An illustrated example of accuracy and precision

The figure above illustrates the meaning of accuracy and precision. They are both important statistical indicators and regularly used for assessing the effectiveness of sampling operations. Their correct interpretation can greatly assist in identifying problem areas and applying appropriate corrective actions where and when necessary.

4.3 Accuracy as a function of sample size



The above diagram illustrates the pattern of accuracy growth when sample size increases. It is worth noticing that:

(a) Accuracy is zero when no samples have been taken and 100% when the entire population has been examined (case of a census).
(b) The pattern of accuracy growth is not linear. The accuracy of a sample equal to half the population size is not 50% but very near 100%.
(c) Good accuracy levels can be achieved at relatively small sample sizes, provided that the samples are representative.
(d) Beyond a certain sample size the gains in accuracy are negligible, while sampling costs increase significantly.

4.4 *A priori* accuracy indicators

A frequent concern of fishery administrations in developing countries is limited budget and human resources for data collection. Such a constraint has direct impact on the frequency and extent of field operations for data collection and requires development of cost-effective sampling schemes.

4.4.1 Design phase of a survey: Facts and problems

(a) A frequent question concerns appropriate sample size guaranteeing an acceptable level of reliability for the estimated population parameters.
(b) Little is known about the distribution and variability of the target populations.
(c) Statistical developers tend to initially operate on a large-sample basis until some guiding statistical indicators become available.
(d) Lack of *a priori* guidance on sample size requirements tends to increase the size and complexity of field operations with direct impact on the logistics aspects of data collection and data management procedures.
(e) Formulation of *a priori* indicators for sampling accuracy during the design phase is feasible and is achieved by:

- ❑ Guessing the general shape of the distribution of the target populations.
- ❑ Setting-up accuracy indicators that are only a function of the population size.

4.4.2 Target populations

Based on earlier discussion on the generic catch formula and estimation of fishing effort (Sections 2 and 3), the two target populations in sample-based catch/effort surveys are:

(a) The set of landings by all boats over a month from which an overall CPUE has to be estimated.
(b) The set of 0-1 values (equivalent to "boat not fishing", "boat fishing") describing the activity status of all boats over a month.

Target population (b) is used to formulate the probability (BAC) that any boat would be fishing on any day. BAC will then be combined with the number of boats from a frame survey and a time extrapolating factor to formulate an estimate for fishing effort.

4.4.3 Sampling requirements

The above two populations have different sampling requirements for achieving the same level of accuracy. Next paragraph provides more details as to how sample size is determined in each case and in accordance with the level of accuracy desired.

4.5 Safe sample size for landings and effort

The question of determining the desired accuracy level in a sampling and estimation process depends on the subsequent use of statistics and the amount of error that users are willing to tolerate. Experience indicates that in basic fishery data the accuracy of estimates ought to be in the range 90% - 95%.

Last point of the previous paragraph concerned the different sampling requirements for the two target populations of landings and boat activities. The table below illustrates sample sizes required for achieving a given accuracy level for each target population.

Table 4.5. Sampling requirements at varying accuracy level – Large populations with size greater then 50,000.

Accuracy in %	Sample size for boat activities (boats sampled)	Sample size for Landing surveys (landings sampled)
90	96	32
91	119	40
92	150	50
93	196	65
94	267	89
95	384	128
96	600	200
97	1067	356
98	2401	800
99	9602	3201

<u>Conclusions on safe sample size</u>

From the table above the following conclusions can be made:

(a) Sample requirements for boat activities are about three times higher than those for landings.
(b) For instance for an accuracy level of 90% it is required that at the end of the month the following samples must be available:

- ❑ A minimum of 32 landing records
- ❑ A minimum of 96 boats interviewed for their state of activity

(c) The above sampling requirements refer only to a given estimating context, that is a geographical stratum, a reference period (i.e. calendar month), and a specific boat/gear category.
(d) The process of determining safe sample size at a given level of accuracy must be repeated for all estimating contexts with the view of determining overall sampling requirements.

4.6 Variability indicators

As already mentioned earlier, the second important statistical indicator is the one related to precision or, in reverse terms, to variability. The *Coefficient of Variation* (CV) is the most commonly used relative index of variability and has the following properties:

(a) It is expressed in percentage form (i.e. 10%, 15%, etc.).
(b) Experience indicates that CVs are indicators of acceptable variability in the samples when they are below 15%.
(c) Repeatedly reported low variability (for instance 0.1%, 0.5%), is rather suspicious. It may mean a very homogeneous population but it may also be an indication of biased samples.
(d) There are standard methods for explaining the overall variability in space and time. This is useful when it is feasible to upgrade sampling operations with the view of decreasing the variability of estimates. In such cases the availability of separate variability

indicators in space and time would direct sampling operations to collect data from more locations or on more days.

4.7 Stratification and its impact on survey cost

4.7.1 Definition

Stratification is the process of partitioning a target population into a number of more homogeneous sub-sets. Stratification is normally based on the following three criteria:

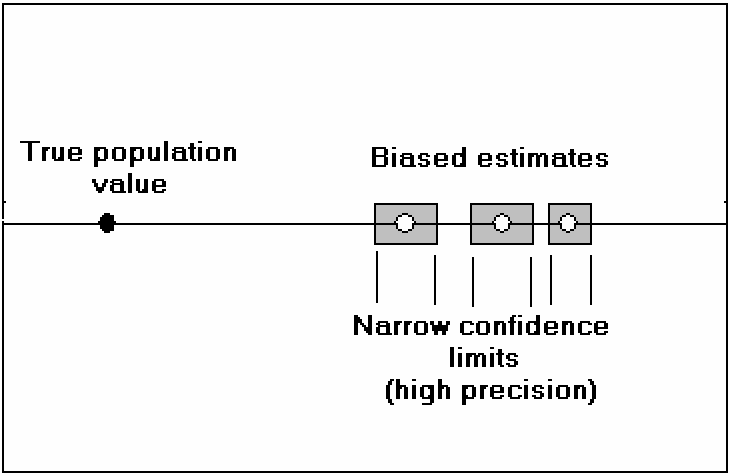
(a) For statistical purposes and when there is a need to reduce the overall variability of the estimates.
(b) For non-statistical purposes and when current estimates are not meaningful to users of the statistics.
(c) At times stratification is “forced” due to administrative needs in terms of data collection and reporting functions and responsibilities.

4.7.2 Impact on costs

Stratification is an expensive exercise and should always be applied with caution since all new strata would have to be covered by the sampling programme. Introducing a large number of strata may have serious cost implications for the following two reasons:

(a) Resulting strata will be more homogeneous than the original population, but the overall accuracy of the estimates will not be increased if data collection effort is kept at the original level.
(b) To fully benefit from a stratified population, safe sample sizes must be determined for each new stratum. In very large populations this would mean that a new set-up with three strata would need three times more samples for achieving the desired accuracy.

4.8 The problem of biased estimates



4.8.1 An illustrated example

In Section 4.6 dealing with variability indicators mention was made on biased estimates. The figure above illustrates in basic terms the problem of bias. To be noted that:

(a) All estimates are systematically found to the right or to the left of the true (but unknown) population value. Here all estimates are higher than the true value.
(b) Bias is independent of the precision (=variability) of the estimates. In this example accuracy is bad but precision is misleadingly good and this is indicated by the narrow confidence limits.

4.8.2 Bias as a major risk in sampling programmes

(a) Biased estimates are systematically lower or higher than the true population value and derive from samples that are not representative of the population.
(b) Users are unaware of such a situation since they do not know the true population value.
(c) Precision (or the relative variability indicator CV) cannot be used to detect bias.
(d) In general, bias is not easily detectable and at times it is not detectable at all.
(e) Bias can remain in the system even with drastic increases in sample size.
(f) Repeated cases of extremely small variability (<1% for instance), may be indications of a biased estimate.
(g) There exist no *a priori* indicators that could be used to safeguard sampling operations against systematic errors.
(h) Attempts to increase the representativeness of samples are often compromised due to operational constraints.

4.9 Need for representative samples

As already mentioned in earlier discussions the risks of biased data are considerably reduced if sampling operations collect data that are as representative as possible.

4.9.1 Data collection at sampling sites

Collection of representative samples at a sampling site is not a difficult task provided that data collectors are adequately trained and briefed. Points to be considered are:

<u>Effort data</u>

(a) Random selection of fishermen for information on activity status.

(b) Fishermen that are known to have been fishing should not be included in the sampling process.

<u>Landing data</u>

(a) When boats land within a short period, recorders at times tend to sample those with small catch in order to cover as many landings as possible. This introduces negative bias in the CPUEs and possibly in species composition.
(b) If landings occur over longer periods and recorders have to visit other sites during the day, only the first landings will be sampled. This may introduce bias in CPUEs, species composition and prices.

4.9.2 Selection of sampling sites

In the previous topic it was assumed that once a recorder has reached a sampling site he/she is capable of applying good sampling practices that were part of his/her training and brief.

In medium and large-scale fishery surveys the major problem in obtaining representative samples is associated with the first sampling stage that concerns *a priori* selection of locations at which data will be collected.

A good approach is to select sampling sites on a rotational basis. Field teams would then cover a good number of sampling locations by visiting all of them at least once during a month. Such a sampling scheme requires sufficient and mobile human resources for data collection as well as a certain amount of survey planning work at the beginning of each operational month.

In most cases and due to operational constraints (accessibility, availability of data collectors, limited mobility, etc.), the above approach is not feasible and data collection is performed at fixed locations that for long periods constitute the sampling sites of the survey.

The risk of biased samples is thus associated with limited geographical coverage and the fact that pre-selected homeports or landing sites are not representative of the entire statistical area.

4.9.3 Criteria for selecting sampling sites

Selection of fixed sampling sites is usually done on an *a priori* basis through the use of frame surveys and existing geographical information.

(a) The geographical location of homeports and landing sites indicates requirements for in-space statistical coverage.
(b) The numbers of boats (fishing units) by site and boat/gear type indicate the relative importance of sites in potential fishing effort terms (i.e. very important, important, less important, etc.).

Thus, the criteria in selecting sampling sites are:

(a) Sampling sites ought to provide a satisfactory geographical coverage of the statistical area. This is usually the major operational constraint due to limited human resources and/or transportation means.
(b) Sampling sites ought to be representative of all boat/gear types involved in the survey.
(c) Sampling should focus on sites with larger numbers of fishing units.

4.9.4 Utility of analytical tools

Selection of suitable sampling sites is a common problem in survey programmes and the reader may find topics of interest in the references of this handbook, particularly in the FAO field documents. It may also be noted that in most cases fishery statistical programmes operate with limited human and financial resources. Due to these constraints the application of analytical techniques for sampling optimization is not always feasible.

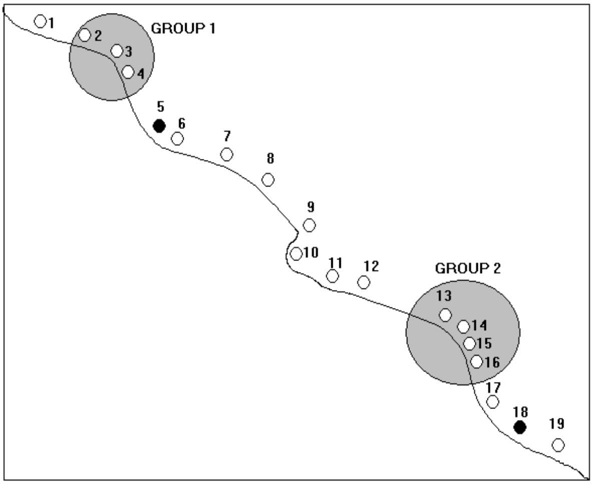
Instead, simple and practical methods may serve as guiding, rather than optimizing, tools and an example of such an approach is discussed in the coming topic.

4.9.5 Example

Rather than examining sites on an individual basis, planners may look at *groups of sites* that, due to their proximity can offer a better statistical coverage.

Criterion for grouping several sites together is:

- whether a recorder can visit all grouped locations within the daily sampling schedules.
- whether the group of sites contains fishing units from most or all boat/gear types and in large enough numbers.



The figure above illustrates a hypothetical example of a minor stratum with 19 homeports. Table 4.9.5 contains the results of a frame survey for gillnets, beach seines and castnets.

Table 4.9.5. Frame survey data

Site	Gillnets	Beach seines	Castnets
1	4	0	7
2	11	0	0
3	1	8	2
4	5	0	9
Group 2,3,4	**17**	**8**	**11**
5	**12**	**4**	**5**
6	3	0	0
7	2	1	3
8	2	2	0
9	4	1	0
10	5	3	6
11	4	3	0
12	3	2	4
13	1	0	9
14	0	0	7
15	8	3	6
16	7	4	3
Group 13,14,15, 16	**16**	**7**	**25**
17	6	0	0
18	**14**	**5**	**9**
19	5	0	7

On an individual basis, sites 5 and 18 are the most important sites since they contain the largest numbers of all boat/gear types. However, if secondary sites are looked as groups they can offer better statistical coverage, as indicated in Table 4.9.5. Thus, if planners consider the options of:

- Sampling from Sites 5 and 18, or
- Sampling from groups 1 and 2

the second option offers more statistical advantages both for in-space coverage and boat/gear representativeness.

4.10 The "boat" and "gear" approaches

4.10.1 Determining statistical units in sample-based surveys

A major aspect in sample-based fishery surveys is determining the fishing unit that will be the subject of sampling operations. In most cases the statistical unit is the fishing boat and data collection for effort and landings focuses on boats.

Generally, definition of the statistical unit depends on the level of detail required for formulating estimated population parameters and for calculating effort and catch totals. Much refined statistical units provide more precise indicators on catch rates and fishing activities but, on the other hand, are more difficult to manage and increase significantly data collection costs.

4.10.2 The "boat" approach

This is the commonest approach in sample-based fishery surveys and uses the fishing boat as statistical unit. Its main characteristics are:

(a) Frame surveys provide numbers of boats by boat/gear type as in-space extrapolating factors for estimating fishing effort.

(b) Fishing activity level is measured by the Boat Activity Coefficient (BAC) that expresses the probability that any boat will be active on any day.
(c) Catch Per Unit of Effort (CPUE) is expressed as the average catch per day of a boat of a certain boat/gear type.

4.10.3 The “gear” approach

This is another common approach in sample-based fishery surveys and uses the fishing gear as statistical unit. Examples of such units are:

(a) Numbers of 100-metre gillnet units.
(b) Numbers of 500-hook line units.
(c) Traps.
(d) Numbers of 100-metre beach seine units.

Its main characteristics are:

(e) Frame surveys provide numbers of gears by boat/gear type as in-space extrapolating factors for estimating fishing effort.
(f) Fishing activity level is measured by the Gear Activity Coefficient (GAC) that expresses the probability that any gear will be active on any day.
(g) Catch Per Unit of Effort (CPUE) is expressed as the average catch per day of a gear of a certain boat/gear type.

4.10.4 Comparison of the two approaches

Overall, the “boat-specific” approach is more advantageous than the “gear-specific” for the following reasons:

(a) Frame surveys for recording gear numbers are more complex and more demanding in staff time. They also tend to become less accurate with time since fishing gears change more frequently than fishing boats.

(b) The *relative* variability of “gear-specific” estimated parameters is, in general, not lower than that of the “boat-specific” ones.
(c) Gear activity level is far more difficult to measure.
(d) Estimates produced from the “gear-specific” approach cannot be easily integrated.

The major advantage of the “gear” approach is that it can better handle cases of multiple gears (whether in sequential or concurrent use).

SUMMARY

In this section readers have reviewed a number of general aspects of sampling methods with specific emphasis on the collection of basic fishery data. The following points have been discussed:

(a) Reason for and objectives of sampling: In small-scale fisheries and in contrast to census approaches, sampling techniques are more economical and can provide estimates of good reliability.
(b) The terms *accuracy* and *precision* used in sampling ought to be used in the appropriate context. Accuracy is a measure of closeness of an estimate to the true population value, while precision is related to its variability. They both are functions of sample size.
(c) *Safe* sample sizes can be set-up on an *a priori* basis and separately for landing and effort surveys.
(d) Interpretation of variability indicators. Variability explained in space and time.
(e) Stratification and its impact on survey cost.
(f) The problem of biased estimates.
(g) The problem of selecting representative sampling sites.
(h) Comparison of “boat-specific” and “gear-specific” statistical approaches.

5. Survey standards

Survey standards constitute the methodological and operational framework of a sample-based fishery survey. In this section, readers will be introduced to the following approaches that are normally used in setting-up survey standards:

(a) Stratification of the domain to be covered by the statistical programme, including:

- Administrative strata
- Logical strata (estimation contexts)
- Sampling locations (homeports and landing sites)

(b) Classifications:

- Boat/gear categories
- Species and species groups
- System units (i.e. weight, currency and effort units)

Well-defined survey standards help in streamlining field operations, producing consistent reports and integrating survey outputs with those resulting from other application domains. They also facilitate computerization of data and their dissemination.

Poorly defined standards have a negative effect on field operations and on the meaningfulness of produced estimates. They also create problems in the computer-related tasks relating to data organization, processing and analysis.

5.1 Stratification

5.1.1 The three basic stratification types

As already mentioned in Section 4, stratification methods are applied in cases of:

(a) Need for more homogeneous target populations, and lower variance in the estimates.
(b) Categorization of the population in order to respond to specific user needs.
(c) “Forced” stratification dictated by administrative, reporting, functional and other non-methodological criteria.

5.1.2 Major Strata

The first step is to divide the entire statistical area in administrative strata or strata for reporting purposes. These are conventionally called *major strata*. To be noted that:

(a) Major strata do not constitute estimation contexts.
(b) Totals at major stratum level are computed by adding up estimates produced at lower (minor) level.
(c) Definition of major strata is usually dictated by external factors and not by real statistical needs.

5.1.3 Minor strata

Within each major stratum there exist “logical strata” that constitute estimation contexts. This means that estimates will be resulting at that level. Conventionally, such sub-divisions are called *minor strata*. Regarding minor strata:

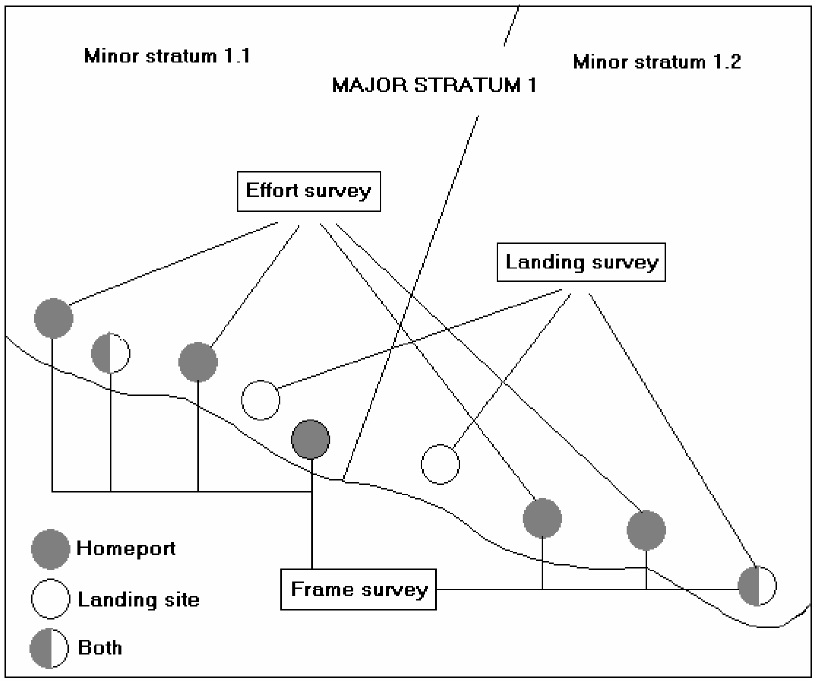
(a) A minor stratum in a major stratum cannot be associated to more major strata.

(b) Minor strata are not limited to geographical areas. They can refer to sub-periods within a month, to fishing grounds or, in general, to any logical estimation context.
(c) Minor strata are controlled by the survey designers. Their purpose is to improve the quality and utility of estimates.
(d) Excessive use of minor strata can compromise the cost-effectiveness of a sampling programme. Stratification is an expensive process and ought to be used with caution.
(e) An important fishing location can itself constitute a minor stratum, if estimates are required at that level.

5.1.4 Homeports and landing sites

(a) Homeports are locations from which fishing craft operate.
(b) Frame surveys that report numbers of fishing craft and gears always refer to homeports.
(c) In estimating fishing effort the homeport concept is used.
(d) Landing sites are locations at which boats land their catch. Landing surveys are conducted at landing sites.
(e) A landing site can also be a homeport.

5.1.5 A theoretical example of stratification



The figure above illustrates a theoretical stratification approach. To be noted that:

(a) Frame surveys are conducted at all homeports (shaded locations).
(b) Effort surveys are conducted at selected (sampling) homeports.
(c) Locations can be both homeports and landing sites (half-shaded).
(d) Landing surveys are conducted at selected (sampling) landing sites (white or half-shaded).
(e) Estimates are produced at minor stratum level.
(f) Totals for major strata are computed by combining the results produced at minor stratum level.

5.2 Classifications

5.2.1 Boat/gear categories

In defining boat/gear categories the following points are usually considered:

(a) Level of detail and degree of refinement. This depends on the feasibility of data collection operations in frame surveys and effort surveys.
(b) Uniformity: Landing surveys, frame surveys and effort surveys must all use the same boat/gear classification.
(c) Criteria for defining boat/gear types are usually based on assumed or known significant differences in:

- ❑ Species composition
- ❑ Species size
- ❑ Catch rates
- ❑ Fishing trip patterns
- ❑ Fishing methods

5.2.2 Species classifications

Criteria for defining species classifications are usually based on the need to priorize statistical monitoring of catches for:

(a) Commercially important species or species categories.
(b) Species that in certain areas are important to the local population.
(c) Species of biological interest.

5.2.3 Setting-up standard survey units

In view of data organization, processing and analysis needs, it is important that the measurement units involved in a sample-based survey dealing with basic fishery data, are consistent throughout the statistical programme. In this handbook the following units are considered:

(a) Weight units should be used consistently in all survey implementation components, except perhaps in those producing reports. For instance, if the agreed weight unit for recording landings is the kilogram, this unit should be used at all data collection sites, so as to avoid confusion and errors.
(b) Same concept applies to currencies.
(c) Effort: By definition effort units differ among the various boat/gear types and fishing methods. However, in fishery surveys dealing with basic data there is a need to easily integrate catch and effort estimates deriving from different boats and gears. For statistical purposes it is generally accepted that the *boat-day* is a reasonably good way of expressing fishing effort uniformly.

5.3 Validity of survey standards over time

5.3.1 Initial set-up

The need for well-defined survey standards has already been underlined in the introductory part of this section. Setting-up of survey standards during the survey design phase is, in general, a straightforward task.

5.3.2 Validity period

By definition, survey standards are defined on an *a priori* basis. Their purpose is to provide a methodological and operational survey framework that will be valid for a certain length of time. Survey standards are supposed to be valid for a complete operational cycle, usually a year, after which period they are reviewed.

5.3.3 Validity problems

Validity problems may occur after the first few months of survey implementation due to the following:

(a) Changes to stratification schemes.
(b) Changes to boat/gear and/or species classifications

Modifications and changes to the survey standards in the middle of an operational cycle are allowed if they do not affect the consistency of the survey framework. The table given below provides some indication regarding permissible changes and those that have implications in data consistency.

Table 5.3.3. Implications of survey standards changes to ongoing operations

Stratification		
Type of change	**Permissible**	**Consistency implications**
Addition of new major or minor strata	Yes	None
Addition of new homeports or landing sites	Yes	Frame survey adjusted
Changes in associations between minor strata and major strata	Yes	Reports at major stratum level to be re-produced
Changes in associations between sites and minor strata	No	Else primary data must be re-organized and estimates re-produced
Classifications		
Type of change	**Permissible**	**Consistency implications**
New species or name changes	Yes	None
New boat/gear types or name changes	Yes	Frame survey adjusted
More detailed or more grouped species level	No	Else data inputting and estimates re-done
More detailed or more grouped boat/gear level	No	Else frame survey re-structured Data inputting and estimates re-done

SUMMARY

In this section readers were presented with the concept of survey standards. Following are the major points discussed:

(a) Survey standards are the methodological and operational framework of a sample-based fishery survey. They basically involve:

- ❑ Stratification of the domain to be covered by the statistical programme, that is major strata, minor strata and sites.
- ❑ Classifications of boat/gear categories and species.
- ❑ System units (i.e. weight, currency and effort units)

(b) Well-defined survey standards help in streamlining field operations, producing consistent reports and integrating the survey outputs with those from other application domains. They also facilitate computerization of data and their dissemination.

(c) Poorly defined standards have a negative effect on field operations and on the meaningfulness of produced estimates. They also create problems in the computer-related tasks relating to data organization, processing and analysis.

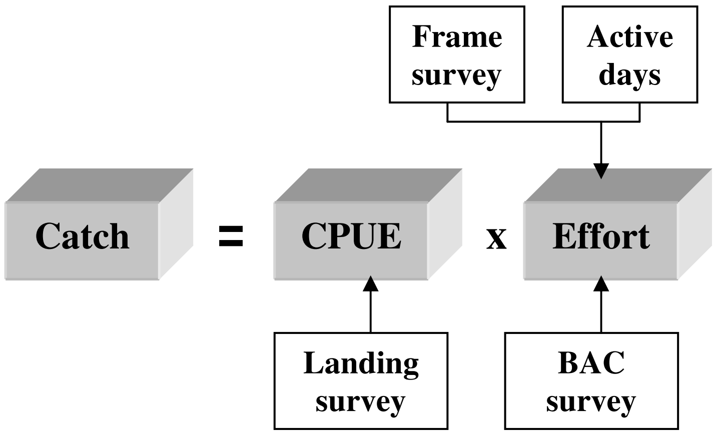
(d) Survey standards are defined on an *a priori* basis and are usually assumed to be valid for one year, after which period they are reviewed.

(e) Validity and consistency problems were summarized in Table 5.3.3.

6. Surveys for basic fishery data

In this section readers will be presented with supplementary guidelines relating to commonly used data collection systems dealing with basic fishery data. Specifically, the following topics will be re-addressed and supplemented:

(a) How approaches become more reliable (at a cost) by working on a generic survey design and removing survey components that are directly associated to assumptions and/or sampling errors.
(b) Brief description of each of the four generic surveys.



The diagram above recalls the generic expression for estimating total catch that was discussed in Section 2. It also indicates that for the formulation of its two parameters (CPUE and fishing effort), a maximum of four surveys are required, of which three are associated with fishing effort and one with the CPUE.

6.1 Sampling in space and in time

The same diagram corresponds to the most economical sampling approach outlined in Section 3.4 and consisting of the following four surveys:

<u>Fishing effort</u>

(a) A census-based frame survey providing the extrapolating factor F that expresses the total number of boats in an estimation context.
(b) A survey (or exercise) to determine a time raising factor A expressing number of days with fishing activities in the estimation context.
(c) A sample-based boat activity survey to determine the Boat Activity Coefficient (BAC) expressing the probability that any boat will be active on any given day in the estimation context.

<u>Overall CPUE</u>

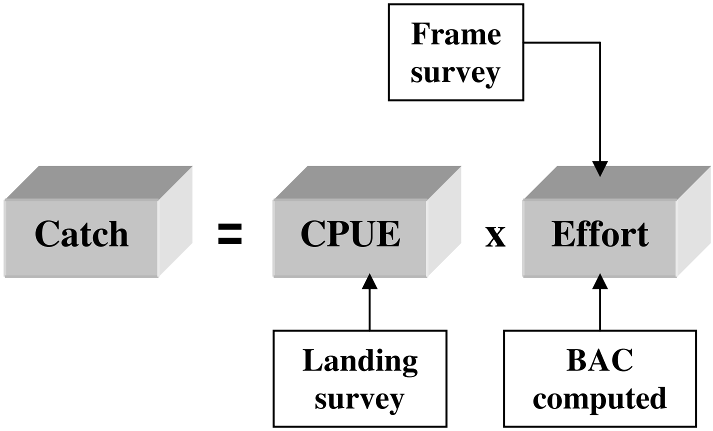
(d) A sample-based Landing survey to determine sample overall CPUEs, species composition, prices and average weight per species.

The generic formula for estimating catch is:

Catch = CPUE x [BAC x F x A], where:

CPUE is estimated from a Landing survey.
BAC is estimated from a Boat Activity survey.
F is provided by a frame survey.
A is determined from an Active Days survey.

6.2 Census in time and sampling in space



This approach was discussed in Section 3.3. The component related to Active Days (time raising factor A) has been removed. Its survey requirements are:

<u>Fishing effort</u>

(a) A census-based frame survey providing the extrapolating factor F that expresses the total number of boats in an estimation context.
(b) A census in time on *selected* sites to determine the total fishing effort and mean effort AverF. It is recalled that AverF expresses the average number of boat-days for a single boat.

Based on AverF, BAC is *computed* as AverF/NC where NC is the number of calendar days in a month.

<u>Overall CPUE</u>

(c) A sample-based Landing survey to determine sample overall CPUEs, species composition, prices and average weight per species.

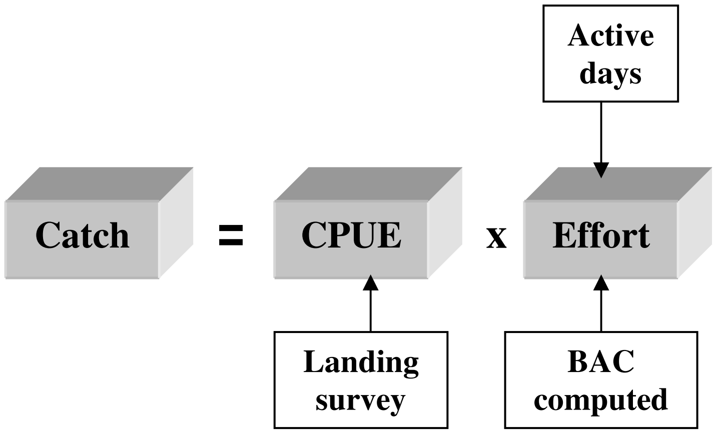
This approach is directly derived from the generic approach 6.1 by removing one of the survey components required, that is the time extrapolating factor A.

The formula for estimating catch remains:

Catch = CPUE x [BAC x F x A], where:

CPUE is estimated from a Landing survey.
BAC is computed as AverF/NC, with NC=number of calendar days.
F is provided by a frame survey.
A is set to NC.

6.3 Census in space and sampling in time



This approach was discussed in Section 3.2. The frame survey component has been removed. Its survey requirements are:

Fishing effort

(a) A survey at all homeports to determine the total fishing effort and average fishing effort per day AverE. Since all homeports are visited at least once during the month, the total number of boats F is known. BAC is computed as AverE/F.
(b) A survey (or exercise) to determine a time raising factor A expressing number of days with fishing activities in the estimation context.

Overall CPUE

(c) A sample-based Landing survey to determine sample overall CPUEs, species composition, prices and average weight per species.

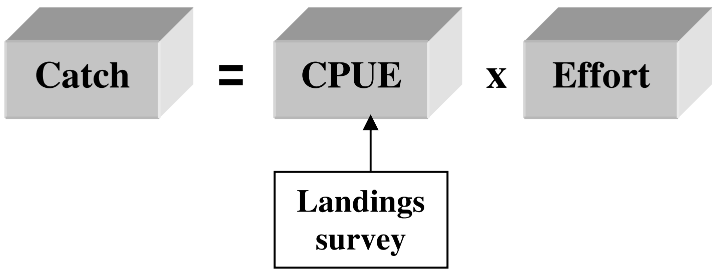
This approach is directly derived from the generic approach 6.1 by removing the frame survey component, as the total number of boats F is always known on a monthly basis.

The formula for estimating catch remains:

Catch = CPUE x [BAC x F x A], where:

CPUE is estimated from a Landing survey.
BAC is computed as AverE/F.
F is always known on a monthly basis.
A is determined from an Active Days survey.

6.4 Census for effort and sampling for landings



This approach was discussed in Section 3.1. Its survey requirements are:

Fishing Effort

A census conducted every day at all homeports to enumerate fishing effort expressed in total number of boat-days for an estimation context.

Overall CPUE

A sample-based Landing survey to determine sample overall CPUEs, species composition, prices and average weight per species.

This approach is directly derived from the generic formula 6.1 by removing all survey components relating to fishing effort, and catch is simply esimated as:

Catch = CPUE x Effort.

6.5 Brief discussion on the four generic surveys

From the presentations given above it may be concluded that in dealing with basic fishery data a maximum of four surveys are required and these are:

Fishing effort

(a) A *frame survey* providing the extrapolating factor F expressing the total number of boats in an estimation context.
(b) A survey (or exercise) to determine a time raising factor A expressing number of days with fishing activities in the estimation context. Conventionally this survey will be referred to as *Active Days* survey.

(c) A *Boat Activity* survey for formulating the Boat Activity Coefficient (BAC) expressing the probability that any boat will be active on any given day in the estimation context.

Overall CPUE

(d) A sample-based *Landing survey* to determine sample overall CPUEs, species composition, prices and average weight per species.

All four surveys mentioned here will be discussed in more detail in the coming sections. In the concluding paragraphs of this section readers will be provided with a general description of their methodological and operational aspects.

6.5.1 Frame survey

The objective of a frame survey is to provide total numbers of *potentially operating* fishing craft for each estimation context, which normally refers to a minor stratum, a calendar month and a boat/gear category.

Following are the basic characteristics of a frame survey:

(a) It must be conducted to cover all homeports.
(b) It is a census-based approach.
(c) In theory it should be conducted on a monthly basis.
(d) In practice it is conducted on a yearly basis, at best.
(e) Usually, it is part of larger data collection programmes that have a much wider data scope.
(f) It must provide total numbers of boats by homeport and by boat/gear category, in accordance to pre-set survey standards.
(g) Optionally, it can provide useful information to be used for planning field operations, such as periods of landings, standard days of little or no activity, sequential or concurrent use of gears, fishing grounds, etc.

6.5.2 Active Days survey

This is usually a study or exercise, rather than a survey, and is carried out at the end of the month, when all sampling has finished and estimates are about to be produced. It provides a time extrapolating factor for estimating total fishing effort. Following are its basic features:

(a) It greatly affects estimation of total fishing effort.
(b) It is formulated by using the calendar days of a month and subtracting days (or fractions of days) for which it is known or assumed that little or no fishing has taken place.
(c) It does not account for individual variability of boat activities (this is the role of BAC). It refers, in a uniform manner, to days for which there is no reason to assume that fishing activities are below normal level.
(d) Examples of days that may be considered as not active: Periods of bad weather, national or religious holidays, standard non-working days such as Fridays, Saturdays, Sundays, market days, etc.
(e) Active Days can be area-specific and boat/gear-specific and are formulated separately for each combination of minor stratum and boat/gear type. For instance, in the same area bad weather may affect boats fishing pelagic and not the beach seines. Or, bad weather may affect the gillnets in Area A but not those in Area B.
(f) Determining Active Days is simplified if sampling in time is frequent enough to cover 12-15 days of the month, so as to give the chance for days of low activity to enter the samples. In this manner the time extrapolating factor A will simply be set to the number of calendar days. This, however, will increase the variability of BACs.

6.5.3 Boat Activity survey

Objective of this sample-based survey is to formulate the Boat Activity Coefficient (BAC). Its basic features are:

(a) This survey is always conducted at homeports.
(b) The basic concept in determining BAC is examining a number of boats and finding out how many have been active on a given day.
(c) BAC accounts for the individual variability of boat activities.
(d) BAC is formulated separately for each boat/gear category and in accordance with survey standards.
(e) There are several alternative ways for determining BAC, the most common of which will be presented in the section specific to this type of sampling survey.

6.5.4 Objectives of Active Days and Boat Activity surveys

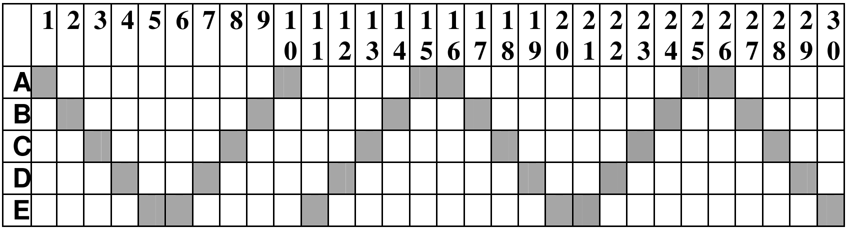
There is at times some confusion regarding the objectives of Active Days and Boat Activity surveys.

Boat Activity surveys examine the *individual level* of boat activities and aim at determining the probability that any boat of a specific boat/gear category will be active on any day.

Active Days, on the other hand, aim at determining a time raising factor expressing the number of days in a month that are *potentially* days of fishing, that is excluding days of no fishing in a uniform manner.

These concepts can be illustrated by the following two examples.

<u>Example 1</u>



The above diagram illustrates fishing activities in April 2000 of a hypothetical fishery of five boats A, B, C, D and E. Fishing is indicated by a shaded area, while non fishing by a blank.

The population-specific BAC is formulated by considering the entire dataset of boat status indicators and finding out how many elements represent boats fishing.

In this case it is evident that the population of boat status indicators consists of 5 x 30 = 150 elements, of which 30 represent fishing.

Thus BAC = 30/150 = 0.2, which is the probability that any boat will be fishing on any day.

The number of boats expected to be fishing on any day is 0.2 x 5 = 1, a fact that is immediately verified by consulting the diagram.

In this example all days in the month are *potentially* fishing days, that is there is no reason to assume that any day should be different from another in terms of activity level. Thus the time raising factor A is set to 30 and the resulting fishing effort in boat-days will be:

E = BAC x F x A = 0.2 x 5 x 30 = 30 boat-days, a result that can also be confirmed by the above diagram.

Example 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A																														
B																														
C																														
D																														
E																														

In this example days 1, 8, 18, 19 and 30 were non-fishing days due to bad weather.

Formulation of the population-specific BAC focuses only on days with fishing and has resulted in the same BAC as before, that is BAC=25/125=0.2.

In estimating total effort the time raising factor A is now set to A = 25, thus resulting E = 0.2 x 5 x 25 = 25 boat-days, a fact confirmed by the diagram above.

6.5.5 Landing survey

Objective of this sampling survey is to formulate the overall CPUE used in the generic formula for estimating total catch, and to provide secondary data regarding species composition, prices at landing and average weight by species. Its basic characteristics are:

(a) It is always conducted at landing sites.
(b) It may record landings of boats operating from a different location.
(c) It requires skilled staff for species identification and accurate recording of fish weights.
(d) Landings are reported separately for each boat/gear category and in accordance with survey standards.

SUMMARY

In this section readers were presented with topics that were in part discussed earlier. They were all relating to survey requirements in the most commonly used data collection systems for basic fishery data.

Specifically, the following topics were re-addressed and supplemented with new ideas and concepts:

(a) How surveys become more reliable (at a cost) by working on the same generic formula and replacing sampling components with census approaches.
(b) How to reduce risks of sampling errors.
(c) The following four generic surveys were outlined:

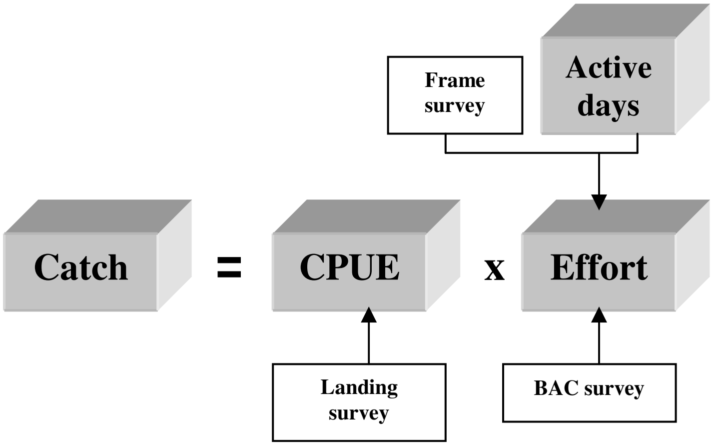
Fishing effort

- Frame survey
- Active Days survey
- Boat Activity survey

Overall CPUE and secondary landing data

- Landing survey

7. Active Days surveys



7.1 Objective

As already discussed earlier in 6.5.2 this is usually a study or exercise, rather than a survey, and is carried out at the end of the month, when all sampling has finished and estimates are about to be produced. Its objective is to determine a time extrapolating factor for estimating total fishing effort when data collection for fishing effort involves sampling in time.

It is worth repeating here its main methodological and operational aspects.

(a) It greatly affects estimation of total fishing effort.
(b) It is formulated by using the calendar days of a month and subtracting these days (or fractions of days) for which it is known or assumed that little or no fishing has taken place.
(c) It does not account for individual variability of boat activities (this is the role of BAC). It refers, in a uniform manner, to days for

which there is no reason to assume that fishing activities are below normal level.

(d) Examples of days that may be considered as not active: Periods of bad weather, national or religious holidays, standard non-working days such as Fridays, Saturdays, Sundays, market days, etc.

(e) Active Days can be area-specific and boat/gear-specific and are formulated separately for each combination of minor stratum and boat/gear type. For instance, in the same area bad weather may affect boats fishing pelagic and not the beach seines. Or, bad weather may affect the gillnets in Area A but not those in Area B.

(f) The problem of Active Days may be overcome if sampling in time is frequent enough to cover 12-15 days of the month, hoping that this will give the chance to days of low activity to enter the samples. In this case the time extrapolating factor A will simply be set to the number of calendar days.

7.2 Data recording

Estimation of fishing effort for June 2001 – Active Days			
Minor stratum	**Boat/gear type**	**Active Days**	**Remarks**
SW Coast	Gillnets	24	2 days of bad weather No fishing during 4 Sundays
	Beach seine	26	No fishing during 4 Sundays
	Hook and line	26	No fishing during 4 Sundays
	Traps	29	**2 half-days** of bad weather
	Shrimp trawlers	-	No such boats in stratum
NE Coast	Gillnets	26	No fishing during 4 Sundays
	Beach seine	30	All days potentially active
	Hook and line	-	No such boats in stratum
	Traps	-	No such boats in stratum
	Shrimp trawlers	30	All days potentially active

The above example illustrates a simple way of recording Active Days for each estimation context (minor stratum, month and boat/gear type). Each entry is the result of consultations and discussions regarding the validity of each raising factor. Such an exercise should take place at the end of each month, since Active Days do not remain constant over time. To be noted that:

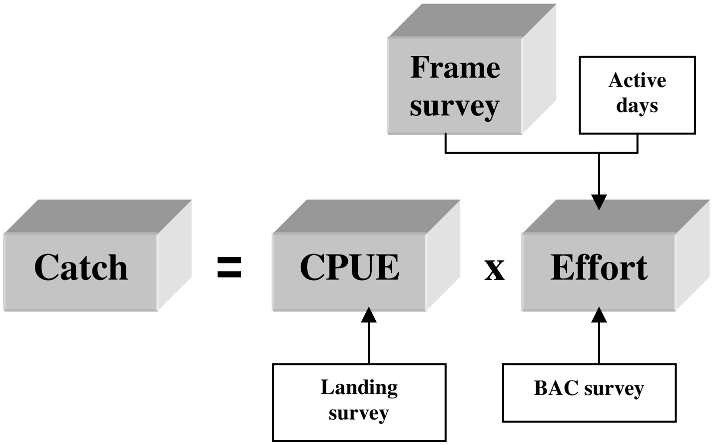
(a) Each raising factor is determined by removing from the number of calendar days (30 for June), the number of days with *uniform* inactivity.
(b) Active Days are boat/gear-specific and area-specific. Events affecting a stratum or a boat/gear category may not be affecting others.
(c) Days of non-activity should not be confused with individual boat activities that are the object of BAC. For instance, if it is known that, on average, boats with traps do not operate more than 15 days in a month, this does not imply that the raising factor should be 15, else fishing effort for that boat/gear would be grossly underestimated.
(d) It is possible that an event will affect only part of a fishery. For instance, bad weather may only affect half of the boats of a certain category. For the boats with traps in SW Coast bad weather affected only half of them, meaning that only one day (or two half days) were subtracted from 30. Such refinements are of course useful but not always feasible.

SUMMARY

In this section readers were presented with supplementary guidelines regarding the use of time raising factors known as Active Days. Points worth considering are:

(a) Active Days are important and greatly affect estimation of total fishing effort.
(b) Active Days express, in a uniform manner, periods during which fishing activities *potentially* occur. In contrast to Boat Activity surveys they do not account for trip variability of individual boats.
(c) Active Days are area- and boat/gear-specific.
(d) Active Days can simply be set to the number of calendar days in a month when sampling in time is frequent enough to cover both normal and exceptional (low or zero activity) events.

8. Frame surveys



This section completes the description of frame surveys. Readers will review aspects already discussed and also obtain supplementary guidelines. They will review the objectives of frame surveys and their main characteristics, and be presented with a number of new topics on survey preparation, implementation and application in the process of estimating fishing effort.

8.1 Objectives

A frame survey is a census-based data collection approach. It is designed and implemented with the primary objective of recording total numbers of *potentially operating* fishing craft to serve as raising factors in the process of estimating fishing effort.

Usually, frame surveys provide the opportunity for recording supplementary information useful for planning and implementation purposes, such as fishing trip patterns and seasonal use of fishing gear.

Following are the basic characteristics of a frame survey:

(h) It is conducted to cover all homeports.
(i) It is a census-based approach.
(j) In theory it should be conducted on a monthly basis.
(k) In practice it is conducted on a yearly basis, at best.
(l) Usually, it is part of larger data collection programmes with a much wider data scope.
(m) It must provide total numbers of boats by homeport and by boat/gear category, in accordance to pre-set survey standards.
(n) Optionally, it can provide useful information to be used for planning field operations, such as periods of landings, standard days of little or no activity, sequential or concurrent use of gears, fishing grounds, etc.

8.2 Sites and boat/gear classifications

Prior to implementing a frame survey users must decide on a general framework regarding homeports and boat/gear types to be covered. Therefore, a list of known homeports and a first attempt to set-up a standard boat/gear classification must precede data collection.

It is of course expected that during and after the implementation of a frame survey the following facts will be revealed:

(a) More homeports have resulted or some envisaged sites are no longer of relevance.
(b) More boat/gear types should be included into the general framework.
(c) More detailed or more grouped boat/gear types are required.

The immediate task after a frame survey has been completed is to finalize the list of homeports and boat/gear types in the survey standards. It is reminded here that fully harmonized lists of sites and boat/gear types are essential for the parallel use of survey data participating in the estimation of catch and effort, that is:

(a) Frame surveys.
(b) Boat Activity surveys.
(c) Active Days.
(d) Landing surveys.

8.3 Seasonal/sequential variation of fishing gear

8.3.1 Multiple gears used sequentially

In determining total numbers of fishing craft at a homeport, it is often observed that fishermen use one type of fishing gear during a season and a different one during another season. Generally, multiple use of fishing gear may not depend on the season but employed according to circumstances, that is one day fishing with gear A, next with gear B, etc., but not simultaneously.

Such use of multiple use of gear is conventionally described as *sequential* or *seasonal*, meaning that although the same fishing unit uses different gear types such use is strictly *not concurrent*.

8.3.2 Recording of boats with gears used sequentially

In such cases the boats ought to be recorded as many times as the number of the different gears used sequentially. This will not result in double counting because each estimation process operates within a fixed context of a minor stratum, a month and a specific boat/gear type.

8.3.3 Example

Assume that at a homeport there exist 20 boats operating gillnets and 10 that operate traps. Of the 20 gillnetters 5 also operate traps but never together with gillnets.

Recording of total number of boats at this homeport should thus be:

Number of boats operating gillnets:	20.
Number of boats operating traps:	10 + 5 = 15.

8.4 Concurrent use of fishing gear

Contrary to multiple gear used sequentially, there are boats that use two or more gears *simultaneously*. In such a case it is usually not possible to estimate the proportion of catch that has resulted from each gear separately, unless the different gears are targeting no overlapping species.

The problem of concurrent use of fishing gear cannot be solved statistically in a satisfactory manner. The following empirical methods are normally used:

(a) The predominant gear is the one to describe the boat/gear type (if such is the case).
(b) Setting-up a new boat/gear category describing the combined use of different gears (i.e. Gillnet+Hook & Line).
(c) Describing all boats with such use of gear as “other”.
(d) Training the data collectors to recognize and correctly record such combined boat/gear types.

8.5 Forms for data collection

There are several ways for recording frame survey data, depending on the data scope of the census. However, as far as numbers of boats are concerned, separate forms (one per homeport) are used containing the following information:

(a) Name of homeport.
(b) Date of recording.
(c) Name of data collector.
(d) As many records as the boats found at the homeport, with an indication of all gears used concurrently. For sequential use of gears boat records are repeated.
(e) Remarks concerning fishing trip patterns and other information useful in the subsequent planning of sampling operations.

The following model form may be used as an example:

Table 8.5. Example of a form for the recording of frame survey data

Statistical monitoring of small-scale marine fisheries - Frame survey					
Date: 05/03/2001 Homeport: Old Harbour (SW Coast) Recorder: John Ovusu					
Fishing Unit	Gillnet	Hook & Line	Traps	Castnet	________
A	X				
B	X				
C	X	X			
D	X	X			
E	X				
E			X		
E				X	
F	X				
F			X		
F				X	
G			X		
H			X		
I			X		
J				X	
K				X	
L				X	
M		X			
TOTALS Gillnet+ Hook & Line	4 2	1	5	5	
Remarks All boats except those using traps land between 08:00 and 11:00 Boats with traps land between 14:00 and 16:00					

In using the form given above the following points were considered:

(a) Boats C and D make concurrent use of gillnets and Hook & Line. It was decided to create a new boat/gear type describing this combined use of gear since such cases are common for several homeports. At the homeport of Tema there are 2 fishing units in this category.
(b) The total number of boats using gillnets will be 4 and not 6, since 2 units were already included in the combined boat/gear type. Likewise the Hook & Line boats will be 1 and not 3.
(c) Boats E and F were repeated to show sequential use of different gears. In total there are 5 boats using traps and 5 using castnet.
(d) Blank columns are reserved for unforeseen boat/gear types.
(e) Remarks were included indicating normal landing times.
(f) Forms can be configured to show only those boat/gear types that are relevant to minor or major strata, thus simplifying the use of forms by the data collectors.

8.6 Briefing of data collectors

Providing data collectors with precise and unambiguous instructions is fundamental for the reliability of the data obtained through frame surveys.

By definition frame surveys are census-based and demand a large number of data collectors. Often additional staff is employed on a temporary basis with the view of supplementing the activities of regular staff. Adequate training is important for they may not be much familiar with basic fisheries aspects.

The following points are worth considering in briefing data collectors:

(a) Explaining in full detail the recording forms, their use in data collection and their purpose and utility in the overall sampling programme.

(b) Clarifying the issues concerning boat/gear types, such as sequential and concurrent use, whether new boat/gear types are significant, others that could be ignored, etc.
(c) Planning with them the visits to homeports.
(d) Methods for approaching fishermen and village authorities in order to obtain complete and reliable information concerning numbers of boat/gear types operating from homeports.
(e) Ways for cross-checking the obtained information and course of action in cases of serious discrepancies.

8.7 Implementation aspects

8.7.1 Pilot phase

Frame surveys are census-based and therefore costly. It is always considered good practice to first implement them on a pilot scale with the view of identifying possible design and operational drawbacks and obtain indications regarding likely timeframes for full-scale operations.

8.7.2 Evaluation and revisions

The pilot results should be critically evaluated in consultation with all staff involved. Based on this feedback forms and classifications would be revised and fresh instructions issued to data collectors.

8.7.3 Testing the entire sampling programme

To be noted here that a pilot implementation of a frame survey (including revisions), ought to be combined with a pilot implementation of the entire sampling programme for catch/effort assessment. Such an exercise should operate for a period sufficiently long to allow for an overall programme evaluation and use of feedback information for programme revisions. Normally, pilot programmes of this type are in operation for 6-12 months.

8.8 Data transcription

Normally, results of frame surveys are summarized prior to their use in the estimation process for total fishing effort. The following table gives an example of such an approach:

Table 8.8. Frame survey summaries by homeport and boat/gear type.

Minor Stratum	Home port	GN	BS	HL	TP	GN + HL	TP + HL
SW Coast	Old Harbour	14	3	-	-	2	5
	Montagu	6	-	3	-	1	2
	Long Beach	10	-	4	-	-	3
	Pirates' Hide	5	2	6	-	-	5
	Fishbone	10	-	2	-	-	10
	West Arm	30	-	-	-	8	-
	Mousetrap	15	-	-	-	1	-
Sub-total		90	5	15	-	12	25
SE Coast	New Harbour	-	5	-	20	-	-
	Airport	-	10	-	10	-	-
	Blue Village	-	4	-	30	-	-
	Windy Beach	-	6	-	40	-	-
	White Sands	-	-	-	15	-	-
	Coral	-	-	-	5	-	-
	Paradise	-	-	-	25	-	-
	Cactus	-	-	-	5	-	-
	Joseph's Cave	-	-	-	30	-	-
Sub-total		-	25	-	180	-	-
TOTALS		90	30	15	180	12	25

To be noted that:

(a) The summary form contains all boat/gear types found in the entire statistical area (all strata).
(b) Each sub-total at minor stratum level provides the extrapolating factor F for estimating total fishing effort within the context of a minor stratum, a calendar month and a boat/gear type as already discussed in Sections 3.3 and 3.4.
(c) Frame survey results are “static”, that is they refer to the period when the frame survey was conducted.
(d) Frame survey summaries can easily be produced by using standard applications software such as electronic worksheets.
(e) Totals that refer to the entire statistical area are for information purposes only. They do not enter into the estimation process described in (b).

8.9 Summaries with grouped homeports

8.9.1 Including all homeports in frame survey summaries

In the example given in Table 8.8 all homeports that were covered by the frame survey have been included. In such a scheme, sampling operations for Boat Activities can be conducted at any homeport and at any given time. This is essential when the sampling scheme does not use pre-selected fixed homeports but keeps changing the sampling locations with the view of obtaining as representative data as possible.

8.9.2 Grouping of homeports

Sampling for Boat Activities is often conducted on fixed homeports that have been pre-selected and used as representative of a minor stratum. This is usually dictated by operational and logistics constraints. In such a case the example given in Table 8.8 can take a simplified form as follows:

Table 8.9. Frame survey summaries with grouped homeports.

Minor Stratum	Home port	GN	BS	HL	TP	GN + HL	TP + HL
SW Coast	Old Harbour	14	3	-	-	2	5
	Pirates' Hide	5	2	6	-	-	5
	UNSAMPLED	71	-	9	-	10	15
Sub-total		90	5	15	-	12	25
SE Coast	Airport	-	10	-	10	-	-
	Blue Village	-	4	-	30	-	-
	Windy Beach	-	6	-	40	-	-
	UNSAMPLED	-	5	-	100	-	-
Sub-total		-	25	-	180	-	-
TOTALS		90	30	15	180	12	25

The following assumptions have been made:

(a) Sampling sites are fixed. They include Old Harbour and Pirates' Cave for SW Coast and Airport, Blue Village and Windy Beach for SE Coast.
(b) In each minor stratum homeports that are not used in sampling are grouped under the name "UNSAMPLED" in a manner that sub-totals at minor stratum level are maintained.
(c) This approach is useful when there are long lists of homeports and only few are used for sampling on a fixed-site basis.

8.10 Absolute and relative accuracy

8.10.1 The static nature of frame survey data

It has already been stated that the weak element of frame surveys is that they provide "static" information that it is valid at the time the survey was conducted but may be losing some or much of its meaningfulness after a period of time.

This problem can be rather acute in cases of significant changes to the fisheries, such as increases or decreases of fishing craft, introduction of new fishing gear, etc.

In theory frame surveys ought to be conducted on a monthly basis so as to be synchronized with the regular sampling programme. In practice this is not feasible and frame surveys are at best conducted on a yearly basis.

For these reasons using frame survey data as extrapolating factors for estimating total fishing effort is always an unavoidable methodological risk. Under certain circumstances such risks can be reduced and in this section some guidelines are given in this respect.

8.10.2 Absolute accuracy of frame surveys

It is recalled here that the generic formula for estimating total fishing effort in a minor stratum is:

Effort = BAC x F x A

where BAC is the Boat Activity Coefficient, F the total number of boats in the minor stratum provided by a frame survey, and A is a time raising factor.

From the formula given above it is evident that when F is outdated and shows a number of boats that it is lower than actual, fishing effort will be underestimated, despite the accuracy with which BAC and A have been formulated.

Likewise if there has been a decrease in the number of boats since the last frame survey, total effort will be overestimated.

In general, the reliability of the effort estimate is a direct function of the *absolute accuracy* of the frame survey.

8.10.3 Relative accuracy of frame surveys

When the Boat Activity survey is conducted in such a manner that homeports are sampled with the same frequency, then the impact of outdated frame survey data is much reduced. This is best illustrated with a numerical example.

Assume a minor stratum with two sampling homeports A and B. Last frame survey has reported that:

1. Number of trawlers in homeport A: 10.
2. Number of trawlers in homeport B: 20.
3. Total number of trawlers in minor stratum: 300

BAC was formulated during three sampling days: 8, 13, 22 for homeport A and: 7, 11, 29 for homeport B. The method used was to observe *all* boats that have been active (=fishing) on the selected days and compare these numbers to those assumed by the frame survey.

Following is the summary of the results:

Table 8.10.3. Results of Boat Activity survey

Sampling days	7	8	11	13	22	29
Homeport A						
Frame data		10		10	10	
Active		7		3	5	
Homeport B						
Frame data	20		20			20
Active	4		6			20

Based on the total number of active boats and the number of boats assumed to be present at each site, the standard approach for formulating BAC is as follows:

BAC =[(7+3+5)+(4+6+20)] / [(10+10+10)+(20+20+20)] = 45/90 = 0.5.

However, by taking into account that data were collected during the same number of days, BAC can also be expressed as:

BAC = 45 / (3 x 30), where 30 is the number of boats in homeports A and B and 3 the number of days that observations were made.

Thus, fishing effort will be estimated as:

Effort = 45/3 x (F/30) x A = 45/3 x (300/30) x A.

In other words the reliability of the estimate now depends on the ratio 300/30. Compared to the absolute accuracy of F discussed earlier, this ratio expresses the *relative accuracy* of a frame survey, and is likely to be more resistant to overall increases or decreases in boat numbers.

To be noted again that in this approach:

(a) All active boats must be counted.
(b) Active boats must be compared to their total number assumed by the frame survey.
(c) Homeports must be visited with the same frequency (same number of days).

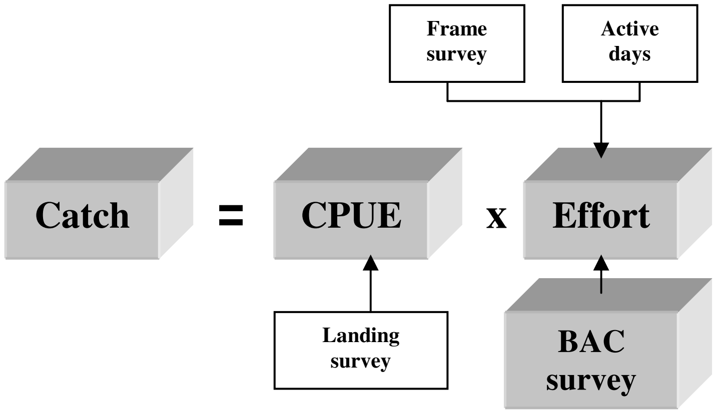
SUMMARY

In this section readers reviewed some aspects already discussed and have obtained supplementary guidelines with regards to frame surveys.

The following topics were presented:

(a) Objectives of frame surveys.
(b) Lists of homeports and boat/gear classifications.
(c) Methods for the recording of boats that use multiple gear.
(d) Examples of forms for the recording of primary data and for preparing frame survey summaries.
(e) Implementation aspects of frame surveys.
(f) Simplified frame survey summaries with grouped sites.
(g) Absolute and relative accuracy in frame surveys.

9. Boat Activity surveys



This section completes the description of surveys needed for estimating fishing effort. Sections 7 and 8 have provided guidelines on the preparation and use of Active Days and Frame surveys.

9.1 Objectives of Boat Activity surveys

9.1.1 Formulation of BAC

The primary objective of a Boat Activity survey is the formulation of Boat Activity Coefficients (BAC). It is reminded that BAC represents the probability that a fishing unit of a given boat/gear type will be active on any day during a month.

BACs are combined with extrapolating factors resulting from frame surveys and Active Days surveys for estimating total fishing effort within the context of a minor stratum, a month and a boat/gear category.

9.1.2 Outdated frame surveys and changes to the fisheries

Boat Activity surveys also serve for assessing (on a sample basis) the level of update of frame surveys, as well as for recognizing significant changes in the fisheries.

9.2 Target population

9.2.1 Activity status

The target population of a Boat Activity survey is the activity status of all operating boats on all days of a reference month. Conventionally, the activity status is set to one if a boat has been found fishing on a given day, or to zero if it has not.

9.2.2 Example of a population-specific BAC

In a minor stratum during April there exist 100 gillnets. Target population will consist of 100 x 30 = 3,000 status elements that are 0 or 1. If the number of “active” (=1) state indicators is 1,500, the population BAC will be computed as 1,500/3,000 = 0.5.

9.2.3 Sampling for BAC

The population BAC is estimated by sampling in space and time. There are several methods for formulating sample BACs, the most common of which will be discussed in the coming paragraphs.

Boat Activity surveys are independent of Landing surveys and may be conducted in a parallel manner using different sampling days and sites. It is recalled that Boat Activity surveys focus on homeports, while Landing surveys on landing sites. At times it is possible to combine the two types of data collection operations, thus facilitating field activities.

9.3 Sampling requirements

Table 9.3. BAC sampling requirements at varying accuracy level and population size

Accuracy (%) Population size	90	91	92	93	94	95	96	97	98	99
		Safe sample size for BACs								
300	73	85	100	119	141	168	200	234	267	291
400	77	91	109	132	160	196	240	291	343	384
500	81	96	115	141	174	217	273	340	414	475
600	83	99	120	148	185	234	300	384	480	565
700	84	101	124	153	193	248	323	423	542	652
800	86	103	126	157	200	260	343	457	600	738
900	87	105	129	161	206	269	360	488	655	823
1000	88	106	130	164	211	278	375	516	706	906
2000	92	112	140	179	235	322	462	696	1091	1655
3000	93	114	143	184	245	341	500	787	1334	2286
4000	94	115	145	187	250	350	522	842	1500	2824
5000	94	116	146	189	253	357	536	879	1622	3288
6000	95	116	146	190	255	361	546	906	1715	3693
7000	95	117	147	191	257	364	553	926	1788	4049
8000	95	117	147	191	258	367	558	942	1847	4364
9000	95	117	148	192	259	368	563	954	1895	4646
10000	95	117	148	192	260	370	566	964	1936	4899
15000	95	118	149	193	262	375	577	996	2070	5855
20000	96	118	149	194	263	377	583	1013	2144	6488
25000	96	118	149	194	264	378	586	1023	2191	6939
30000	96	118	149	195	264	379	588	1030	2223	7275
35000	96	118	149	195	265	380	590	1036	2247	7536
40000	96	118	150	195	265	381	591	1039	2265	7745
45000	96	118	150	195	265	381	592	1042	2279	7915
50000	96	118	150	195	265	381	593	1045	2291	8057
> 50000	96	119	150	196	267	384	600	1067	2401	9602

9.3.1 Safe sample size for BAC

The above table indicates recommended sample sizes for estimating BAC at a desired level of accuracy. It is recalled that in sample-based surveys for basic fishery data the minimum accuracy level of an estimate is empirically set to 90%.

Safe sample sizes are a function of the population size but for populations with more than 50,000 elements their differences are practically negligible.

9.3.2 Interpretation of safe sample size

Sample sizes are interpreted as follows:

(a) In the example given in 9.2.2 the population BAC was 0.5. The population size is 3,000 and related safe sample sizes are indicated in the corresponding line.
(b) Assuming a desired accuracy level of 95%, then at the end of the month 341 boats ought to be examined for activity status.
(c) Using 341 samples of examined boats, the sample BAC would be formulated by finding the number of boats that were marked as active (=1) and dividing it by 341.
(d) The safe sample size of 341 corresponding to an accuracy level of 95% will assure that, at worst, the resulting BAC estimates would be as high as 0.55 or as low as 0.45.
(e) Assuming that sampling occurs during 10 days then about 35 boats should be examined on each sampling day in the minor stratum.
(f) By lowering the level of accuracy to 90% the corresponding sample size becomes 93. At worst the population BAC would be then estimated as 0.4 or 0.6. Working with 10 sampling days would mean that about 10 boats should be examined on each sampling day in the minor stratum.

9.4 BACs relying on frame surveys

9.4.1 Type of approach

This is a commonly used approach for formulating BACs. On each sampling day data collectors visit a number of pre-selected homeports and record the *total number* of boats that were found active at these sites. This number is then divided by the total number of boats indicated by the frame survey.

9.4.2 Absolute accuracy of frame survey

Table 9.4.2. Results of Boat Activity survey

Sampling days	7	8	11	13	29
Homeport A					
Frame data		10		10	
Active		7		3	
Homeport B					
Frame data	20		20		20
Active	4		6		20

Assume a minor stratum with two sampling homeports A and B. Last frame survey has reported that:

1. Number of trawlers in homeport A: 10.
2. Number of trawlers in homeport B: 20.
3. Total number of trawlers in minor stratum F: 300

Based on the total number of active boats and the number of boats assumed to be present at each site, the standard approach for formulating BAC is as follows:

BAC =[(7+3)+(4+6+20)] / [(10+10)+(20+20+20)] = 40/80 = 0.5.

Assuming also an extrapolating time factor A=30, total fishing effort is estimated as:

Effort (for trawlers) = BAC x F x A = 0.5 x 300 x 30 = 4,500 boat-days.

Generally, the weakest parameter in the estimation of effort is the extrapolating factor F, since it has been provided by a frame survey that may be outdated.

In this example the reliability of the estimated effort depends on the absolute accuracy of the frame survey, that is the accuracy of extrapolating factor F. To be noted that boat activities were sampled on *an unequal* number of sampling days.

9.4.3 Relative accuracy of frame surveys

Table 9.4.3. Results of Boat Activity survey

Sampling days	7	8	11	13	22	29
Homeport A						
Frame data		10		10	10	
Active		7		3	5	
Homeport B						
Frame data	20		20			20
Active	4		6			20

In this example homeports A and B were visited the same number of times, three days each.

BAC is formulated as follows:

BAC =[(7+3+5)+(4+6+20)] / [(10+10+10)+(20+20+20)] = 45/90 = 0.5.

By taking into account that data were collected during the same number of days, BAC can also be expressed as:

BAC = 45 / (3 x 30), where 30 is the number of boats in homeports A and B and 3 the number of days that observations were made.

Thus, fishing effort will be estimated as:

Effort (for trawlers) = BAC x F x A = 45/3 x (300/30) x 30 = 4,500 boat-days.

The reliability of the estimate now depends on the ratio 300/30. Compared to the absolute accuracy of F discussed earlier, this ratio expresses the *relative accuracy* of a frame survey, and is likely to be more resistant to overall increases or decreases in boat numbers that might have occurred in the minor stratum.

9.4.4 Characteristics of the approach

(d) All active boats must be identified at a sampling site on a sampling day.
(e) Active boats must be compared to their total number assumed by the frame survey.
(f) Risks of outdated extrapolating factors F are reduced if sampling has occurred on the *same* number of sampling days for all sampling sites. Note that sampling should take place with the same frequency but not necessarily on exactly the same days.
(g) For large homeports this approach may prove impractical due to the large number of operating boats.
(h) Expected minimum accuracy is known by examining the actual sample size used. This is simply the denominator of the BAC fraction.

9.4.5 Data collection forms

Following is an example of a data collection form for this approach. It can be used for data recording purposes and also as effort inputting document in computer operations.

Boat Activity Survey		**Stratum: SW Coast Homeport: Channel**		**Recorder: Samuelson**	
Active boats					
Frame: **Day**	**Trawlers** **10**	**Gillnets** **30**	**Beach seines** **9**	**Castnets** **12**	**Traps** **11**
1					
2					
3					
4	**5**	**12**	**3**	**1**	**4**
5					
6					
7					
8	**4**	**14**	**2**	**5**	**2**
9					
10					
11					
12					
13					
14	**6**	**20**	**3**	**4**	**7**
15					
16					
17					
18					
19					
20	**5**	**9**	**3**	**5**	**6**
21					
22					
23					
24					
25	**1**	**5**	**0**	**2**	**3**
26					
27					
28					
29	**7**	**18**	**4**	**6**	**8**
30					
31					

9.5 Sampling for boat activities

In this approach no use is made of frame survey information regarding formulation of BACs. These are calculated on the basis of representative samples of boats that are interviewed to determine their state of activity on a sampling day. Frame survey data are only used as extrapolating factors.

Boat Activity Survey		Stratum: SW Coast Homeport: Channel		Recorder: Samuelson	
Active boats					
Day	Trawlers	Gillnets	Beach seines	Castnets	Traps
1					
2					
3					
4	5/8	12/19	3/6	1/4	4/8
5					
6					
7					
8	4/9	14/22	2/5	5/8	2/6
9					
10					
11					
12					
13					
14	6/9	20/24	3/5	4/9	7/11
15					
16					
17					
18					
19					
20	5/12	9/16	3/8	5/6	6/13
21					
22					
23					
24					
25	1/3	5/12	0/5	2/5	3/8
26					
27					
28					
29	7/15	18/19	4/9	6/12	8/10
30					
31					

9.5.1 Formulation of BAC

In this type of approach data recorders must indicate the number of boats that were found active out of a number of boats that were sampled. For instance, 5/8 for trawlers means that 8 fishermen were asked and 5 answered that they were fishing, while three specified that they were not. The BAC for trawlers is:

BAC = (5 + 4 + 6 + 5 + 1 + 7) / (8 + 9 + 9 + 12 + 3 + 15) = 28/56 = 0.5

9.5.2 Characteristics of the approach

(a) It is recommended for large ports, when it is difficult for the recorders to identify all boats that were active.
(b) It is recommended in cases of frequent migration of fishermen from one place to another.
(c) Boats should be sampled without prior knowledge on their activity. It would be wrong to approach fishermen that are known to have been fishing on the sampling day, since they would all be found active.
(d) When feasible, good practice is to pre-select boats or fishermen prior to visiting a site and then track down the activities of the pre-selected fishing units or fishermen.
(e) The data collection form given above can be used for data recording purposes and also as effort inputting document in computer operations.

9.6 Combination with Landing surveys

In 9.2.3 it was mentioned that Boat Activity surveys are independent of Landing surveys and may be conducted in a parallel using different sampling days and sites. It is recalled that Boat Activity surveys focus on homeports, while Landing surveys on landing sites. At times it is convenient to combine the two types of data collection operations in order to facilitate field activities.

9.6.1 Example

Landings form

Date:	**17/03/2001**
Stratum:	**SW Coast**
Site:	**Channel**
Boat/gear:	**Gillnets**
Recorder:	**John Silver**

Boat Activities (0 or 1)

Day -3	Day -2	Day –1
0	1	1

Effort parameters

Species composition

In the example given above the form used for the recording of landings is also used to capture boat activity data.

Landings of a boat were sampled on 17 March 2001. The fisherman was also asked to specify whether he went out fishing the day before, the day before yesterday and one more day back. This was indicated by a 0 or 1 in the boxes printed to the right part of the form.

The following three assumptions have been made:

(a) The fisherman remembers his activities over the last three days.
(b) The same gear was used (in theory this is not essential but data recording and transcription would become too complex).
(c) His homeport is also the landing site (again, to avoid complex data transcription).

9.6.2 Characteristics of the approach

(a) It usually applies to boats that operate on a “one-trip-per-day” basis.
(b) Current day should not be included since all fishermen will specify “YES-fishing” for that day.
(c) It is convenient. It combines sampling for landings with sampling for boat activities.
(d) It can provide good time coverage for effort. If the Landing survey is conducted 10 times during a month, this approach will cover 30 days (three days per sampling day for landings).
(e) It requires that the 0-1 answers are further elaborated and then transcribed in order to produce an inputting form similar to that provided in 9.5.

9.7 Briefing of data collectors

Providing data collectors with precise and unambiguous instructions is fundamental for the reliability of the data obtained through Boat Activity surveys.

The following points are worth considering in briefing data collectors:

(f) Explaining in full detail the recording forms, their use in data collection and their purpose and utility in the overall sampling programme.
(g) Clarifying the issues concerning boat/gear types, such as sequential and concurrent use.
(h) Planning with them the visits to homeports.
(i) Methods for approaching fishermen and village authorities in order to obtain complete and reliable information.
(j) Ways for cross-checking the obtained information and course of action in cases of serious discrepancies.

9.8 Implementation aspects

9.8.1 Pilot phase

Boat Activity surveys require representative samples and good timing at visiting homeports. It is always considered good practice to first implement them on a pilot scale with the view of identifying possible design and operational drawbacks and obtain indications regarding likely timeframes of full scale operations.

9.8.2 Evaluation and revisions

The pilot results should be critically evaluated in consultation with all staff involved. Based on this feedback forms and classifications would be revised and fresh instructions issued to data collectors.

9.8.3 Testing the entire sampling programme

To be noted here that a pilot implementation of Boat Activity surveys (including revisions), ought to be combined with a pilot implementation of the entire sampling programme for catch/effort assessment. Such an exercise should operate for a period sufficiently long to allow for an overall programme evaluation and use of feedback information in programme revisions. Normally, pilot programmes of this type are in operation for 6-12 months.

9.9 Frequent problems

9.9.1 Timing of field activities.

(a) Depends on the type of approach.
(b) When BACs are based on frame survey data a quick way of finding out active boats is to visit a homeport before boats have started landing and count the boats that are present. The difference (frame boats) – (boats present) will provide an indication of “boats active”.
(c) When pre-selected boats or fishermen are used for sampling it would be better to visit homeports when most boats have returned.
(d) When pre-selected boats or fishermen are used for sampling and trips are longer than one day, some boats may not be possible to trace. Information may be obtained from other fishermen.

9.9.2 Multiple use of fishing gear

BACs must be formulated according to survey standards and for each boat/gear element of the related classification. A frequent problem is that of boats operating different gears. Variation of fishing gear might be sequential or concurrent. Sections 8.3 and 8.4 provide some guidelines on these aspects.

9.9.3 Migration of fishing units.

(a) Migration of fishing units distort the presence of boats at homeports and for this reason the sampling approach ought to be used for formulating BACs (see topics 9.4 and 9.5 discussed earlier).
(b) If migration occurs within a minor stratum there will be no implications in the estimation of total fishing effort within that context.
(c) If migration occurs across strata then for some strata effort will be under-estimated while in others will be over-estimated.
(d) If migration is seasonal and could be anticipated to some degree of expectancy, frame surveys ought to reflect such boat movements.

9.9.4 Outdated frame surveys

(a) Sampling at homeports for BACs should take place on an equal number of days, so as to rely on the relative rather than the absolute accuracy of frame surveys (see topics 9.4.2 and 9.4.3 on this aspect).
(b) If no significant migration of boats has occurred and sampled homeports show a consistent increase or decrease of boats not accounted by frame survey information, this might indicate that overall increases or decreases have occurred to the fishery and a new frame survey should be implemented, or its present contents adjusted to reflect such changes.

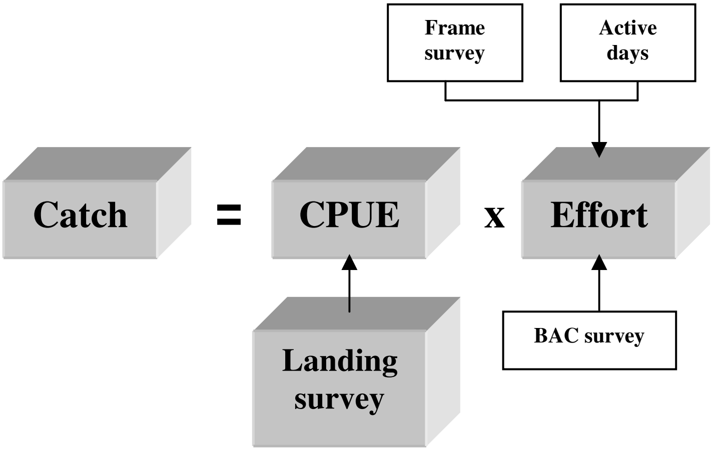
SUMMARY

This section completed the discussion on methodological and operational aspects of surveys that are involved in the estimation of total fishing effort. Specifically, this section described sampling aspects in formulating Boat Activity Coefficients (BACs).

The following topics have been presented and discussed:

(a) Objectives of Boat Activity surveys.
(b) Target population.
(c) Sampling requirements and safe sample sizes achieving a desired level of accuracy in the estimation of BACs.
(d) Commonly used sampling approaches.
(e) Need for training and effective briefing of data recorders.
(f) Pilot implementation, feedback and survey expansion.
(g) Frequent problems in Boat Activity surveys.

10. Landing surveys



In this section readers will be presented with methodological and operational aspects of sample-based Landing surveys. It is recalled that these surveys constitute the fourth generic component involved in the estimation of total catch. Sections 7, 8 and 9 have all concerned fishing effort. In this handbook Landing surveys focus on overall CPUEs, species composition, prices and average fish size.

The following topics will be discussed:

(a) Objectives and basic data coverage.
(b) Sampling requirements.
(c) Example of a general-purpose form.
(d) Case studies.
(e) Training and briefing of data collectors.
(f) Implementation aspects.
(g) Data editing and checking.
(h) Frequent problems.

10.1 Objectives of Landing surveys

Landing surveys are conducted at landing sites with the purpose of collecting sample data on total catch and species composition, associated effort, and other secondary data such as prices and fish size (in weight units). In this handbook the following basic data are described:

(a) Catch of all species.
(b) Associated fishing effort.
(c) Overall CPUE.
(d) Catch by species.
(e) First-sale prices.
(f) Number of fish in catch by species.

The primary objective is to formulate, on a sample basis, overall CPUEs and species proportions within the estimating context of a minor stratum, a calendar month and a specific boat/gear category. Section 2.1 has provided guidelines in relation to this process.

10.2 Sampling requirements

It is recalled that in Landing surveys sampling takes place at *landing sites* and not at homeports, unless a homeport is also a landing centre.

In Landing surveys sampling requirements and safe sample sizes achieving minimum accuracy levels, are different from those used in Boat Activity surveys. This stems from the fact that the target populations of landings are much less demanding in sample size than those of boat activities.

Safe sample sizes in Landing surveys are determined on the basis of:

(a) Desired accuracy level (with a minimum of 90%).

(b) Population size (unless the population is very large that can be considered as infinite).

The population size for landings is usually set at the theoretical maximum number of landings that can occur during a month. For instance, if 100 trawlers in a minor stratum operate in June 2001, then the maximum possible number of landings is 30 x 100 = 3,000 landings. Based on that limit and the desired level of accuracy it is possible to determine the number of samples that will be required at the end of a month.

Table 10.2 indicates recommended sample sizes for landings at a desired level of accuracy and as a function of population size. It is recalled that in sample-based surveys for basic fishery data the minimum accuracy level of an estimate is empirically set to 90%.

Sample sizes are interpreted as follows:

(g) Assume a population of 3,000 landings and an overall CPUE of 5 kg/day. For an accuracy level of 95% 123 landings ought to have been sampled by the end of the month.
(h) The safe sample size of 123 corresponding to an accuracy level of 95% will assure that, at worst, the resulting CPUE estimates would be as high as 5.5 or as low as 4.5 kg/day.
(i) Assuming that sampling occurs during 10 days then about 13 landings should be sampled on each sampling day from the sampling sites in the minor stratum.
(j) By lowering the level of accuracy to 90% the corresponding sample size becomes 32. At worst the overall CPUE would be then be estimated as 4 or 6 kg/day. Working with 10 sampling days would mean that about 4 boats should be sampled on each sampling day in the entire minor stratum.

Table 10.2. Sampling requirements for landings at varying accuracy level and population size

Accuracy (%) / Population size	90	91	92	93	94	95	96	97	98	99
			Safe sample size for landings							
300	29	35	43	54	69	90	120	163	218	274
400	30	36	44	56	73	97	133	188	267	356
500	30	37	45	58	75	102	143	208	308	432
600	30	37	46	59	77	106	150	223	343	505
700	31	37	47	60	79	108	156	236	373	574
800	31	38	47	60	80	110	160	246	400	640
900	31	38	47	61	81	112	164	255	424	703
1000	31	38	48	61	82	114	167	262	445	762
2000	32	39	49	63	85	120	182	302	572	1231
3000	32	39	49	64	86	123	188	318	632	1549
4000	32	39	49	64	87	124	191	327	667	1778
5000	32	39	50	64	87	125	192	332	690	1952
6000	32	39	50	65	88	125	194	336	706	2088
7000	32	39	50	65	88	126	195	339	718	2197
8000	32	39	50	65	88	126	195	341	728	2286
9000	32	39	50	65	88	126	196	342	735	2361
10000	32	39	50	65	88	126	196	343	741	2425
15000	32	39	50	65	88	127	197	347	760	2638
20000	32	39	50	65	89	127	198	349	770	2760
25000	32	39	50	65	89	127	198	351	776	2838
30000	32	39	50	65	89	128	199	352	780	2893
35000	32	39	50	65	89	128	199	352	782	2933
40000	32	39	50	65	89	128	199	353	785	2964
45000	32	39	50	65	89	128	199	353	786	2989
50000	32	39	50	65	89	128	199	353	788	3009
> 50000	32	40	50	65	89	128	200	356	800	3201

10.3 A general-purpose form

In Landing surveys there is generally no rule concerning data collection forms, the design of which depends on their data coverage and intended use. However, there are some major considerations relating to the structure and utility of landing data and some of these are summarized in the following general-purpose document. In the given example optional data are shaded.

Part A - Document identification

Part B - Sampling Activity

1. **Date**
2. **Landing site**
3. **Minor stratum**
4. **Recorder's name**

Part C - Fishing Operation

1. **Boat/gear type**
2. **# Units landing**
3. **Duration of trip**
4. **Total landing**

Part D – Species information

1. **Landing by species**
2. **Price**
3. **# fish in sample**
4. **Sum of landings by species (control total)**

Part E – Supplementary information and remarks

10.3.1 Part A - Document Identification.

Documents should be identified in order to facilitate the following operations:

(a) Organization and filing of hardcopy information.
(b) Cross-reference between hardcopy forms and computer records.

Usually documents are identified by sequential numbers assigned as follows:

(c) Pre-assigned numbers printed on forms and distributed to data collectors. These numbers are also inputted during computer operations.
(d) Numbers are automatically assigned by the inputting procedure and then penciled on forms during inputting.

10.3.2 Part B – Sampling Activity.

(a) Date (essential). It automatically directs grouping of landing data by month.
(b) Landing site (essential). It automatically directs grouping of landing data according to stratification criteria.
(c) Stratum (optional). Its presence facilitates manual grouping of forms.
(d) Name of recorder (optional). It facilitates cross-checking, queries and evaluation of workload of data collectors. Its use is recommended.

10.3.3 Part C – Fishing operation

(a) Boat/gear type (essential). It directs grouping of data by boat/gear types as per survey standards.
(b) # Units landing (essential). Usually it is 1. At times it can be greater than 1 to indicate the number of boats that operated together. It affects sample effort.

(c) Duration (essential). It specifies the number of days of a fishing trip. It affects sample effort.
(d) Total landing (optional). It is used when species composition is only a sub-sample of the total.

10.3.4 Part D – Species information

(a) Landing by species (essential). Quantity of catch of a specific species.
(b) Price (optional). Highly recommended. When used on a sub-sample basis it provides prices and values by species and also overall value of production.
(c) # fish in sample (optional). Highly recommended. When used on a sub-sample basis it provides useful data on average fish size, thus allowing various comparisons across gears, seasons and geographical areas.
(d) Sum of landings by species (essential). It is manually computed. It provides a good checking tool for avoiding inputting errors. It is also the basis for raising to total landing when only a proportion was used for species composition.

10.3.5 Part E – Supplementary information and remarks.

Its use is optional. Information on fishermen, fishing units, events occurring at sites, etc. may be recorded here.

10.3.6 Example of a completed form

A. Landing survey – June 2001 – DOCUMENT: 0234

B. Sampling Activity

Date:	**25/6/2001**
Landing site:	**New Harbour**
Minor stratum:	**SW Coast**
Recorder:	**Samuelson**

C. Fishing Operation

Boat/gear:	**Handline**
# Units:	**1**
Duration:	**3**
Total landing:	**45 kg**

D. Species Information

Species	Quantity (kg)	Price (1000 C/kg)	Value (1000 c)	# fish
Grouper				
Red snapper	10	6		40
Seabass	30	5		20
Shrimp				
Other	5		10	-

TOTAL	**45**

E – Supplementary information and remarks

Good weather conditions. Arrived at 10:00 and stayed until 14:00.

To be noted that:

(a) Duration of trip was 3 days.
(b) All catch was sampled (45 kg).
(c) All species are pre-printed to facilitate the recorder's work.
(d) Values are sometimes recorded instead of prices.
(e) In this example the associated sample effort is (1 unit) x (3 days), or 3 boat-days.

(f) Species proportions in this specific landing are defined from the species samples divided by 45.
(g) The form can be directly used in computer operations for inputting primary data on landings.

10.3.7 Computation of overall CPUE from samples

The CPUE parameter in the generic catch estimation formula given at the beginning of this section is calculated in a compound manner as follows:

Assume n sampled landings for a specific boat/gear type collected over a month. The related data collection forms contain records of total landings L1,L2,...,Ln and associated effort E1,E2,...,En.

The overall CPUE is formulated for an estimation context of a minor stratum, a calendar month and a specific boat/gear type. Its formula is:

Overall CPUE = L / E

where L = L1 + . . . + Ln and E = E1 + . . . + En.

<u>Example</u>

Assume five samples with landings 10, 5, 20, 25, 10 (in kg) and effort 1, 2, 3, 2, 2 (in boat-days).

In this case the compound CPUE is (10+5+20+25+10) / (1+2+3+2+2) = 7 kg/boat-day.

10.4 Case studies

The following paragraphs present a number of frequently encountered landing types and discuss the use of catch and effort parameters.

10.4.1 Sub-sampling for large landings

C. Fishing Operation

Boat/gear:	**Handline**
# Units:	**1**
Duration:	**3**
Total landing:	**450 kg**

Assume the document discussed in example 10.3.6 but with a total landing of 450 kg. This means that only 45 kg were used for species composition. The presence of this field is now essential and indicates that catch by species will be raised by a factor of 450/45=10.

10.4.2 Boats landing together

C. Fishing Operation

Boat/gear:	**Gillnets**
# Units:	**2**
Duration:	**3**
Total landing:	**120 kg**

In this example two gillnetters operated and landed together. Sample effort is 2 x 3 = 6 boat-days.

10.4.3 Fishing units with multiple operations per day

C. Fishing Operation	
Boat/gear:	**Beach seine**
# Units:	**1**
Duration:	**0.5**
Total landing:	**100 kg**

In this example a beach seine made two hauls during a day but only one with 100 kg was recorded. Here the effort is set to 0.5 boat-days to indicate that a total of 200 kg would be expected during the whole day.

Such cases can be a problem. They generally apply to fishing units that can operate several times during a day (the beach seine is a typical example). The following points ought to be explained to the data recorder:

(a) If the recording is done at the end of the day, the fisherman would specify how many times he operated during the day. This number will be used to calculate duration as a fraction of a fishing day.
(b) If the recording is done earlier in the day, the fisherman would be asked to specify if more operations would follow and the total number used to calculate duration as a fraction of a fishing day. This information is of course not as reliable as before.
(c) If there is doubt as to the reliability of the number of operations, it would be preferable to drop the sample from the dataset of sample landings.

10.4.4 Processed or packed fish

If such landings occur occasionally then they should simply be ignored in data collection. If they are regular then conversion factors should be introduced.

10.4.5 Catch sorted by species

All landings will be combined into a single form in a normal manner.

10.4.6 Catch sorted by commercial category

If all landings have been sampled then they should all be combined into a single form as follows:

<u>INPUTS</u>

Total landing: 100 kg.   Effort: 1 boat-day.

Total large species: 60 kg.

Large species A: 40 kg.
Large species B: 20 kg.

Total small species: 40 kg.

Small species A: 30 kg.
Small species B: 10 kg.

<u>RESULTS (on a single form)</u>

Total landing: 100 kg.   Effort: 1 boat-day.

Species A: 70 kg.
Species B: 30 kg.

If, on the other hand, sub-samples are used the two alternative procedures are:

1. Using a single form

INPUTS

Total landing: 1000 kg.   Effort: 1 boat-day.

Total large species: 600 kg.
Sampled large species: 20 kg.

Large species A: 15 kg.
Large species B: 5 kg.

Total small species: 400 kg.
Sampled small species: 10 kg.

Small species A: 6 kg.
Small species B: 4 kg.

RESULTS (on a single form)

Total landing: 1000 kg.   Effort: 1 boat-day.

Species A: 15/20 x 600 + 6/10 x 400 = 450 + 240 = 690 kg.
Species B: 5/20 x 600 + 4/10 x 400 = 150 + 160 = 310 kg.

In the above process manual calculations are required for raising catch by species.

2. Using multiple forms

Form 1

Total landing: 600 kg. **Effort: 0.5 boat-days.**

Sampled: 20 kg.

Large species A: 15 kg.
Large species B: 5 kg.

Form 2

Total landing: 400 kg. **Effort: 0.5 boat-days.**

Sampled: 10 kg.

Small species A: 6 kg.
Small species B: 4 kg.

In the above process raising of catch by species will be done automatically. To be noted that the effort used in the multiple forms should be split in order to add to the actual 1 boat-day. Earlier topic 10.3.7 on the formulation of a compound overall CPUE from samples provides the explanation for this effort recording technique.

10.4.7 Non-fishing boats landing catch

Generally, such landings need not be sampled because they do not provide information on associated sample effort. It is recalled that in computing the overall CPUE emphasis ought to be placed on the reliability of samples rather than on their quantity.

10.4.8 Migration of fishing units

In theory, migration of fishing units only affects effort-related surveys. There should be no reason for not sampling landings from boats that operate from sites different from the one being visited and, in fact, this might be the correct approach at locations that are strictly landing centres and not homeports. However, it would perhaps be preferable to give priority to local boats and include non-local only when the total number of samples is below safety limits.

10.5 Training of data collectors

Compared to effort-related data collection schemes, Landing surveys are less demanding in sample size but require more skills on the part of recorders. Lack of adequate training has direct implications on the reliability of data relating to total landings, catch by species, prices, values, sample effort and fish size. The following major points ought to be considered in this respect:

<u>Fishing operations</u>

(a) Identification of boat/gear type.
(b) Cases when samples should or should not be taken.
(c) How to obtain representative samples from boats that are landing.
(d) Effective ways of measuring or eye-estimating total catch.
(e) How to correctly record sample effort data.

<u>Species composition</u>

(f) Species identification.
(g) Effective ways of measuring or eye-estimating catch by species.
(h) When and how to obtain information on first-sale prices or values.
(i) When and how to recognize number of fish in samples.

10.6 Briefing of data collectors

Providing data collectors with precise and unambiguous instructions is fundamental for the reliability of the data obtained through Landing surveys.

The following points are worth considering in briefing data collectors:

(k) Explaining in full detail the recording forms, their use in data collection and their purpose and utility in the overall sampling programme.
(l) Clarifying the issues concerning boat/gear types, such as sequential and concurrent use.
(m) Planning with them the visits to landing sites.
(n) Methods for approaching fishermen and village authorities in order to obtain complete and reliable information.

10.7 Implementation aspects

10.7.1 Pilot phase

Landing surveys require representative samples and good timing at visiting landing sites. It is always considered good practice to first implement them on a pilot scale with the view of identifying possible design and operational drawbacks and obtain indications regarding likely timeframes of full scale operations.

10.7.2 Evaluation and revisions

The pilot results should be critically evaluated in consultation with all staff involved. Based on this feedback forms and data collection techniques would be revised and fresh instructions issued to data collectors.

10.7.3 Testing the entire sampling programme

To be noted here that a pilot implementation of Landing surveys (including revisions), ought to be combined with a pilot implementation of the entire sampling programme for catch/effort assessment. Such an exercise should operate for a period sufficiently long to allow for an overall programme evaluation and use of feedback information in programme revisions. Normally, pilot programmes of this type are in operation for 6-12 months.

10.7.4 Supervision and assistance

Supervision of data collectors is essential for ensuring that data collection is conducted according to planned procedures and schedules. Typical supervisory functions involve:

(a) Ensuring that recorders visit landing sites according to work schedules and they perform their job as instructed.
(b) Providing assistance usually needed during early implementation phases.
(c) Checking the way data are sampled and recorded.
(d) Ensuring that recorders are equipped with all items essential for their job and that effective use is made of such equipment.
(e) Back-reporting of problems relating to movement, timing of visits and duration of stay at sites.

10.7.5 Data editing and checking

Data collection forms usually undergo a certain amount of reviewing prior to be used for processing. Such a process involves:

(a) Organizing field documents in a manner that will facilitate subsequent processing. For instance forms may be grouped by:

- Month
- Minor stratum
- Landing site
- Boat/gear type
- Date

or in any other sequence that will be convenient to the data operators.

(b) Checking that sites and boat/gear types are recorded according to survey standards.
(c) If species are not printed as a standard list, checking the species names recorded by the data collector.
(d) Calculating species totals for cross-checking purposes.
(e) Spotting suspiciously high or low values in catch, prices and sample effort data.
(f) Controlling the number of samples for each estimation context (minor stratum, month, boat/gear type).

Such data organization and editing greatly facilitates processing of the data and reduces delays caused by inconsistent or incomplete primary information.

10.8 Frequent problems

10.8.1 Timing of field activities.

(e) Few or no landings occur during the allocated time at a landing site. The work schedule for that site ought to be reviewed.
(f) Recorders remain “idle” for long periods at a landing site. If feasible better use should be made of their time.

10.8.2 Selection of landing sites

(a) Sites are not representative of all boat/gear types and for certain fisheries no samples can be collected. Sampling sites should be reviewed.
(b) Sites are not representative of the population of landings. For instance, catch and effort data are atypically high or low. Sampling sites should be reviewed.
(c) Very important sites do not show individually in the estimates since estimates are produced at minor stratum level. To remedy such reporting problems important landing centers ought themselves to be considered as minor strata.

10.8.3 Concurrent use of fishing gear

In recording sample effort of a landing it may happen that a boat has operated different gears in one fishing trip. Section 8.4 provides some guidance on this aspect.

SUMMARY

This section dealt with Landing surveys, thus completing the discussion on methodological and operational aspects of surveys that are involved in the estimation of total catch. Specifically, the following major topics were presented:

(a) Objectives and basic data coverage.
(b) Sampling requirements and safe sample size limits achieving minimum accuracy levels.
(c) Example of a general-purpose form for the recording of landings.
(d) Case studies. Commonly used sampling techniques in artisanal fisheries.
(e) Training and briefing of data collectors.
(f) Implementation aspects.
(g) Data organization, editing and checking.
(h) Frequent problems in field operations.

11. Data processing

In this section readers will be presented with general aspects concerning automatic processing of basic fishery data. The following topics will be discussed:

(a) Need for automated procedures.
(b) Basic system functions.
(c) Data flows.
(d) Computerized survey standards.
(e) Processing of primary data.
(f) Data checking and monitoring.
(g) Estimation process
(h) Basic reporting functions.
(i) Training and operational guidelines.

11.1 Need for automated procedures

Appropriate data processing tools and methods are decisive factors in the operations of fishery statistical programmes. Due to the wide spread of microcomputers and increased computer literacy among data producers and users, computer systems (of varying sophistication and robustness) have become an inseparable component of fishery statistical systems.

A computer system for the processing of fishery statistical data should respond to a wide variety of functional needs and its design ought to be:

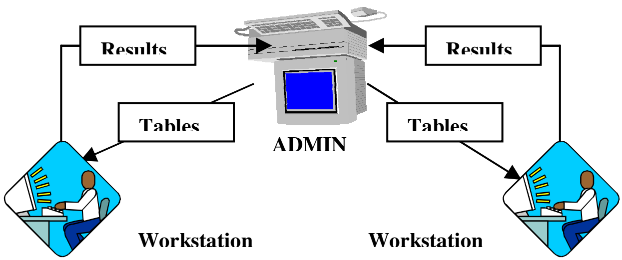
(a) Flexible in order to respond to changing survey needs.
(b) Robust to avoid software interventions.
(c) Modular to avoid processing bottlenecks and permit decentralized offices to locally process and analyze their own data.
(d) Sustainable to allow data producers to operate it regularly without need for externally supplied assistance.

11.2 Basic functions

Typical functions of a computerized system that handles basic fishery data are:

(a) Organization of survey standards.
(b) Organization and inputting of sample data collected from the field.
(c) Data quality reports.
(d) Automatic computation of estimates.
(e) Basic reporting of estimated data.
(f) Exchange of estimates with other user groups.
(g) Exportation of results to other application environments.

11.3 Data flows



The above diagram gives an example of a simple system architecture servicing a statistical programme for basic fishery data.

(a) A central unit (system administrator or ADMIN) is responsible for setting-up survey standards and distributing them to decentralized units (workstations).
(b) Decentralized units each operate on their own primary data and produce estimates at workstation level. Resulting estimates are submitted to the ADMIN centre for integration.

This or similar structures offer the following advantages:

(a) Survey standards are the responsibility of an ADMIN central unit, thus ensuring overall conformity.
(b) Handling of primary data is nearer to their source, thus achieving better and quicker corrective actions when necessary.
(c) Inputting of primary data is distributed, thus reducing bottlenecks that at times occur in centralized operations.
(d) Decentralized users are the first to view, check and use the estimates produced.
(e) Data integration based on decentralized results is generally an easy task for the ADMIN central unit.

11.4 Survey standards

In Section 5 it was pointed out that survey standards constitute the methodological and operational framework of a sample-based fishery survey. In this section, readers will be presented with a number of aspects concerning their computerization.

It should be stressed again that well-defined survey standards help in streamlining field operations, producing consistent reports and integrating survey outputs with those resulting from other application domains. They also facilitate computerization of data and their dissemination.

11.4.1 Validity of survey standards

Survey standards are usually valid for a complete operational cycle of a survey programme (i.e. one year), after which period they are reviewed. However, there are cases of seasonal changes in a survey framework and it is thus essential for survey standards to reflect such changes.

Normal practice is to automatically replicate survey standards over the months and thus be able to modify them accordingly.

11.4.2 Strata and geographical areas and locations

First step in the computerization of survey standards is to set-up the following tables:

(c) A list of administrative or reporting strata (major strata).
(d) A list of logical strata that will be used in an estimation context. It is recalled that estimates are produced within the context of a minor stratum, a month and a boat/gear type.
(e) Associating minor strata to major strata. It is recalled that minor strata should not overlap major strata.

(f) A list of homeports and landing sites that will participate in sampling operations.
(g) Associating homeports and landing sites to minor strata. This is essential for directing the use of primary data in the estimation of catch and effort.
(h) Stratification schemes ought to be thought out well and finalized prior to initiating inputting of other data.

```
Major strata                              Sites

Code Description                          Code Description
================================          ============================
0001 LAKE VOLTA                           0001 Dzemeni
0002 OTHER INLAND WATER BODIES            0002 Kedekope
                                          0003 Kpatsakope
Minor strata                              0004 Kpeve Tornu
                                          0005 LV-StrII-uns
Code Description                          0006 Accra Town
========================                  0007 Gbetekpo
0001 LV STRATUM II                        0008 Gbevukpo
0002 LV STRATUM VII                       0009 Logakope
0003 LV OTHER STRATA                      0010 LV-StrVII-uns
0004 OIWB TO BE DEFINED                   0012 LV other strata (sites)
Associations MINOR strata  > MAJOR     Associations sites > Minor strata
===================================    =================================

0001 LAKE VOLTA                        0001 LV STRATUM II

     0001 LV STRATUM II                   0001 Dzemeni
     0002 LV STRATUM VII                  0002 Kedekope
     0003 LV OTHER STRATA                 0003 Kpatsakope
                                          0004 Kpeve Tornu
```

The figure above provides an example of a computer set-up for strata, sites and their associations.

11.4.3 Boat/gear types

Second step is to set-up a table of boat/gear categories. The following considerations apply:

(a) Boat/gear types should be easily recognizable by the recorders in case pre-printed lists are used in data collection forms.
(b) It would be rather inconvenient to anticipate standardization and harmonization aspects relating to future uses of data. These would be catered for at a much later stage.
(c) Use of codes in data collection procedures ought to be avoided.
(d) All possible boat/gear types of the survey programme must appear in the list to avoid frequent changes to survey standards.

Fishing units

Code	Description
0001	ATIDZA
0002	BAMBOO
0003	BAMBOO_MOTORISED
0004	BEACH SEINE
0005	CAST NET
0006	GILLNET
0007	GILLNET_MOTORISED
0008	HOOK & LINE
0009	HOOK & LINE_MOTORISED
0010	NIFANIFA
0011	TRAPS
0012	TRAPS_MOTORISED
0013	WINCHNET
0014	WINCHNET_MOTORISED
0015	WANGARA
0016	WANGARA_MOTORISED

The figure above gives an example of a computer set-up for boat/gear types.

11.4.4 Frame surveys

A table with frame survey data is the next task. Such a table requires that the list of homeports and landing sites, as well as the table of boat/gear types have all been set-up.

Usually the computer system would operate on the tables of sites and boat/gears and prepare blank records containing all “site – boat/gear” combinations. Users would then complete these records with numbers of fishing units potentially operating in each combination.

Site & boat/gear type		*# Units*
Dzemeni	CAST NET	5
Dzemeni	GILLNET	12
Dzemeni	GILLNET_MOTORISED	6
Dzemeni	HOOK & LINE	23
Dzemeni	HOOK & LINE_MOTORISED	11
Dzemeni	NIFANIFA	0
Dzemeni	TRAPS	3
Dzemeni	TRAPS_MOTORISED	31
Dzemeni	WINCHNET	7
Dzemeni	WINCHNET_MOTORISED	9
Dzemeni	WANGARA	12
Dzemeni	WANGARA_MOTORISED	4
Kedekope	ATIDZA	67
Kedekope	BAMBOO	12
Kedekope	BAMBOO_MOTORISED	19
Kedekope	BEACH SEINE	3
Kedekope	CAST NET	0
Kedekope	GILLNET	0

The figure above illustrates an example of a computer set-up for frame surveys.

11.4.5 Species lists

Next step is to set-up a species table. The following considerations apply:

(a) Species names should be easily recognizable by the recorders in case pre-printed lists are used in data collection forms.
(b) It would be rather inconvenient to anticipate standardization and harmonization aspects relating to future uses of data. These would be catered for at a much later stage.
(c) Use of codes in data collection procedures ought to be avoided.
(d) All species that are potentially encountered must appear in the list to avoid frequent changes to survey standards.

Species

Code	Description
0001	Alestes baremoze
0002	Auchenoglanis occidentalis
0003	Bagrus bajad
0004	Brycinus nurse
0005	Chrysichthys auratus
0006	Chromidotilapia guntheri
0007	Chrysichthys nigrodigitatus
0008	Citharinus citharus
0009	Clarias anguillaris
0010	Distichodus rostratus
0011	Gymnarchus niloticus
0012	Hemichromis bimaculatus
0013	Hemichromis fasciatus
0014	Hemisynodontis membranaceus
0015	Heterotis niloticus
0016	Hydrocynus forskalii
0017	Hydrocynus vittatus

The figure above illustrates an example of a computer set-up for species.

11.4.6 Standard units

In view of data organization, processing and analysis needs, it is important that the measurement units involved in a sample-based survey dealing with basic fishery data, are consistent throughout the statistical programme. In this handbook the following units are considered:

(d) Weight units should be used consistently in all survey implementation components. For instance, if the agreed weight unit for recording landings is the kilogram, this unit should be used at all data collection sites, so as to avoid confusion and errors.
(e) Same concept applies to currencies.
(f) Effort: By definition effort units differ among the various boat/gear types and fishing methods. However, in fishery surveys dealing with basic data there is a need to easily integrate catch and effort estimates deriving from different boats and gears. For statistical purposes it is generally accepted that the *boat-day* is a reasonably good way for expressing fishing effort uniformly.

Units
Kg
1000C

Above is an example of a computer set-up for standard measurement units. To be noted that currency is expressed in 1000 Cedis for easier handling of very large values.

11.5 Processing of primary data

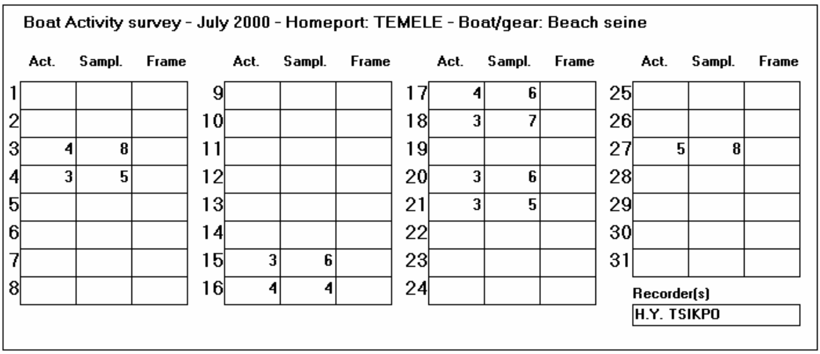
Primary data are samples on boat activities and landings, collected from the field. Data inputting procedures are briefly reviewed in this topic.

11.5.1 Inputting of data on boat activities

The computer procedure must be flexible enough to handle data that are collected by means of different sampling schemes. These have been discussed in Section 9. Usually inputting is done directly from documents that have been organized as follows:

- By month
- By homeport
- By boat/gear type

Following is an example of a general-purpose computer screen used for entering data on boat activities:



Boat Activity survey - July 2000 - Homeport: TEMELE - Boat/gear: Beach seine

	Act.	Sampl.	Frame		Act.	Sampl.	Frame		Act.	Sampl.	Frame		Act.	Sampl.	Frame
1				9				17	4	6		25			
2				10				18	3	7		26			
3	4	8		11				19				27	5	8	
4	3	5		12				20	3	6		28			
5				13				21	3	5		29			
6				14				22				30			
7				15	3	6		23				31			
8				16	4	4		24							

Recorder(s)

H.Y. TSIKPO

In this example no frame survey data are used. Numbers of active boats are recorded together with the total number sampled at a homeport on a given day.

11.5.2 Inputting of landing data

Case studies on landing data have been discussed in Section 10. Usually inputting is done directly from documents that have been organized as follows:

- By month
- By stratum and homeport
- By boat/gear type

Following is an example of a general-purpose computer screen used for entering sampled landings.

Landing survey - July 2001 Form: 0034

Stratum: SW Coast

Landing site: Denu

Date: 23 July 2001

Recorder(s)

Yelowomi Paul

Boat/gear type: Gillnet

 # Units: 1
Duration: 2 days

Sampled: 147 kg
Total: 147 kg

Species	Quant.	# of	Price	Value
Rock Soles	5	16	6.5	32.50
Roncador	0	0	0	0.00
Round Sardinella	124	0	1.29	160.00
Royal Spiny Lobste	0	0	0	0.00
Sardinella Unspeci	0	0	0	0.00
Scad Mackerel	0	0	0	0.00
Seabream (Sikasik	18	9	6	108.00
Seabreams Unspec	0	0	0	0.00
Sea Snail	0	0	0	0.00
Shad/Bonga	0	0	0	0.00
Sharks	0	0	0	0.00
Shrimps	0	0	0	0.00

11.5.3 Inputting of Active Days

It is recalled that Active Days provide time extrapolating factors for estimating fishing effort in an estimation context of a minor stratum, a month and a specific boat/gear type.

In the example given below a table has automatically been created by the computer system to contain all combinations of minor strata and boat/gear types. Such records need to be updated with the number of Active Days corresponding to each combination. Initially, the table contained zeroes.

Minor stratum & boat/gear type		*# days*
KETU	APW canoe	27
KETU	Beach Seine	27
KETA	APW canoe	27
KETA	Beach Seine	27
KETA	Set Net	27
KETA	Drifting Gillnet	27
DANGBE EAST	APW canoe	27
DANGBE EAST	Beach Seine	0
DANGBE EAST	Set Net	27
DANGBE EAST	Drifting Gillnet	27
DANGBE WEST	APW canoe	0
DANGBE WEST	Beach Seine	27
DANGBE WEST	Hook & Line	27
DANGBE WEST	Set Net	0
DANGBE WEST	Drifting Gillnet	27
TEMA MUNICIPAL	APW canoe	0
TEMA MUNICIPAL	Beach Seine	0
TEMA MUNICIPAL	Hook & Line	0
TEMA MUNICIPAL	Set Net	0

11.6 Data checking and monitoring

Prior to producing estimates for fishing effort and catch a certain amount of data checking and monitoring must be performed with the purpose of ascertaining the state of completeness and the quality of primary data. Such control functions involve:

Monitoring

(a) Summary lists and reports providing quick indications as to the availability of samples on boat activities in each estimation context.
(b) Same for sampled landings.

Data checking

(a) Lists showing "extreme" values for catch, sample effort and prices. These must be automatically linked with the forms used for data entry. Suspiciously high or low values ought to be verified.
(b) Lists showing sample size for boat activities and landings and the expected accuracy level of the estimates. It is recalled here that safety limits for accuracy are known on an *a priori* basis and have been discussed in Sections 9 and 10.

11.7 Estimation process

A computer-based estimation process involves the following computational steps:

Estimation of fishing effort

(a) Boat activity samples, active days and frame survey data are directed to the appropriate estimation context of a minor stratum, a month and a boat/gear type.
(b) BACs are formulated in each context.
(c) The accuracy of BAC estimates is computed.
(d) The overall BAC variability and its confidence limits are computed.
(e) BAC variability is explained in space and time.
(f) BACs are combined with frame survey data and active days to produce estimates of fishing effort.
(g) Effort variability and confidence limits are computed.

Estimation of catch

(a) Sampled landing data are directed to the appropriate estimation context of a minor stratum, a month and a boat/gear type.
(b) Overall CPUEs are formulated in each context.
(c) The accuracy of CPUE estimates is computed.
(d) The overall CPUE variability and its confidence limits are computed.
(e) CPUE variability is explained in space and time.
(f) Sample species proportions are formulated.
(g) Sample prices are formulated.
(h) Estimates of average fish size (in weight units) are produced.
(i) Estimated CPUEs are combined with estimated effort to produce estimates of total catch.
(j) Variability of catch estimates and related confidence limits are computed.
(k) Sample species proportions are combined with estimated total catch to produce estimated catch by species.

(l) Sample prices are combined with catch by species to produce estimated values by species.
(m) Values by species are added up to produce total values for landings.

The computational steps given above are repeated for each estimation context of a minor stratum, a month and a boat/gear type. At the end of this process the following data grouping procedures are performed:

Data grouping

(a) Catch, effort and values are grouped at major stratum and grand total levels.
(b) Average CPUEs and prices are formulated at major stratum and grand total levels.

11.8 Basic reporting

There are several ways for the preparation of basic reports on estimated data and this topic only provides some examples. Generally, monthly catch/effort estimates constitute “first generation” statistics that does not require much sophistication in its reporting functions. The following points may be considered:

(a) First reporting level must be that of the estimation context where all computations and related statistical indicators and diagnostics are produced.
(b) Prior to analyzing the results, users should check the system messages to ascertain the level of completion of each estimating context.
(c) All data involved in the estimation process must be reported so as to allow manual verification of the results if needed.
(d) Reporting sequence ought to respect the computational steps discussed earlier in topic 11.7.

11.8.1 System diagnostics

The example given below illustrates system messages that were produced during an estimation process. For each estimation context messages are displayed describing the outcome of the estimations.

```
KETA                              Beach Seine                    Estimated

Accuracy for CPUE below 90%

..............................................................................
KETA                              Hook & Line                    Not estimated

No active days
No frame data
..............................................................................
KETA                              Set Net                        Not estimated

No landings
No effort data
..............................................................................
KETA                              Drifting Gillnet               Estimated

Only one site for landings
Only one site for effort
Accuracy for BAC below 90%
Accuracy for CPUE below 90%
No variance computed for CPUE
```

To be noted that in the example given above the messages displayed for different estimation contexts inform users that:

(a) Accuracy for CPUE is below 90%. Estimation continued.
(b) No extrapolating factors. Estimation failed.
(c) No landings and no effort data. Estimation failed.
(d) Limited geographical coverage. Accuracy levels for BAC and CPUE are below 90%.

11.8.2 Estimated effort

```
KETA : Beach Seine
══════════════════════════════════════════════════
Estimation of effort

BAC - Boat Activity Coefficient......... 25.000 %
Accuracy level.......................... 91.173 %
Units sampled........................... 120
Active.................................. 30

# sites................................. 2
# days.................................. 10
BAC variability......................... 28.912 %
BAC var component (space)............... 8.393 %
BAC var component (time)................ 20.520 %
BAC lower limit at 95%.................. 10.833 %
BAC upper limit at 95%.................. 39.167 %

Units in frame survey................... 168
Active days............................. 27.000
Estimated effort (days)................. 1 134
Effort lower limit at 95%............... 491
Effort upper limit at 95%............... 1 777
```

In this example estimated effort is described in three sections.

(a) Estimation of BAC and resulting accuracy can be verified with the sampling information displayed.
(b) The variability of BAC is high (29%) and is explained in space and time. Note that variability in time (20.5%) is the primary cause.
(c) Estimation of fishing effort can be verified using the estimated BAC and the data on active days and frame survey extrapolating factors. Confidence limits for estimated effort are also displayed.

11.8.3 Estimated total catch

```
Estimation of catch

CPUE................................... 402.967
Accuracy level......................... 89.798 %
Smp. size required for accuracy  90%.... 31
Landings sampled....................... 30
Sample catch........................... 12 089
Sample effort.......................... 30

# sites................................ 2
# days................................. 10
CPUE variability....................... 31.993 %
CPUE var component (space)............. 4.421 %
CPUE var component (time).............. 27.572 %
CPUE lower limit at 95%................ 150.284
CPUE upper limit at 95%................ 655.650

Estimated catch (Kg) .................. 456 964
Catch variability...................... 43.121 %
Catch lower limit at 95% (Kg) .......... 70 747
Catch upper limit at 95% (Kg) .......... 843 182
```

In this example total estimated catch is described in three sections.

(d) Estimation of overall CPUE and resulting accuracy can be verified with the sampling information displayed. To be noted that the resulting accuracy is slightly below the acceptable level of 90% because 30 samples, instead of 31 required, were used.
(e) The variability of CPUE is high (32%) and is explained in space and time. Note that variability in time (27.5%) is the primary cause.
(f) Estimation of total catch verified using the estimated CPUE and the estimated fishing effort described earlier. The compound variability of catch is very high (43%) because of the high variability in CPUE and fishing effort. Confidence limits for estimated total catch are also displayed.

11.8.4 Catch by species

```
Total value (1000 C) .................. 221 571
Average price (1000 C/Kg) ............. 0.485


Catch by species                  Quant.              CPUE          Value
                                  Effort              Aver.W        Price

Anchovy                          362 899 ( 79.4%)    320.017       152 244 ( 68.7%)
                                   1 134               0.000         0.420

Burrito                           26 366 (  5.8%)     23.250         8 490 (  3.8%)
                                   1 134               0.000         0.322

Round Sardinella                  29 030 (  6.4%)     25.600        28 341 ( 12.8%)
                                   1 134               0.000         0.976

Scad Mackerel                     38 669 (  8.5%)     34.100        32 496 ( 14.7%)
                                   1 134               0.000         0.840
```

In this example results by species are displayed in three columns describing:

(a) Estimated catch by species and related effort.
(b) CPUE by species.
(c) Average weight per species.
(d) Sample price and estimated value by species.

On the top users will find total value of all landings and their unit-value.

11.8.5 Grand totals

GRAND TOTALS : Drifting Gillnet

Units in frame survey	4				
Estimated effort (days)	27				
CPUE	35.000				
Estimated catch (Kg)	945				
Total value (1000 C)	851				
Average price (1000 C/Kg)	0.900				

Catch by species	Quant. / Effort		CPUE / Aver.W	Value / Price	
Atlantic Little Tuna	203	(21.4%)	7.500	162	(19.0%)
	27		0.000	0.800	
Sharks	473	(50.0%)	17.500	473	(55.6%)
	27		0.000	1.000	
Skipjack Tuna	270	(28.6%)	10.000	216	(25.4%)
	27		0.000	0.800	

This example illustrates grand totals computed for a specific boat/gear type (drifting gillnet). These figures have resulted by grouping all statistics for this boat/gear type that were produced in different minor strata.

11.9 Training and operational guidelines

The overall assessment of a computer system for basic fishery data involves not only design criteria but also the capacity of fisheries personnel to operate it efficiently. Training aspects include:

(a) Mastering by data operators of all system functions.
(b) Preparation of regular backup copies of data.
(c) Availability of quick start-up guides for system operations.
(d) Training of data users on accessing catch/effort estimates for further processing.
(e) Effective monitoring of data entry, estimation and data submission procedures.

SUMMARY

In this section readers have reviewed general aspects concerning automatic processing of basic fishery data. The following topics were presented:

(j) Need for automated procedures performed by robust, modular and sustainable computer systems.
(k) Basic system functions.
(l) Data flows. Advantages of a decentralized system structure.
(m) Computerized survey standards. Strata, sites and associations. Species and boat/gear classifications. Frame surveys, Active Days and standard measurement units.
(n) Processing of primary data. Boat Activities and Landings.
(o) Data checking and monitoring.
(p) Estimation process. Data involved. Statistical indicators and diagnostics.
(q) Basic reporting functions.
(r) Importance of training and operational guidelines.

12. Data dissemination

The previous sections reviewed the various steps in designing and implementing fishery surveys involving basic fishery data. They also presented practical approaches in the use of computing techniques for organizing primary data and producing catch/effort estimates within the logical context of a minor stratum, a month and a boat/gear category.

In this section readers will be introduced to data processing concepts that concern accessing and use of basic fishery statistics. The following topics will be discussed:

(a) Setting-up of databases for general-purpose use.
(b) General functional characteristics of general-purpose databases.
(c) Passing on data to commercial applications software.
(d) Principles in developing sub-regional and regional databases for shared use.

12.1 General-purpose databases

Section 11 described commonly used procedures for handling primary fishery data and producing estimates within the logical context of a minor stratum, a month and a boat/gear type.

After an operational cycle (i.e. a year) has been completed, it is essential to integrate monthly estimates into a single database to be used for a variety of applications, such as bulletins, analytical studies, submission of data to regional and international bodies, etc.

Table 12.1 illustrates an example of such a database that can be produced automatically from existing monthly outputs.

Table 2.1. Example of an integrated database

Identifiers				Yearly data	Monthly data			
Major stratum	Minor stratum	Boat/ gear	Species		1	2	. . . . .	12

Cell contents

CATCH, EFFORT, CPUE
PRICES, VALUES

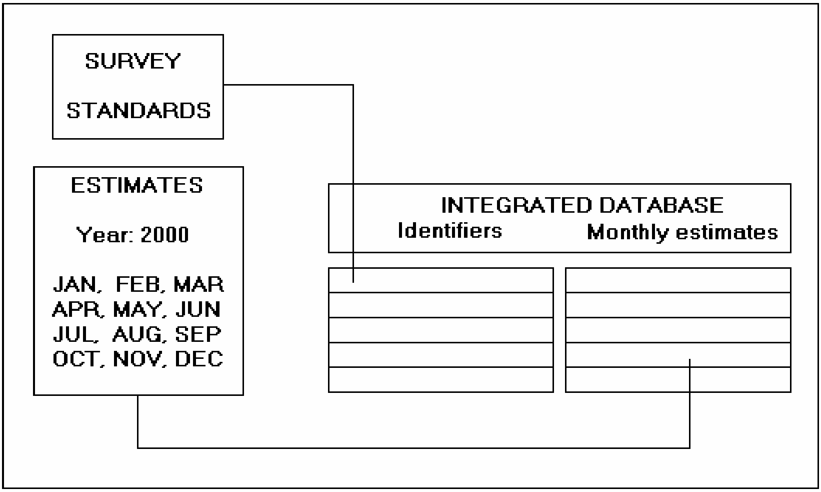
In this example the database structure consists of:

(a) Four identifiers (major and minor stratum, boat/gear type and species).
(b) Monthly figures corresponding to estimated catch, effort, CPUE, prices and values.
(c) Yearly totals for catch, effort, values and averages for CPUEs and prices.

12.2 Functional characteristics

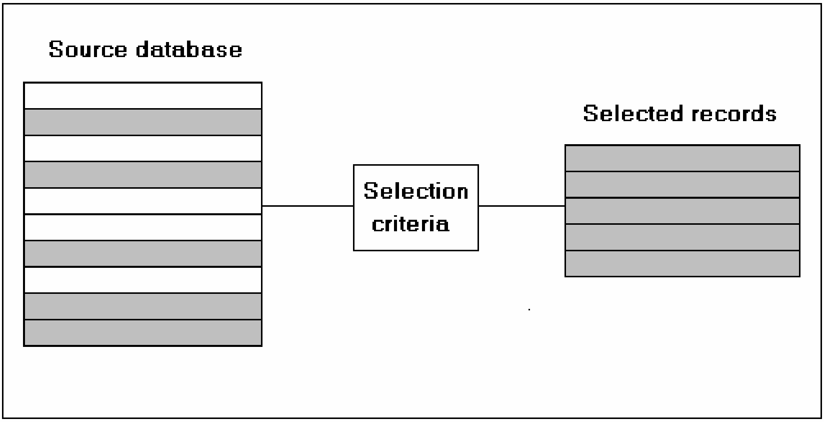
12.2.1 Creation

Creation of an integrated database is automatic and performed as illustrated below:



12.2.2 Flexible selection

Users ought to be able to work on the entire database or on selected sub-sets. Following is an illustrated example of a flexible selection function:



Examples of selection criteria:

- Select major stratum A and shrimp for trawlers
- Select gillnets in all strata and for all species
- Select only trawlers in all strata and for all species

12.2.3 Data grouping

Data grouping functions use selected sub-sets or the entire database to produce sub-totals and totals at variable grouping level. Typical data grouping functions involve:

- Totals by boat/gear by species
- Totals by species by boat/gear
- Boat/gear totals (all species)

- Species totals (all boat/gears)

Such data groupings are performed at major and minor stratum level as well as at grand total level.

12.2.4 Data ranking

Data ranking is useful for highlighting data in terms of their relative importance within a selected database sub-set. For instance the following questions need the use of data ranking functions:

- Species with highest values
- Boat/gear types with highest overall CPUE
- Boat/gear types that account for more than X% of total production
- Species that account for more than X% of total value
- Minor strata ranked according to total production
- Major strata ranked according to total fishing effort

12.2.5 Use of commercial applications software

Custom-oriented computer systems are usually build around known application needs and their reporting functions, however flexible, cannot respond to all user requirements. On the other hand users are becoming more and more knowledgeable and experienced in the use of commercial applications software and are themselves capable of working out studies and reports provided that the required data can be made available.

An essential function of an integrated database system is allowing users to extract the required information from the database and pass it on to a commercial package for further elaboration. This is usually a straightforward process involving:

(a) Possible use of flexible selection criteria (discussed in 12.2.2).
(b) Possible use of data grouping functions (discussed in 12.2.3)
(c) Possible use of ranking functions (discussed in 12.2.4)

(d) Formatting the processed database records for easy transfer to an external application environment (such as Word, Excel, Access, etc.)

12.3 Regional databases

Axiomatically, the establishment of a regional database (RDB) is justified only when there is a need to conduct studies on shared resources. This, for instance, is the case when in a fishing area with several coastal countries there are transboundary species for which responsible fisheries management is needed.

Development of an RDB is essentially a matter of *standardization* and *harmonization*. These two aspects are discussed in more detail in the coming topics. At this stage it would suffice to state that setting-up of regional standards and harmonizing data submission from contributing countries is not easy to achieve in the short term.

The following stages are usually involved:

12.3.1 Regional needs and standardization

(a) Identifying the data scope for the short- and medium-term, (e.g. catch, effort, CPUE, prices, values, etc.).
(b) Determining the required level of detail for each target regional data record, (e.g. time period, geographical identifier(s), fishing locations, boat/gear types and species level).
(c) Preparing a checklist to examine the feasibility of obtaining such data from contributing countries. This is usually the subject of workshops and consultations at regional level.
(d) Standardization. Deciding on geographical, boat/gear type and species classifications to be used in operating and using the RDB.
(e) Preparing country-orientated lists for comparing national standards in use against the standard RDB classifications.
(f) Establishing commonly accepted formats and operational modalities for data submissions.

12.3.2 RDB development and implementation

(g) Design of a basic RDB architecture and preparation of technical specifications concerning types of outputs, accessing of data and RDB maintenance requirements.
(h) Selecting appropriate database engine and programming tools.
(i) Developing the RDB applications. This process assumes that all previous steps have been carried out successfully and that some test data are flowing in from contributing countries.
(j) Testing of RDB applications and preparation of operational guidelines.
(k) Stepwise use of the RDB by contributing countries.
(l) Recording of problems encountered, including revisions suggested by users. Incorporating revisions.

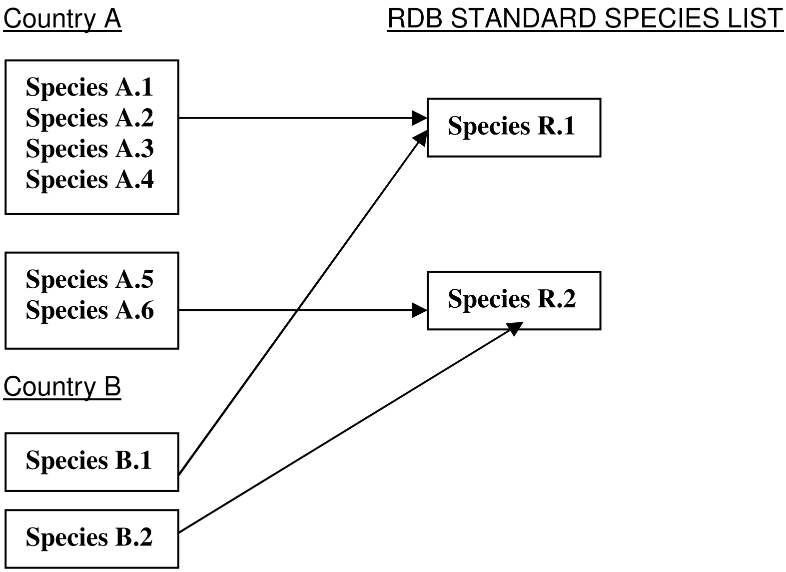
12.3.3 Standardization and harmonization

The term *standardization* usually applies to a commonly used information source, such an RDB. *Harmonization*, on the other hand, applies to different information systems (such as national fishery statistical programmes), that operate in concert in order to supply data under RDB standards. To be noted that:

(a) Setting-up of regional standards and harmonization of national systems are key factors in developing and operating an RDB.
(b) Harmonization of national systems does not require that these systems be 100% compatible.
(c) National systems may be 100% comparable and yet not responding to RDB standards.

12.3.4 Example of harmonized systems

In this example two countries A and B use different fishery statistical systems that are not comparable. However, these two systems have been harmonized in order to submit data under pre-set RDB standards. This is illustrated below:

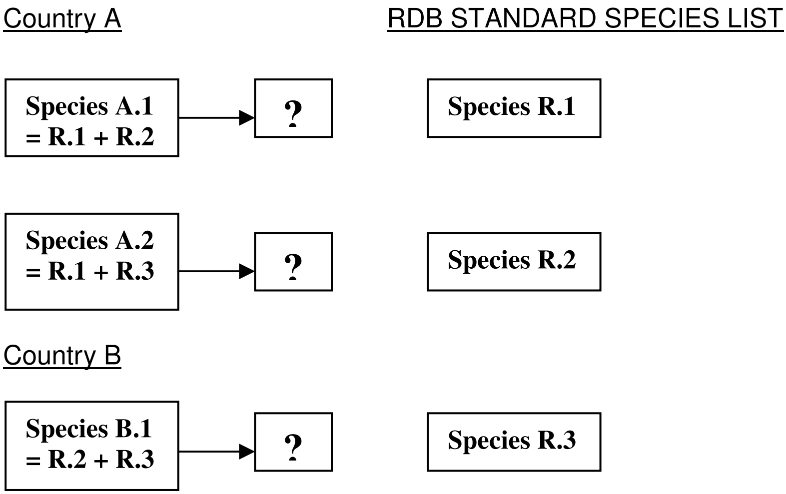


To be noted that:

(a) Systems A and B are not 100 % compatible since system A uses a species classification that is more refined than that used by B.
(b) RDB standards have been set-up and national species are mapped onto RDB species in an unambiguous manner.
(c) Systems A and B are harmonized since they can share information under RDB standards.
(d) Same considerations apply to boat/gear and geographical classifications.

12.3.5 Example of non-harmonized systems

In this example two countries A and B use different fishery statistical systems that are not comparable. Also, these two systems have not been harmonized in order to submit data under pre-set RDB standards. This is illustrated below:



To be noted that:

(a) Systems A and B are not compatible since they use different species classifications.
(b) RDB standards have not been set-up effectively and national species cannot be mapped onto RDB species in an unambiguous manner.
(c) Systems A and B are not harmonized since they cannot share information under RDB standards.
(d) Same considerations may apply to boat/gear and geographical classifications.

SUMMARY

In this section readers were introduced to data processing concepts that concerned accessing and use of basic fishery statistics. The following topics were discussed:

(e) Setting-up of databases for general-purpose use.
(f) General functional characteristics of general-purpose databases.
(g) Passing on data to commercial applications software.
(h) Principles in developing sub-regional and regional databases for shared use.

13. Further reading

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