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425

Sample-based fishery surveys

A technical handbook

Food and Agriculture Organization of the United Nations

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Preface

Among the major tasks of 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 always been extremely important, the more so at present as they form the essential basis for planning sustainable harvesting and environmental protection within the precautionary approach. Statistical programmes, however, require a significant effort and funds for their development and implementation and these are major constraints for many countries with limited human and financial resources. The merits of sampling approaches lie in providing cost-effective and efficient methods for the collection of data, further contributing to the development of the statistics urgently needed by fishery managers and planners.

Collection of basic data on catches, fishing effort and prices provides the primary data for a wide variety of statistical applications. In addition, more detailed data (fishing vessels, gear and operations; socio-economic data; etc) from sample-based fishery surveys conducted on a regular basis are 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. 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 recent years in fishery statistical development by the Fishery Information, Data and Statistics Unit (FIDI) of 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 to most 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 the statistics and related indicators collected, 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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ABSTRACT

The purpose of this handbook is to summarize experience gained over recent years in fishery statistical development by the Fishery Information, Data and Statistics Unit (FIDI) of 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 to most 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 the statistics and related indicators collected, 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.

CONTENTS

1. INTRODUCTION

Fishery statistics are the primary means to measure the performance of a fishery within the social, economic, biological and environmental framework in which it is conducted. The collection of fishery data is based on a relatively small group of concepts and approaches, including most importantly the quantities harvested (catch), the related type and duration of fishing operations (fishing effort), the economic costs and returns of fishing and the distribution of these in time and space.

Sections 1-5 of this handbook outline these key concepts and describe the general approach to achieving them through sample-based fishery surveys. Sections 6-10 take a more detailed look at basic survey types, from Frame Surveys to Landings Surveys. Sections 11 and 12 address basic approaches to data processing and information dissemination.

This section presents some general aspects of sample-based fishery surveys with emphasis on:

- Basic fishery data.
- Justification for regular collection of basic fishery data.
- Scope and utility of basic fishery data.
- Need for fishery surveys to be cost-effective and sustainable.
- 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

In this handbook basic fishery data refers to catch, catch by species, fishing effort, first-sale prices (i.e. prices at landing), values, and fish size (in weight units). These are the general-purpose datasets that may be subsequently used for a variety of statistical applications.

Justification for regularly conducted and costly fishery surveys can be achieved through reference to a long list of potential uses of basic fishery data, the commonest of which include:

1.1.1 Food security

Food security is often the over-riding concern for senior 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 many people are entirely 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, when combined with data on catch distribution, imports and exports, constitute the basis for calculating per capita consumption of fish and the subsequent formulation of food balance sheets.

Basic data: total catch, catch by species, imports, exports, human population

1.1.2 Fishing mortality

Fishing mortality is a fundamental variable in stock assessment; representing the proportion of stock that is removed due to fishing, i.e. separate from the stock reductions due to natural population mortality. Effort is one of the variables used to estimate fishing mortality. Controlling the amount of fishing effort (and hence the resulting fishing mortality), say through limits to vessel numbers or fishing days, is one of the most common methods to control the extent of stock removals.

Basic data: fishing effort

1.1.3 Fishing operations

Fishing operations indicators describe the composition of fishing fleets and fishing patterns and are the basis of many management decisions. They are important for monitoring compliance with fishery management controls, such as fleet numbers, days fishing, or seasonal and area limits.

Basic data: locations of homeports and landing sites, numbers of fishing units by gear category, fishing effort by boat/gear category

1.1.4 Species/gear selectivity

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

Basic data: species composition, average weight (and size) of fish by boat/gear type

1.1.5 Abundance and exploitation

Catch-Per-Unit-Effort (CPUE) - also called catch rate - is frequently the single most useful index for long-term monitoring of a fishery. Declines in CPUE may mean that the fish population cannot support the level of harvesting. Increases in CPUE may mean that a fish stock is recovering and more fishing effort can be applied.

CPUE can therefore be used as an index of stock abundance, where some relationship is assumed between that index and the stock size. Catch rates by boat and gear categories, often combined with data on fish size at capture, permit a large number of analyses relating to gear selectivity, indices of exploitation and monitoring of economic efficiency.

Basic data: 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 by taking into account important variables and indicators, such as product prices and gross value of production.

Basic data: total catch, catch and price by species

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: catch, fishing effort, average price of catch

1.1.8 Socio-economic studies

Time series of fishing effort, catch (hence CPUE) and prices are often used in socio-economic studies in which declining or increasing trends of fisheries in districts and regions can be used for the determination of appropriate fishery management controls or in infrastructure investment.

Basic data: catch, effort (hence CPUE), prices and values

1.2 Cost-effective fishery surveys

Regularly conducted fishery surveys are costly and will include field and office personnel costs, field operations costs and other overhead and maintenance costs relating to office infrastructure and operations. In many developing countries these total costs may constitute a major constraint on the effective development of fishery statistics. However, cost-effective sample-based fishery surveys can be achieved when:

- they are economical in data collection effort and produce reliable estimates;
- existing human and financial resources involved in data collection and processing are used efficiently; and
- they respond to user (planners, managers, scientists) needs in a timely and reliable manner.

1.3 Sustainable fishery surveys

Statistical analysis most often requires time-series of data through regularly conducted fishery surveys. A sample-based fishery survey is considered sustainable when:

- its design is robust enough to permit continuity when changes occur to the fisheries being statistically monitored;
- training of field and office staff is appropriate and regular so that data collection and processing/analysis are safeguarded against staff changes and turnover; and
- it has minimal or no dependence on external technical assistance.

1.4 Role of field staff

The backbone of a fishery survey is the field team of data collectors and their supervisors who form the primary interface between fishers and fisheries management. They collect and submit data 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

The quality of produced statistics is a direct function of the effectiveness and timeliness of field operations involving data collectors and supervisors. Data quality affects its utility in meeting the aims of its collection and in satisfying acceptable statistical reliability.

1.4.2 Training

Training and re-training of data collectors must be thorough, appropriate to their tasks and take into consideration their capacity to carry out instructions.

1.4.3 Realistic survey design

All survey designs must be broken down into achievable tasks which can be accomplished within realistic work schedules and through unambiguous instructions for data collectors.

1.4.4 Mobility of data collectors and supervisors

The mobility of data collectors and their supervisors (to provide support and guidance) affects the quantity of collected data as well as their representativeness. Low mobility due to lack of transportation usually results in reduced statistical coverage (time and area) and increases the risks of biased data, since survey data collection will usually be conducted at the same few locations.

1.4.5 Motivation and operational experience

Data collectors and supervisors should be motivated to perform their work, and not only financially. They should have a good understanding of the purpose and utility of their work, feel part of the overall statistics team and be provided with recognised feedback mechanisms to enable their participation in the structuring and implementation of surveys. To enable this, field staff should attend workshops and training courses concerning operational aspects of data collection, since their operational experience would contribute positively in survey planning and the revision of survey design.

1.5 Role of office staff

Primary data collected by field staff are of little or no utility unless there is appropriate statistical office infrastructure. The responsibilities and functions of statistical office staff are:

1.5.1 Design and planning

Design and planning of fishery surveys, including implementation scheduling, training, equipment and logistics support and the 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 as 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 Processing and Dissemination

Statistical office staff should be trained in basic statistical analysis for the preparation of statistical reports and the correct interpretation of statistical indicators and diagnostics. Although some compilation and filing of raw data may be paper-based it is more usual that robust and user-friendly computing tools and methods, and adequate computing capacity, are available for routine and ad hoc processing, analysis and dissemination of fishery statistical data to fishery managers and other national, regional and international user groups.

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 important role of office staff and equipment for the effective analysis and dissemination of fishery statistical data.

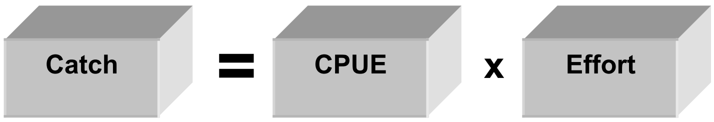
2. CONCEPTS IN ESTIMATING CATCH

In this handbook there is no discussion of complete enumeration (=census) approaches for determining total catch, such as compulsory logbook data. In most small-scale fisheries the amount of information on total landings, species composition, prices, etc., is often large, highly distributed and difficult to collect so that the use of census approaches is impractical and sampling techniques are nearly always employed. Some exceptions occur in estimating total fishing effort and a detailed discussion on alternative approaches is given in Section 3.

This section describes a generic approach for estimating total catch from basic fishery sample data. Such estimation can be performed against any reference (= estimation context), most commonly a combination of a) a geographical stratum, b) a reference period and c) a specific boat/gear category. The estimation of secondary data such as catch by species, values and average fish size are also presented on the basis of the estimated total catch.

2.1 A generic formula for estimating catch

Total catch can be estimated from sample CPUE multiplied by estimated effort.



where:

- **Catch** (total)

  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) and c) a specific boat/gear category.

- **CPUE** (sample, overall Catch-Per-Unit-Effort)

  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.

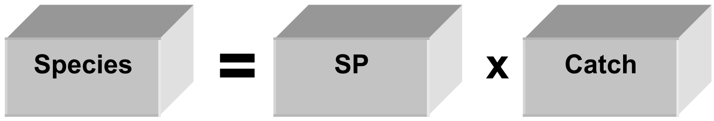
- **Effort** (estimated from sample)

  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.

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:



where:

- **Species catch**

  is the estimated catch for each species within the estimating context described earlier.

- **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.

- **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:

Value = **P** x **Species**

where:

- ***P*** is the sample first-sale price of a landed species.
- ***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 and sample data

Estimating context: *Lake Volta, Area VII, February 2001, Gillnets*

Estimated effort = 1,000 boat-days

Sample overall CPUE = 10 kg/boat-day

Species 1

Proportion of species 1 in samples = 60%

Sample price of Species 1 = 5,000 Cedis/kg

1,000 fish found in sub-samples of 500 kg

Species 2

Proportion of species 2 in samples = 40%

Sample price of species 2 = 6,000 Cedis/kg

1,000 fish found in sub-samples of 800 kg

B. Estimations

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

Species 1

Catch of species 1 = 6,000 kg (from 2.2.1)

CPUE = 6 kg/boat-day

Value of species 1 = 30,000,000 Cedis (from 2.2.2)

Average weight of Species 1 = 0.5 kg

Species 2

Catch of species 2 = 4,000 kg (from 2.2.1)

CPUE = 4 kg/boat-day

Value of species 2 = 24,000,000 Cedis (from 2.2.2)

Average weight of Species 2 = 0.8 kg

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 statistics. The following points have been emphasized:

(a) All estimations are performed within the 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.

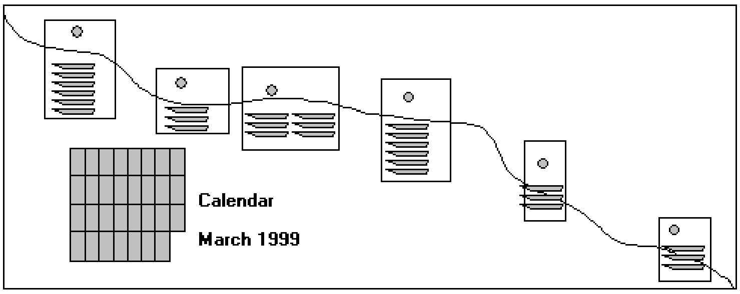
(e) Total values for landings are computed on the basis of estimated species values.

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 numerical example given earlier, which applied the generic approach for estimating total catch, it was assumed that total fishing effort was known. There are four approaches to the estimation of fishing effort: 1) complete enumeration through census of fishing activities; 2) census in space and sampling in time; 3) sampling in space and census in time; and 4) sampling in both space and time. Their applicability depends on the local conditions within the region as well as on the human capacity 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. All features are shaded - all fishing sites along the coast, all boats at each fishing site and all 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

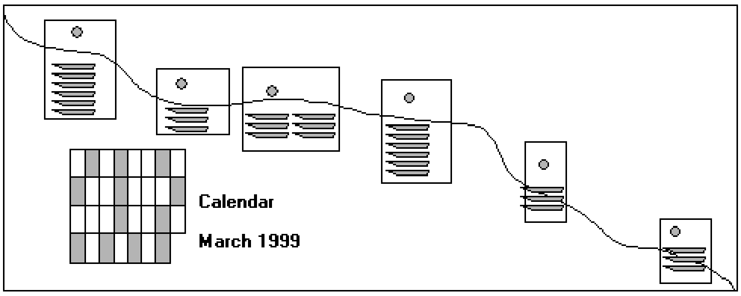
This approach is feasible when:

- Fishing units are concentrated at few locations.
- A mechanism is in place for obtaining exact records of all fishing units that are active (= fishing) on each and for every day of the reference period. This may involve the port authorities, vessel operators, and a sufficient number of recorders to carry out the work.
- 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

Since complete enumeration covers all sites, vessels and days, the census approach is not strictly sampling (although it may be an approach used for Frame Surveys, see section 8.) and contains no sampling errors.

3.2 Census in space, sampling in time



3.2.1 An illustrated example

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

3.2.2 Type of approach

This approach is similar to the census approach but with a limited number of days during which data is collected, 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:

- ***AverE*** is the average fishing effort in boat-days over the sample days.
- ***A*** is a raising factor expressing total number of days of fishing activities during the month, i.e. it is calculated each month.

3.2.4 Reliability of estimate

Reliability of the estimate for fishing effort depends on:

- The accuracy with which the mean effort ***AverE*** has been formulated.
- The correctness of the raising factor ***A***.

3.2.5 Applicability

The census in space - sampling in time approach is recommended when:

- The level of activity of fishing units is more or less regular during the month and ***AverE*** is good enough to be considered as representative.
- The raising 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.

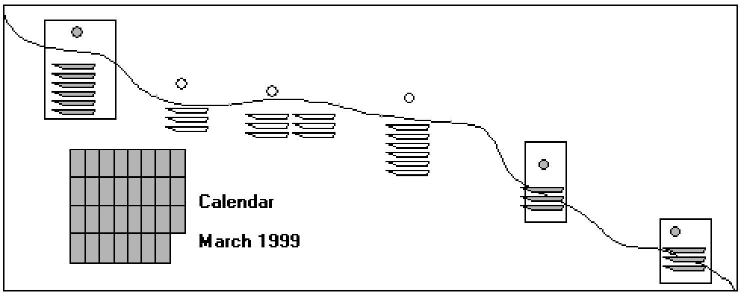
3.2.6 A numerical example

In January 2001 a complete enumeration of fishing effort at all locations was conducted on each of 10 pre-selected days, excluding four Sundays during 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 raising 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

Census in time and sampling in space is illustrated in the figure above. Three fishing sites are shaded as participating in the samples. Sampling at these three sites takes place every day, 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 fishing sites.

3.3.3 Staff time

It is also assumed that there is availability of staff time for daily collection of information from the selected sampling locations; i.e. 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:

- ***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.
- ***F*** is a raising factor expressing the total number of fishing units that are *potentially operating* at all fishing sites (i.e. the overall geographical stratum).

3.3.5 Reliability of estimate

The reliability of the estimate for fishing effort depends on:

- The accuracy with which the mean fishing unit effort ***AverF*** has been formulated.
- The correctness of the raising factor ***F***.

3.3.6 Applicability

The census in time - sampling in space approach is recommended when:

- Monthly effort ***AverF*** of a single fishing unit operating from the sampled sites is also representative enough for the entire statistical area.
- The raising 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 during a Frame Survey.

3.3.7 Evaluation of approach

This approach is less robust because the raising factor ***F*** must be obtained through a frame survey which is conducted, at best, on a yearly basis. In comparison to scenario 3.2 discussed earlier, the 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 1,000 gillnet canoes operating from 20 fishing sites, i.e. F = 1,000.

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

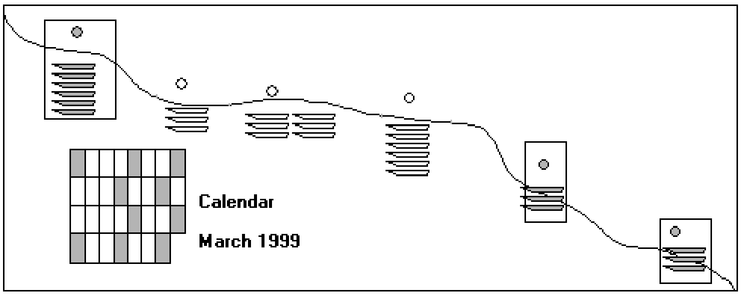
The sampled 40 canoes was found to operate for 800 boat-days, thus the average effort of a single canoe during January 2001 was:

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

In this approach three fishing sites are sampled over 10 days during the month.

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:

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

- ***F*** is a raising factor expressing the total number of fishing units that are *potentially operating* at all fishing sites (i.e. the overall geographical stratum as already discussed in 3.3).
- ***A*** is a raising time factor expressing total number of days with fishing activities during the month (already discussed in 3.2).

3.4.3 A numerical example

Assume that in the province of Fako in Cameroun during April 2001 a fishing effort survey was conducted for gillnets. The last Fako frame survey was conducted in June 1999 and reported that *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 all days in the month ought to be considered without exception as days with fishing activities, i.e. A=30 days.

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

- 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.
- If 400 boats are expected to be active on any day then the expected boat-days over the month will be: 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

- This approach is the most economical since it requires that effort data are collected only from a few locations and only during selected days.
- 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 four different approaches for the estimation of fishing effort were presented with the following characteristics:

(a) When feasible the census approach is the most accurate in calculating total fishing effort (Approach 3.1).

(b) When the census approach cannot be done sampling operations are unavoidable, and 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.

(e) 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. The mechanics for collecting the data required for formulating the above effort parameters is discussed in more detail in the coming sections that deal with the operational aspects of sample-based fishery surveys.

4. GENERAL SAMPLING CONSIDERATIONS

Choosing to undertake sample-based surveys is based primarily on the recognition that complete enumeration through census-based surveys imposes huge costs that are both unsustainable and unnecessary if the nature and methods of statistical sampling are properly considered. Such considerations include understanding of:

- the reasons for and objectives of sampling.
- the relationship between accuracy and precision.
- the reliability of estimates with varying sample size.
- the determination of safe sample sizes for surveys.
- the variability of data.
- the nature of stratification and its impact on survey cost.
- the risks posed by biased estimates.
- the differences between “boat” and “gear” statistical approaches.

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 outlines the logistics problems and costs involved in census-based surveys.

4.1 Census costs and objectives of sampling

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

1) There would 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 (species composition, weight, etc) (Note that there

will be no need for a separate survey for fishing effort, since all trips will be recorded.)

2) 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 minimum of 240,000 minutes (4,000 work hours) will be needed.

3) 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. This assumes that such a level of data collection is feasible and that landings and hence fisher availability is spread evenly over the day.

4) In addition to the costs of data collectors there would also be the costs of a) supervision, b) data editing, checking and inputting for 24,000 landings per month, and c) computer data storage for 12 x 24,000 = 288,000 landings per year.

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.

Thus there are three objectives of a sampling programme:

- to examine **representative** sub-sets of the data with the purpose of producing **estimates** of parameters, such as CPUE, prices, etc, that are as close as possible to the ‘true’ values that would be obtained through complete enumeration.
- to reduce operational costs.
- to reduce analytical and 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 Sampling Accuracy

- Sampling accuracy is usually expressed as a relative index in percentage form (i.e. between 0 and 100%) and indicates the closeness of a sample-based parameter estimator to the true data population value.
- When expressed as a relative index, sampling accuracy is independent of the variability of the data population, i.e. data population parameters of high variability can still be estimated with good accuracy.
- When sample size increases and samples are representative, sampling accuracy also increases. Its rate of growth, very sharp in the region of small samples, becomes slower beyond a certain sample size.

4.2.2 Sampling Precision

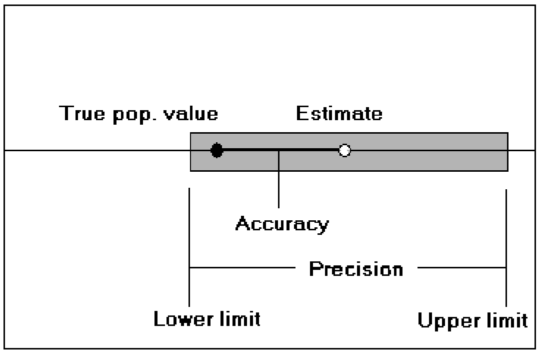
Sampling precision is related to the variability of the samples used. It is measured, in reverse sense, by the coefficient of variation (CV), a relative index of variability that utilizes the sample variance and the sample mean.

The CV index also determines the confidence limits of the estimates, that is the range of values that are expected to contain the true data population values at a given probability.

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 lower or higher than the true data population value.

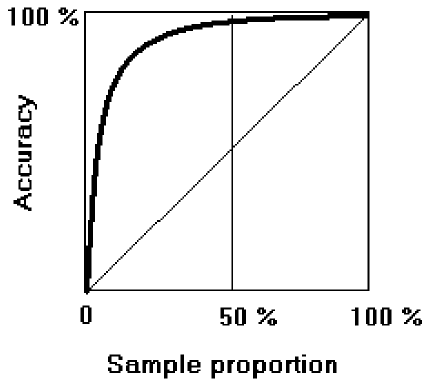
When sample size increases precision also increases as a result of decreasing variability. Its growth, very sharp in the region of small samples, becomes slower and steadier beyond a certain sample size.

The figure below 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 as necessary.



4.3 Accuracy as a function of sample size

The following diagram illustrates the pattern of accuracy growth when sample size increases (see also table 4.5).



To be noted that:

- Accuracy is 100% when the entire population has been examined (as in the case of a census).
- The pattern of accuracy growth is not linear. The accuracy of a sample equal to half the data population size is not 50% but very near to 100%.
- Good accuracy levels can be achieved at relatively small sample sizes, provided that the samples are representative.
- The result of this relationship is that 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 is the limited budgetary and human resources for data collection. Such constraints have direct impacts on the frequency and extent of field operations for data collection and demand the development of cost-effective sampling schemes. Therefore, during survey design it is better to establish accuracy indicators so that sample sizes can guarantee an acceptable level of reliability for the estimated data population parameters. This is at times difficult, since at the outset little may be known about the distribution and variability of the target data populations. Until some guiding statistical indicators become available statistical developers will tend to require large samples which increase the size and complexity of field operations and data management procedures.

Formulation of *a priori* indicators for sampling accuracy during the design phase is feasible and may be achieved by:

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

4.4.1 Target data populations

In the estimation of total catch and fishing effort (Sections 2 and 3), the two target data populations in sample-based catch/effort surveys are:

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

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

The above two data populations have different sampling requirements for achieving the same level of accuracy. The next paragraph provides more detail on 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 desired accuracy level for a sampling and estimation process depends on the subsequent use of the statistics and the amount of error that users are willing to tolerate. In general, experience indicates that the accuracy of basic fishery estimates should be in the range 90% - 95%.

The table below illustrates safe sample sizes required for achieving a given accuracy level for two target data populations, boat activities and landings.

Table 4.5 Sampling requirements at varying accuracy levels
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	1,067	356
98	2,401	800
99	9,602	3,201

From the table above the following conclusions can be made:

- Sample requirements for boat activities are about three times higher than those for landings.
- For a general sampling survey accuracy level of 90%, 32 landing records and 96 boats' state of fishing activity records are required.

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. The process of determining safe sample size at a given level of accuracy must be repeated for all estimating contexts with the view to determining overall sampling requirements.

4.6 Variability indicators

As already mentioned earlier, the second important statistical indicator is related to precision or, in reverse terms, to variability. The *Coefficient of Variation* (CV) is the most commonly used relative index of variability, usually expressed in percentage (i.e. 10%, 15%, etc). Experience indicates that CVs below 15% are indicators of acceptable variability in data samples. When very low variability (e.g. 0.1%, 0.5%) is repeatedly reported these results may be suspicious. Although this may indicate a very homogeneous data population, it may also be an indication of biased samples.

There are standard methods for explaining the overall variability in space and time. This is useful when it is feasible to increase sampling operations with the view to 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. Reducing variability in estimates can also be addressed through the stratification of sampling (see below and section 5).

4.7 Stratification and its impact on survey cost

4.7.1 Definition

Stratification is the process of partitioning a target data population (e.g. all fishing vessels) into a number of more homogeneous sub-sets based on their characteristics (e.g. trawl, gillnet, purse seine; or large, medium, small; or commercial, artisanal, subsistence). Stratification is normally undertaken for the following reasons:

- For statistical purposes (e.g. to show the difference in catch by vessel type) and when there is a need to reduce the overall variability of the estimates. For example, catch rates will differ greatly between vessels of a similar type but of a different size, therefore sampling of each size class separately will enable the preparation of meaningful statistics. If all vessel size classes are ‘lumped’ together - i.e. not stratified - then, say, average catch is not meaningful for any one size class.

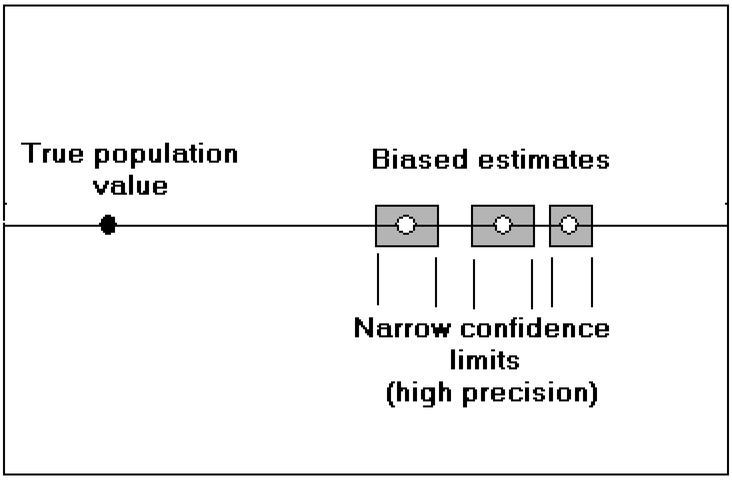
- For non-statistical purposes (e.g. different geographic regions) and when current estimates are not meaningful to users of the statistics unless estimates are shown separately.
- At times stratification is “forced” due to administrative needs such as limits to data collection and reporting.

4.7.2 Impact on costs

The implementation of sampling stratification can be an expensive exercise and should always be applied with caution because all new strata need to be covered by the sampling programme. Introducing a large number of strata may have serious cost implications because the overall accuracy of the estimates will not be increased if data collection effort is kept at the original level, even though the results from strata will be more homogeneous than the original data population. In general, more strata means greater sampling costs, although obtaining better value (= statistical accuracy) for money.

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 sampling scheme with three strata would need three times more samples for achieving the desired accuracy, hence greater costs.

4.8 The problem of biased estimates



4.8.1 An illustrated example

The figure above illustrates in basic terms the problem of bias. Biased estimates may be found systematically above or below the true (but unknown) population value (here all estimates are shown higher than the true value). 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

Biased estimates are systematically lower or higher than the true population value, generally because they are derived from samples that are not representative of the data population. Bias is not easily detectable and at times not detectable at all. Consequently users may be unaware of the problem since they also do not know the true population value.

Precision (or the relative variability indicator CV) cannot be used to detect bias. However, repeated cases of extremely small variability (e.g. CV<1%) may be indications of a biased estimate.

Although attempts to increase the representativeness of samples are often compromised due to operational constraints, the best approach to the reduction of bias is through the application of appropriate stratification.

4.9 Need for representative samples

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. For the collection of effort data, sampling should always be undertaken from a random selection of fishers without prior knowledge of whether they have been fishing or not.

When boats land within a short period, recorders at times tend to sample those with a small catch in order to cover as many landings as possible. Also, if landings occur over longer periods and recorders must visit other sites during the day, only the first landings at the first site will be sampled. These selections may introduce negative bias in CPUEs, species composition and prices. Therefore, care should always be taken to sample from a random selection of landings at random times.

4.9.2 Selection of sampling sites

In medium and large-scale fishery surveys the major task in obtaining representative samples is at the first sampling stage through selection of the locations where data will be collected. Often, a good approach is to select sampling sites on a rotational basis as part of an overall sampling strategy. Field teams would then cover the chosen sampling locations by visiting all of them at appropriate times, say once a month. Such an *a priori* selection of sampling sites enables planning for sufficient and mobile human resources.

When there are other operational constraints (accessibility, availability of data collectors, limited mobility, etc.), a planned rotational approach may not be feasible and data collection may be performed from sampling sites at fixed locations for long periods. The problem is that pre-selection of sampling sites runs the risk of biased samples if the landing sites are not representative of the entire statistical area.

4.9.3 Criteria for selecting sampling sites

Frame surveys and existing geographical information are used to make *a priori* selection of fixed sampling sites. The main criteria in selecting sampling sites are:

- Sampling sites should provide a satisfactory geographical coverage of the statistical area. Limited human resources or transport will usually be the major operational constraint to this coverage.

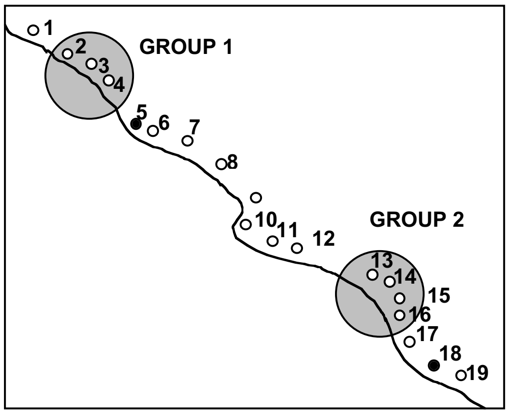
- Original frame surveys of the numbers of boats (fishing units) by site and boat/gear type will indicate the relative importance of sites in terms of potential fishing effort (i.e. very important, important, less important, etc.). Sampling sites should represent all boat/gear types involved in the survey, and sampling should focus on sites with larger numbers of fishing units.

4.9.4 Example

Rather than examining sites on an individual basis, planners may look at *groups of sites* that offer a better statistical coverage because of their proximity. Criteria for grouping several sites together are:

- whether a recorder can visit all grouped locations within the periodic (e.g. daily) sampling schedules.

- whether the group of sites contains sufficient fishing units from most or all boat/gear types.



The figure above illustrates a minor geographic stratum with 19 fishing sites. 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 grouped they can offer better statistical coverage. Thus, if planners consider the two sampling options from:

- Sites 5 and 18, or
- 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

Determining the fishing unit (boat or gear) that will be the subject of sampling operations is a major decision in planning sample-based fishery surveys.

4.10.1 The “boat” approach

The fishing boat as statistical unit is the commonest approach because:

- Frame surveys usually provide numbers of boats by boat/gear type, which can then be used for in-space raising factors for estimating fishing effort.
- Fishing activity level is most often measured by the Boat Activity Coefficient (BAC), which expresses the probability that any boat will be active on any day.
- Catch Per Unit of Effort (CPUE) is often expressed as the average catch per day of a boat of a certain boat/gear type.

4.10.2 The “gear” approach

Alternatively the fishing gear type can be used as the statistical unit, e.g. 100-metre gillnet units, 500-hook line units, 100-metre beach seine units or traps, etc. This approach can be used when:

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

4.10.3 Comparison of the two approaches

Overall, the “boat-specific” approach is more advantageous than the “gear-specific” because:

- Frame surveys of gear numbers are more complex, more demanding in staff time and become less accurate over time since fishing gears change more frequently than fishing boats.
- Gear activity level is far more difficult to measure, and the relative variability of “gear-specific” estimated parameters is not lower than “boat-specific” ones.
- 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 general aspects of sampling methods have been discussed, including:

(a) The reason for and objectives of sampling: sampling techniques can provide estimates of good reliability and are more economical than census approaches.

(b) The appropriate context of the terms accuracy and precision: Accuracy is a measure of closeness of an estimate to the true data population value, while precision is related to its variability. Both are functions of sample size.

(c) Safe sample sizes can be determined on an a priori basis, and separately for landings and effort surveys.

(d) The interpretation of variability indicators 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

The definition and application of survey standards are key features of the methodological and operational framework of a sample-based fishery survey. Setting up survey standards includes the processes of stratification and classification.

Stratification of the domain to be covered by the statistical programme will include decisions on:

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

Classification of the units that will be measured, including:

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

Well-defined survey standards help in streamlining field operations, facilitating computerization, producing consistent reports and integrating survey outputs with the results of other application domains. Poorly defined standards have a negative effect on field operations, computer operations and on the meaning of produced estimates.

5.1 Stratification

5.1.1 Objectives of stratification

Stratification methods are applied in cases of:

- the need for more homogeneous target populations, which will provide lower variances in the estimates.
- categorization of the data population in order to respond to specific user needs.

- “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 into administrative or reporting strata, also called *major strata*. It should be noted that:

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

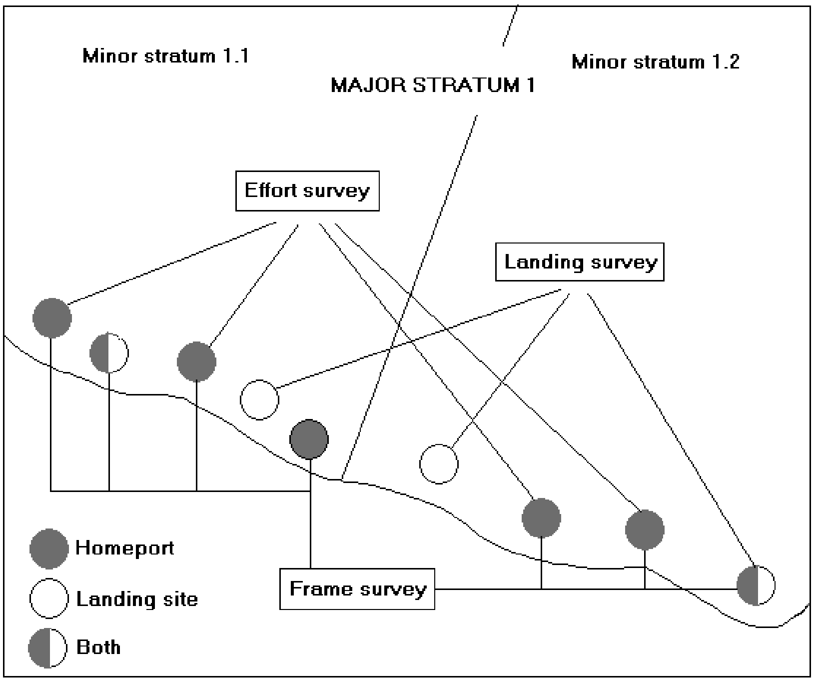
5.1.3 Minor strata

Within each major stratum there exist “logical strata” that constitute the estimation contexts of the survey. These sub-divisions are called *minor strata*. It should be noted that:

- A minor stratum in a major stratum cannot be associated with another major stratum.
- Minor strata are not limited to geographical areas. They can refer to any logical estimation context including sub-periods within a month, to fishing grounds or fishing vessels. An important fishing location can itself constitute a minor stratum, if estimates are required at that level.
- Minor strata are controlled by the survey designers, and their purpose is to improve the quality and utility of estimates.
- Excessive division of potential data sources/types into minor strata can compromise the cost-effectiveness of a sampling programme.

5.1.4 Homeports and landing sites

Homeports are locations from which fishing boats operate, i.e. where they are based. Individual boats may use one or more landings sites, including the homeport. The homeport is always the basis for reporting the numbers of fishing boats and gears in frame surveys, and for the estimation of fishing effort.



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

- Frame surveys are conducted at all homeports (shaded locations).
- Effort surveys are conducted at homeports selected for sampling.
- Locations can be both homeports and landing sites (half-shaded).

- Landing surveys are conducted at landing sites selected for sampling (white or half-shaded).
- Estimates are produced at minor stratum level.
- 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:

- *Level of detail required:* This depends on the feasibility of data collection operations in frame surveys and effort surveys.
- *Uniformity:* Landing surveys, frame surveys and effort surveys must all use the same boat/gear classification.

The criteria for defining boat/gear types are usually based on known (or assumed) significant differences in:

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

5.2.2 Species classifications

The criteria for defining species classifications are usually based on the need to prioritize statistical monitoring of catches for:

- Commercially important species or species groups.
- Species that are important in certain areas to the local people.
- Species of particular biological interest.

5.2.3 Measurement units

Standard measurement units must be consistent throughout the statistical programme. Weight should normally be recorded in metric units, usually the kilogram.

In surveys for basic fishery data there is often a need to easily integrate catch and effort estimates deriving from different boats and gears. For small-scale fisheries the *boat-day* is a reasonably good way of expressing fishing effort uniformly.

5.3 Validity of survey standards over time

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 should be valid for a complete operational cycle, usually a year, after which period they may be reviewed.

Validity problems may occur after the first few months of survey implementation if changes are required to stratification schemes or to boat/gear or species classifications. However, as shown in table 5.3.3 below, modifications and changes to survey standards in the middle of an operational cycle are permissible when they do not affect the consistency of the survey framework.

Table 5.3.3 Implications of changes in survey standards 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 the concept of survey standards was discussed.

(a) Survey standards are the methodological and operational framework of a sample-based fishery survey through:

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

(b) Well-defined survey standards help in streamlining field operations, facilitating computerization, producing consistent reports and integrating the survey outputs with those from other application domains.

(c) Poorly defined standards have a negative effect on field operations and on the meaning 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.

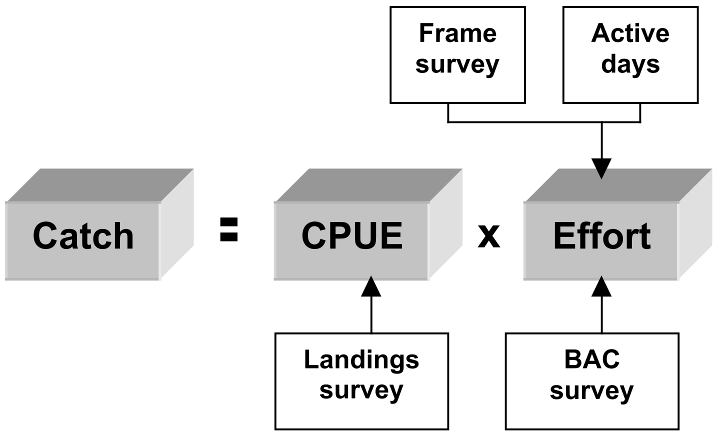
6. SURVEYS FOR BASIC FISHERY DATA

This section extends the concepts of catch estimation outlined in sections 2 and 3 by looking at the generic expression for estimating total catch using the CPUE and Effort parameters, and the four different survey schemes (in time and space) that may be used to estimate these parameters.

Supplementary guidelines are also presented, relating to commonly used basic fishery data collection systems, including:

(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 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 above diagram also corresponds to the most economical sampling approach outlined in Section 3.4. (All surveys and estimates are made within the estimation context or stratum.) This sampling in space and time approach consists of the following four surveys:

Fishing effort

- A census-based *Frame Survey* providing the raising factor ***F*** that expresses the total number of boats.
- An *Active Days Survey* to determine a time raising factor ***A*** expressing number of days with fishing activities.
- 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.

Overall CPUE

- A sample-based *Landing Survey* to determine sample overall ***CPUE***s (usually at the same time as other data on species composition, prices and average weight per species).

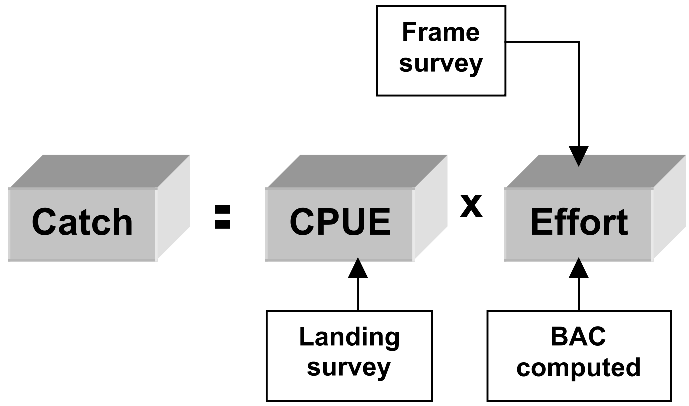
The generic formula for estimating catch is thus:

$$Catch = CPUE \times [BAC \times F \times A]$$

Where:

- ***CPUE*** is estimated from a *Landings 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 now three types as follows:

Fishing effort

- A census-based *Frame Survey* providing the raising factor ***F*** that expresses the total number of boats.
- A Census in time on selected sites to determine the total fishing effort and mean effort ***AverF***, which 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 the month.

Overall CPUE

- A sample-based *Landing Survey* to determine sample overall ***CPUE***s (usually at the same time as other data on species composition, prices and average weight per species).

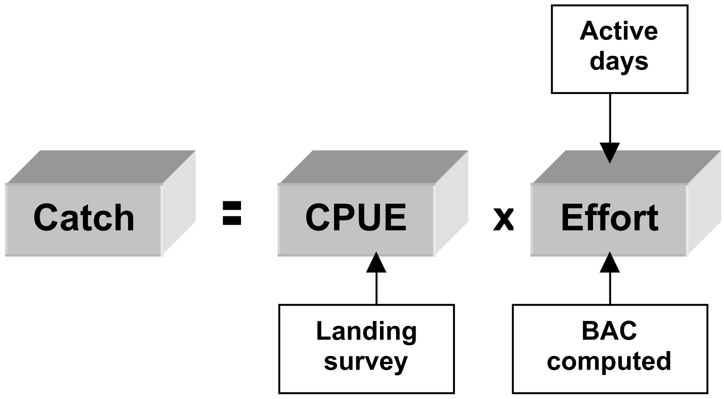
The formula for estimating catch remains:

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 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***.
- A survey (or exercise) to determine a time raising factor ***A*** expressing number of days with fishing activities.

Overall CPUE

- A sample-based *Landing survey* to determine sample overall ***CPUE***s (usually at the same time as other data on species composition, prices and average weight per species).

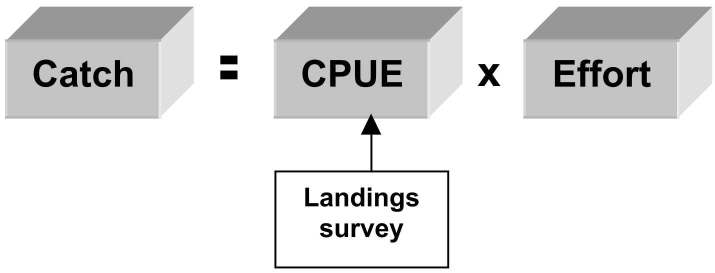
The formula for estimating catch remains:

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.

Overall CPUE

- A sample-based *Landing Survey* to determine sample overall ***CPUE***s.

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

Catch = CPUE x Effort.

6.5 Brief discussion on the four generic surveys

Catch estimation can be made through the use of between 1 and 4 different survey types, combined with census estimates where necessary.

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. Frame Survey basic characteristics are:

- It must be conducted to cover all homeports, all fishing boats and gears and in accordance with pre-set survey standards and categories. It is thus a census-based approach.
- It should be conducted as often as possible to record any fundamental changes to the distribution of boats and gear, but in practice it may only be conducted on a yearly basis.
- In addition to the data required for the estimation of fishing effort it can provide much other useful information on the socio-economics of fishing communities and also for planning field data collection 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 carried out at the end of the month, when all sampling has finished and estimates are about to be produced. It provides a time raising factor for estimating total fishing effort. Active Days Survey characteristics are:

- 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.
- It does not account for individual variability of boat activities (this is the role of BAC). It refers to days for which there are no reasons to assume that fishing activities are below normal level.
- Examples of not active days are periods of bad weather, national or religious holidays, standard non-working days such as Fridays, Saturdays, Sundays, market days, etc.
- 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 example, in the same area bad weather may affect boats using purse seine and not the beach seines. Or, bad weather may affect gillnet fishing in one area but not in another.
- Determining Active Days is simplified if sampling in time (landings and/or effort) is frequent enough to cover 12-15 days of the month, which gives sufficient days for low or zero activity to enter the samples. In this case the total number of days in the month is used as raising factor.

6.5.3 Boat Activity Survey

The sole objective of this sample-based survey is to formulate the Boat Activity Coefficient (BAC). Boat Activity Survey characteristics are:

- This survey is always conducted at homeports. BAC is formulated separately for each boat/gear category and in accordance with survey standards.
- BAC accounts for the individual variability of boat activities and is determined by examining an appropriate number of boats and finding out how many have been active on a given day.

6.5.4 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 one day. Active Days Surveys, 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.

Example 1

	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																														

The above diagram illustrates fishing activities of a hypothetical fishery of five boats A, B, C, D and E. Fishing is indicated by a shaded area, non fishing is blank. The BAC for this group of boats 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 data population of boat status indicators consists of 5 boats x 30 days = 150 elements, of which 30 days represent fishing. Thus;

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

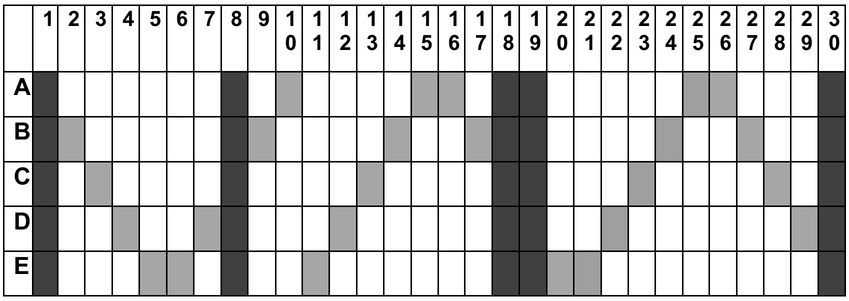
The number of boats expected to be fishing on any day is

- ***0.2 x 5 = 1***, a fact that is immediately verified by the diagram.

In this example all days in the month are potentially fishing days; i.e. 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 diagram.

Example 2



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

The main objective of sampling through a Landings Survey is to formulate the overall CPUE used in the generic formula for estimating total catch landings. Surveys can also provide secondary data on species composition, prices at landing, average weight by species and other data. Its basic characteristics are:

- It is always conducted at landing sites and may record landings of boats operating from different home port locations.
- Landings are reported separately for each boat/gear category and in accordance with survey standards.
- It requires skilled staff for species identification and accurate recording of fish weights.

SUMMARY

In this section survey requirements in the most commonly used data collection systems for basic fishery data were presented, including how catch estimates can become more reliable using the same generic formula by replacing sampling components with census approaches; that is replacing the cheaper sampling method with the more expensive, full data coverage method of the census.

The following four generic surveys outlined were:

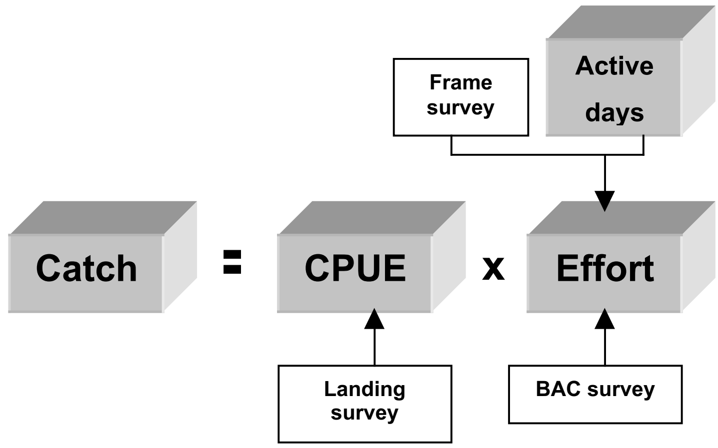
Fishing effort

- Frame Survey
- Active Days Survey
- Boat Activity Survey

Overall CPUE and secondary landing data

- Landing Survey

7. ACTIVE DAYS SURVEYS



7.1 Objective

Active Days Surveys are usually 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 raising factor for estimating total fishing effort.

7.2 Data recording

The following theoretical example illustrates a simple way of recording Active Days for each estimation context (minor stratum, month and boat/gear type) through discussions with fishers at the end of each month, since Active Days do not remain constant over time.

In the example there are two minor strata (SW Coast and NE Coast) and five boat/gear types, comprising gillnets, beach seine, hook and line, traps and shrimp trawlers. Each combination of minor stratum – boat/gear type requires an indication as to the number of active days to be used as time raising factor for the given survey period.

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

To be noted that:

- Each raising factor is determined by removing the number of days with uniform inactivity from the number of calendar days (in this case 30 for June),
- Active Days are boat/gear-specific and area-specific. Events affecting a stratum or a boat/gear category may not be affecting others.
- Days of non-activity should not be confused with individual boat activities that are the object of BAC (see section 9). 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.

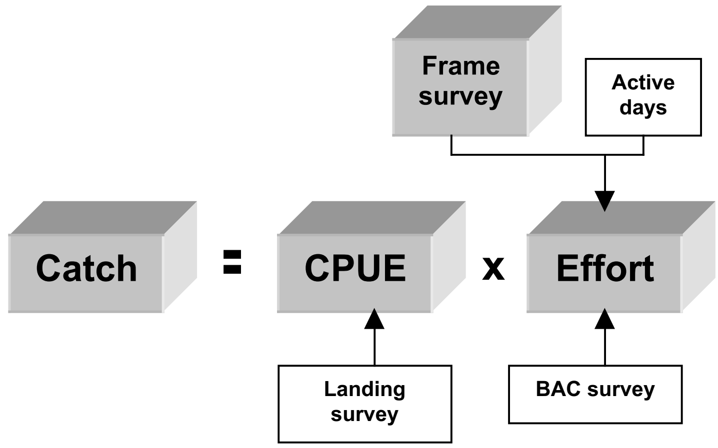
It is possible that an event will affect only part of a fishery. For instance, bad weather may only affect half of the boats of a certain category. For the boats with traps in SW Coast bad weather affected only half of them, meaning that only one day (or two half days) were subtracted from 30. Such refinements are of course useful but not always feasible.

SUMMARY

In this section supplementary guidelines regarding the use of time raising factors known as Active Days were considered, noting that:

- Active Days are very important and greatly affect the estimation of total fishing effort.
- Active Days express, in a uniform manner, periods during which fishing activities can potentially occur. In contrast to Boat Activity Surveys, they do not account for trip variability of individual boats.
- Active Days are area- and boat/gear-specific.
- 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 by reviewing the objectives of frame surveys and discussing survey preparation, implementation and application in the process of estimating fishing effort.

8.1 Objectives

A Frame Survey is a census-based approach in which data is collected on all fishing vessels and gear (at all homeports/fishing sites), which could be *potentially operating* within the estimation context or stratum,

Usually, Frame Surveys also provide the opportunity for recording supplementary information useful for planning and implementation purposes, such as fishing trip patterns and seasonal use of fishing gear. They can also be used to provide information on the socio-economics and demography of fishing communities.

8.2 Sites and boat/gear classifications

Prior to implementing a Frame Survey users must decide on a general framework regarding the homeports (hence the geographical strata) and the 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.

During, or as a result of, a Frame Survey, information may be collected that will demonstrate a need to include more homeports than previous surveys, or to exclude homeports that are no longer relevant. Similarly, fleet and operational changes since a previous survey will indicate a need to include new boat/gear categories or to group some categories together.

The immediate task after a frame survey has been completed is to finalize the list of homeports and boat/gear types as survey standards, which should then be used as the basis for the conduct of other surveys, including Boat Activity surveys, Active Days Surveys and Landings 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 fishers use one type of fishing gear during one fishing season and a different one during another season. Generally, multiple use of fishing gear may not depend on the season but are employed according to circumstances, that is one day fishing with gear A, next with gear B, etc., but not simultaneously. Such 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.

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.

The record of the total number of boats at this homeport would thus be:

Boats operating gillnets:	20
Boats operating traps:	10 + 5 = 15

8.4 Concurrent use of fishing gear

Sometimes fishing boats use two or more gears *simultaneously*. In such cases it is usually not possible to estimate the proportion of catch that has resulted from each gear separately, unless the different gears are targeting completely different species. For example, one boat might gillnet for small sardines while also setting lines for tunas thus enabling a statistical separation of catch and effort for these species/gear combinations. However, in another case, a boat might carry both trammel nets and traps for lobster and crab.

The problem of concurrent use of fishing gear (for similar species or species groups) cannot be solved statistically in a satisfactory manner. In practice the following methods of recording might be used:

- The predominant gear is used to describe the boat/gear type.
- Setting-up a new combination boat/gear category describing the combined use of different gears (i.e. Gillnet+Hook & Line).
- Describing all boats with such use of gear as “other”.

8.5 Forms for data collection

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

- Name of homeport.
- Date of recording.
- Name of data collector.
- 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.
- 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	Castnets	Other
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	**4**	**1**	**5**	**5**	
Gillnet +Hook & Line	**2**				
Remarks: All boats except those using traps land between 08:00 and 11:00 Boats with traps land between 14:00 and 16:00					

Notes on form:

- Boats C and D make concurrent use of Gillnets and Hook & Line. A new boat/gear type describing this combined use of gear is created since such cases are common for several homeports.
- The total number of boats using Gillnets is 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.
- Boats E and F were repeated to show sequential use of three different gears. In total there are 5 boats using Traps and 5 using Castnets.
- An 'Other' column is reserved for unforeseen boat/gear types.
- Remarks were included indicating normal landing times.
- 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

By definition frame surveys are census-based and may often demand a large number of data collectors, who may be employed on a temporary basis to supplement the activities of regular staff. Providing data collectors with precise and unambiguous instructions is fundamental for the reliability of the data obtained through Frame Surveys.

The following points are important in briefing data collectors:

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

- Clarifying the nature of boat/gear types, sequential and concurrent gear use, and whether new boat/gear types are significant or can be ignored, etc.
- Planning the visits to homeports.
- Methods for approaching and interviewing fishers and village authorities to obtain complete and reliable information on numbers of boat/gear types operating from homeports.
- Ways of cross-checking the obtained information and the appropriate course of action in cases of serious discrepancies.

8.7 Survey testing and implementation

Implementation of successful Frame Surveys needs careful planning because they are costly and will form the basis (possibly for several years) for many statistical estimations and for planning other surveys. The process of planning includes:

Pilot phase: small scale testing (e.g. within one or two homeports) to identify possible design and operational drawbacks and to assess likely timeframes for full-scale operations.

Test the entire sampling programme: combine the Frame Survey (including revisions) with pilot implementation of the entire sampling programme (normally 6-12 months) to ensure both meet their requirements.

Evaluation and revision phase: forms and classifications are revised and new instructions issued to data collectors.

8.8 Frame Survey data summaries

Frame Survey results are summarized prior to their use in supporting surveys, as in table 8.8 below.

Table 8.8 **Frame Survey - summaries by homeport and boat/gear type**

Minor Stratum	Home port	Gill net	Beach Seine	Hand line	Trap	GN+ HL	TP+ HL
		Single gear				Multigear	
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**

Notes on the summary form:

- The summary form contains all boat/gear types found in the entire statistical area (all strata) and at all homeports.
- Each sub-total at minor stratum level provides the raising factor ***F*** for estimating total fishing effort within the context of that minor stratum, calendar month and boat/gear type.
- Frame survey results are "static", that is they refer only to the period when the frame survey was conducted.

- Totals that refer to the entire statistical area are for information purposes only, not for the estimation processes resulting from other surveys.

8.9 Summaries with grouped homeports

Table 8.8 provides individual homeport information so that a sampling scheme (e.g. Boat Activity Survey) may change sampling locations and still have 'frame' information to do the appropriate raising at each site. However, sometimes operational and logistics constraints may mean that surveys need to be conducted at fixed, pre-selected homeports and used as representative of a minor stratum. This is undertaken by grouping homeport information and producing a frame summary that represents pre-selected homeports as in Table 8.9.

Table 8.9 Frame survey - summaries with grouped homeports

Minor Stratum	Home port	Gill net	Beach Seine	Hand line	Trap	GN+ HL	TP+ HL
		Single gear				Multigear	
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**

Notes on form:

- Sampling sites are fixed at SW Coast (Old Harbour and Pirates' Cave) and SE Coast (Airport, Blue Village and Windy Beach).

- In each minor stratum homeports that are not used in sampling are grouped under the name “UNSAMPLED” so that sub-totals at the minor stratum level are maintained.
- This approach is useful when there are long lists of homeports and only a few are used for sampling on a fixed-site basis.

8.10 Absolute and relative accuracy

The weakness of frame surveys is that they provide “static” information that it is valid only at the time of the survey - a “snapshot” of the fishery. Any significant changes to the fisheries, such as increases or decreases of fishing boats, introduction of new fishing gear, etc will affect the use of frame survey results as raising factors for estimating total fishing effort.

Since,

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,

if ***F*** is outdated and there are more boats operating, fishing effort will be underestimated, despite the accuracy with which ***BAC*** and ***A*** have been formulated. Similarly, if there has been a decrease in the number of boats since the last frame survey, total effort will be overestimated.

To ensure ‘absolute’ accuracy, Frame Surveys should be conducted on a monthly basis to synchronize with the regular sampling programme. However, in practice this is often not feasible and frame surveys are conducted, at best, on a yearly basis.

Some of these problems can be overcome by introducing calculations that measure the ‘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. The last frame survey reported that:

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

BAC was formulated during three selected sampling days as follows:

- Days 8, 13, 22 for homeport A
- Days 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 Comparison of Results of Frame and Boat Activity Surveys

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:

$$BAC = [(7+3+5)+(4+6+20)] / (3 \times 30),$$

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:

$$Effort = 45/3 \times (F/30) \times A = 45/3 \times (300/30) \times A.$$

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.

This approach requires that:

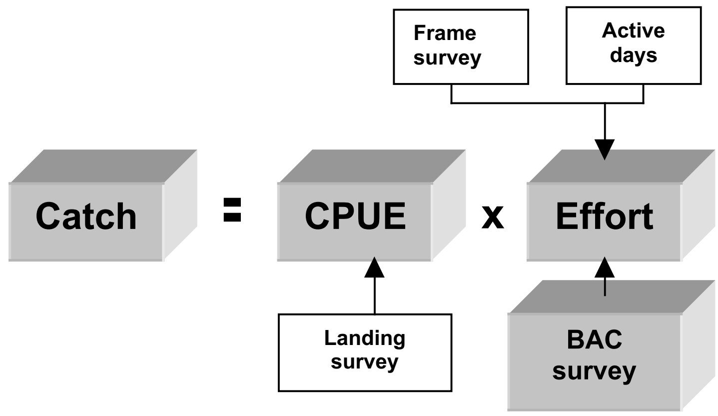
- All active boats must be counted.
- Active boats must be compared to their total number assumed by the frame survey.
- Homeports must be visited with the same frequency (same number of days).

SUMMARY

In this section frame surveys were reviewed, including:

- Objectives of frame surveys.
- Lists of homeports and boat/gear classifications.
- Methods for the recording of boats that use multiple gears.
- Examples of forms for the recording of primary data and for preparing frame survey summaries.
- Implementation aspects of frame surveys.
- Simplified frame survey summaries with grouped sites.
- Absolute and relative accuracy in frame surveys.

9. BOAT ACTIVITY SURVEYS



9.1 Objectives of Boat Activity Surveys

The primary objective of a Boat Activity Survey is the formulation of Boat Activity Coefficients (***BAC***), which represent the probability that a fishing unit of a given boat/gear type will be active on any day during a month. ***BAC***s are then combined with raising factors resulting from Frame Surveys and Active Days Surveys for estimating total fishing effort within a minor stratum, month and boat/gear category.

Boat Activity Surveys also assist in assessing the general accuracy of previous Frame Surveys through sampling (see section 8.10), as well as for recognizing significant changes in the fisheries.

9.2 Target data population and activity status

The target data population of a Boat Activity Survey is the activity status of all operating boats on all days of a reference month. 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.

Example: In a minor stratum during April (30 days) there are 100 gillnets. The target data population consists of 30 x 100 = 3,000 status elements for the month that are either 1 or 0. If the number of “active” (= 1) status indicators is 1,500, the ***BAC*** will be computed as 1,500/3,000 = 0.5.

9.3 Sampling requirements

The target data population is thus the number of fishing boats (as estimated by a Frame Survey) multiplied by the days in the month. Since the Boat Activity Survey is a sampling approach, the question is, How many of the target data population should be sampled to ensure that the estimate is representative of the entire data population? Or: What is the safe sample size for estimation of the BAC? (see also section 4. General Sampling Considerations).

Table 9.3 BAC sampling requirements at varying accuracy levels and data population size

Accuracy (%)	90	91	92	93	94	95	96	97	98	99
Data Population size	**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
*see notes **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

The above table indicates recommended sample sizes for estimating BAC at a desired level of accuracy. In a sample-based survey 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 (equivalent in one month to about 1800 boats in the stratum) their differences are practically negligible. For a graphic interpretation of the table see also Figure 4.3.

Notes on the table:

Sample sizes are interpreted as follows:

In the example given in 9.2 the data population ***BAC*** was 0.5. The data population size is 3,000 (100 boats x 30 days) and related safe sample sizes at varying degrees of accuracy are indicated in the highlighted line.

At a desired accuracy level of 95%,

- by the end of the month 341 boats should have been examined for activity status. Using 341 samples of examined boats, the sample ***BAC*** would be formulated by finding the number of active boats and dividing it by 341.
- 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 (in the example case).
- Assuming that sampling occurs during 10 days then about 35 boats should be examined on each sampling day in the minor stratum.

At a lower level of accuracy, to 90%,

- the corresponding sample size by the end of the month would be 93.
- At worst the data population BAC would be then estimated between 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

This is a commonly used approach for formulating ***BAC***s and has been addressed in detail in section 8.3. 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 total number is then divided by the total number of boats indicated by the Frame Survey. An example data collection form for this approach is given by Table 9.4.

9.5 Sampling for boat activities

In this approach no use is made of frame survey information. ***BAC***s 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 raising factors. An example data collection form for this approach is given by Table 9.5.

Table 9.4 **Boat Activity Survey - data form with Frame Survey data**

Boat Activity Survey		**Stratum:** SW Coast **Homeport:** Channel		**Recorder:** Samuelson	
Active boats					
	Trawlers	**Gillnets**	**Beach seines**	**Castnets**	**Traps**
Frame data	**10**	**30**	**9**	**12**	**11**
Day					
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					

Table 9.5 Boat Activity Survey - form showing sample numbers

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					

In the example 9.5 data recorders indicate the number of boats found active out of the number of boats sampled. For instance, 5/8 for trawlers means that 8 fishers were asked and 5 answered that they were fishing, while three specified that they were not. Therefore, the ***BAC*** for trawlers is:

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

The characteristics of the approach are as follows:

- It is recommended for large ports, when it is difficult for the recorders to identify all boats that were active, or in cases of frequent migration of fishers from one place to another.
- Boats should be sampled without prior knowledge on their activity. It would be wrong to approach fishers that are known to have been fishing on the sampling day, since they would all be found active.
- It is good practice to pre-select boats or fishers prior to visiting a site and then track down the activities of the pre-selected fishing units or fishers.

9.6 Combination with Landing Surveys

At times it is convenient to combine Boat Activity Surveys with Landings Surveys. This can be done using a single form as follows:

Landings form

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

Boat activities over last three days

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. In addition to landings information for effort parameters and species composition, the fisher was asked to specify if he went fishing on the three previous days. This was indicated by a 0 or 1 in the boxes printed on the right part of the form. The following three assumptions have been made:

- The fisher remembers his activities over the last three days.
- The same gear and boat were used (in theory this is not essential but data recording and transcription would be too complex).
- His homeport is also the landing site (again, to avoid complex data transcription).

The characteristics of the approach are as follows:

- It usually applies to boats that operate on a “one-trip-per-day” basis.
- Current day **should not** be included since all fishers will specify “YES-fishing” for that day.
- 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).
- It requires that the 0-1 answers are further elaborated and summed for other fishers to produce an inputting form similar to that provided in table 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 important in briefing data collectors:

- Explaining in full detail the recording forms, their use in data collection and their purpose and utility in the overall sampling programme.
- Clarifying the nature of boat/gear types, sequential and concurrent gear use, and whether new boat/gear types are significant or can be ignored, etc.
- Planning the visits to homeports.
- Methods for approaching and interviewing fishers and village authorities to obtain complete and reliable information on numbers of boat/gear types operating from homeports.
- Ways of cross-checking the obtained information and the appropriate course of action in cases of serious discrepancies.

9.8 Implementation aspects

Implementation of successful Boat Activity Surveys needs careful planning including:

Pilot phase: small scale testing (e.g. within one or two landing sites) to identify possible design and operational drawbacks and to assess likely timeframes for full-scale operations.

Testing of the entire sampling programme: combine a pilot implementation of the Boat Activity Survey with the entire sampling programme for catch/effort assessment (normally 6-12 months) to ensure both meet their requirements.

Evaluation and revision phase: forms and classifications are revised and new instructions issued to data collectors.

9.9 Frequent problems

9.9.1Timing of field activities

- When ***BAC***s 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".
- When pre-selected boats or fishers are used for sampling it would be better to visit homeports when most boats have returned.
- When pre-selected boats or fishers 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 fishers.

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, which might be sequential or concurrent. Sections 8.3 and 8.4 provide some guidelines on these aspects.

9.9.3 Migration of fishing units

The migration of fishing units distorts the presence/absence of boats at homeports and for this reason the sampling approach should be used for formulating ***BAC***s.

- If migration occurs within a minor stratum there will be no implications in the estimation of total fishing effort within that context.
- If migration occurs across strata, for some strata effort will be under-estimated while in others it will be over-estimated.

- If migration is seasonal and can be anticipated, frame surveys should reflect such boat movements.

9.9.4 Outdated frame surveys

Sampling at homeports for ***BAC***s should take place on an equal number of days, so as to rely on the relative accuracy rather than the absolute accuracy of Frame Surveys.

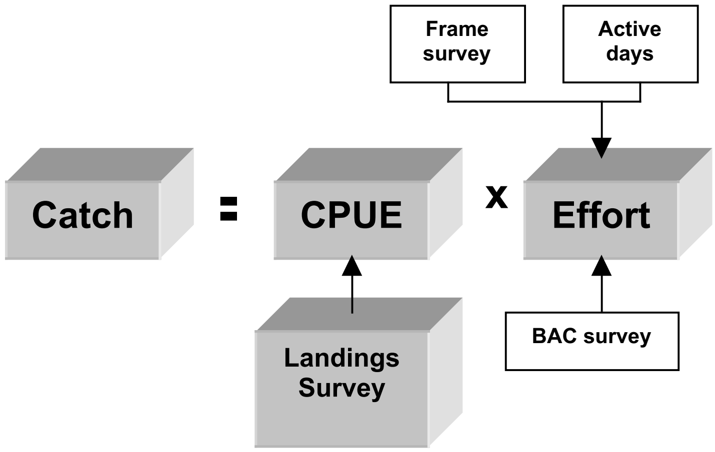
If no significant migration of boats has occurred and sampled homeports show a consistent increase or decrease of boats not accounted by Frame Survey information, this might indicate that overall increases or decreases have occurred to the fishery and a new Frame Survey should be implemented, or its present contents adjusted to reflect such changes.

SUMMARY

This section on Boat Activity Surveys completed the discussion on methodological and operational aspects of surveys that are involved in the estimation of total fishing effort using the Boat Activity Coefficient, including:

- Objectives of Boat Activity Surveys.
- Target population.
- Sampling requirements and safe sample sizes achieving a desired level of accuracy in the estimation of ***BAC***s.
- Commonly used sampling approaches.
- Need for training and effective briefing of data recorders.
- Pilot implementation, feedback and survey expansion.
- Frequent problems in Boat Activity surveys.

10. LANDING SURVEYS



In this section the methodological and operational aspects of sample-based Landing Surveys are presented, including:

- Objectives and basic data coverage
- Sampling requirements
- Example of a general-purpose form
- Case studies
- Training and briefing of data collectors
- Implementation aspects
- Data editing and checking
- Frequent problems

10.1 Objectives of Landing Surveys

Landings 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:

- Catch of all species
- Associated fishing effort
- Overall ***CPUE***
- Catch by species
- First-sale prices
- Number of fish in catch by species

The primary objective is to formulate, on a sample basis, overall ***CPUE***s 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

In Landing Surveys sampling requirements and safe sample sizes to achieve 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:

- Desired accuracy level (with a minimum of 90%)
- Data population size (above 50,000 the population of landings is considered 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 data population size.

Table 10.2 Landings Surveys sampling requirements at varying accuracy levels and data population size

Accuracy (%)	90	91	92	93	94	95	96	97	98	99
Data Population size	**Safe sample size for BACs**									
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
*** see notes 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

Notes on the table:

Sample sizes are interpreted as follows:

At a desired accuracy level of 95%, for a data population of 3000 (= 100 boats x 30 days) with an overall ***CPUE*** of 5 kg/day:

- 123 landings should have been sampled by the end of the month.
- 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.
- 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.

At a lower accuracy level of 90%, for the same data population of 3000 with an overall ***CPUE*** of 5 kg/day:

- the corresponding safe sample size is 32.
- At worst the overall ***CPUE*** would be then be estimated at between 4 and 6 kg/day.
- Assuming that sampling occurs during 10 days then about about 4 landings should be sampled on each sampling day from the sampling sites in the minor stratum.

10.3 A general-purpose form

There are five key areas that should form part of a Landings Survey form, although their detailed design depends on their data coverage and intended use. In the example below optional data are shaded.

Part A - Document identification

Part B - Sampling Activity

Date
Landing site
Minor stratum
Recorder's name

Part C - Fishing Operation

Boat/gear type
Number of Units landing
Duration of trip
Total landing

Part D – Species information

Landing by species
Price
Number of fish in sample
Sum of landings by species (control total)

Part E – Supplementary information and remarks

Part A - Document Identification

Landings Survey forms should always be identified to facilitate the organization and filing of hardcopy information, and cross-referencing between hardcopy forms and computer records.

Usually documents are identified by sequential numbers assigned as either:

- Pre-assigned numbers printed on the Landings Survey forms and distributed to data collectors. These numbers are also input during computer operations; or
- Numbers automatically assigned by the input procedure and then penciled on forms during input.

Part B – Sampling Activity

- **Date** (essential) - enables automatic grouping of landing data by month (or other period).

- **Landing site** (essential) - enables automatic grouping of landing data according to stratification criteria.
- **Stratum** (optional) - facilitates manual grouping of forms.
- **Name of recorder** (optional) - facilitates cross-checking, queries and evaluation of workload of data collectors. Its use is recommended.

Part C – Fishing operation

- **Boat/gear type** (essential) - directs grouping of data by boat/gear types as per survey standards.
- **Number of 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.
- **Duration** (essential) - specifies the number of days of a fishing trip. It affects sample effort.
- **Total landing** (optional). It is used when species composition is only a sub-sample of the total.

Part D – Species information

- **Landing by species** (essential) - Quantity of each species.
- **Price** (optional) - Highly recommended. When used on a sub-sample basis it provides prices and values by species and hence overall value of production.
- **Number of 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.
- **Sum of landings by species** (essential) - manually computed as a control total to avoid input errors. It is also the basis for raising the sample to total landings when only a proportion was used for species composition.

Part E – Supplementary information and remarks

Information on fishers, fishing units, events occurring at sites, etc.

Example of 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**
Number of Units:	**1**
Duration:	**3**
Total landing:	**45 kg**

D. Species Information

Species	Quantity (kg)	Price (1000 C/kg)	Value (1000 c)	Number of 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.

The data on this form show that:

Trip Duration was 3 days. All catch was sampled (45 kg). Total values of ‘other’ species was recorded as well as prices/kg by species. Associated sample effort is (1 unit) x (3 days), or 3 boat-days.

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**
Number of Units:	**1**
Duration:	**3**
Total landing:	**450 kg**

If the total landing in the example form was 450 kg, this means that only 45 kg were sampled and recorded for species composition. The presence of the Total Landing field is now essential (not optional) because it indicates that catch by species will need to be raised by a factor of 450/45=10.

10.4.2 Boats landing together

C. Fishing Operation

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

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

10.4.3 Fishing units with multiple operations per day

C. Fishing Operation

Boat/gear:	**Beach seine**
Number of 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, such as beach seines. The following points should be explained to the data recorder:

1) 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 trip duration as a fraction of a fishing day.

2) 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 then used to calculate trip duration as a fraction of a fishing day.

3) If there were 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 processed or packed fish landings occur occasionally then they should simply be ignored in data collection. However, if they are regular then conversion factors that enable calculation of whole fish weight from processed fish weight need to be developed and used in the estimation of total landings.

10.4.5 Catch sorted by commercial size category

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

INPUTS		
	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.*
RESULTS (on a single form)		
	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 this 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. The effort used in the multiple forms should be split in order to add to the actual 1 boat-day.

10.4.6 Non-fishing boats landing catch

Generally, such landings need not be sampled because they do not provide information on the sample effort associated with the catch.

10.4.7 Migration of fishing units

In theory, the 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. In fact, this is the correct approach at locations that are only landing sites and not homeports. Usually it would be preferable to give priority to local boats and include non-local boats only when the total number of samples is below safety limits.

10.5 Training of data collectors

Compared to effort-related data collection schemes, Landings Surveys are less demanding in sample size but require more skills on the part of data 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 should be considered in this respect:

Fishing operations

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

Species composition

- Species identification
- Effective ways of measuring, or estimating by eye, catch and number of fish by species
- When and how to obtain information on first-sale prices or values

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, including:

- Explaining in full detail the recording forms, their use in data collection and their purpose and utility in the overall sampling programme
- Clarifying the issues concerning boat/gear types, such as sequential and concurrent use
- Planning visits to landing sites
- Methods for approaching fishers and village authorities in order to obtain complete and reliable information

10.7 Implementation aspects

Implementation of successful Landings Surveys needs careful planning including:

Pilot phase: small scale testing (e.g. within one or two landing sites) to identify possible design and operational drawbacks and to assess likely timeframes for full-scale operations.

Testing of the entire sampling programme: combine a pilot implementation of the Landings Survey with the entire sampling programme for catch/effort assessment (normally 6-12 months) to ensure both meet their requirements

Evaluation and revision phase: forms and classifications are revised and new instructions issued to data collectors.

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:

- Ensuring that recorders visit landing sites according to work schedules and perform their job as instructed
- Checking the way data are sampled and recorded
- Ensuring that recorders are equipped and make effective use of items essential for their job
- Back-reporting of problems relating to movement, timing of visits and duration of stay at sites

Data editing and checking: Data collection forms are usually reviewed prior to processing, including:

- Organizing field documents to facilitate subsequent processing by grouping forms by Month, Minor stratum, Landing site, Boat/gear type, Date, or in any other sequence that will be convenient to the data operators

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

10.8 Frequent problems

Timing of field activities

- If few or no landings occur during the allocated time at a landing site, and recorders remain “idle” for long periods, then the work schedule for that site should be reviewed and better use of their time should be made.

Selection of landing sites

- Sites are not representative of all boat/gear types and for certain fisheries no samples can be collected. Sampling sites should be reviewed.
- 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.
- 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.

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 presented Landings Surveys, thus completing the discussion on methodological and operational aspects of surveys that are involved in the estimation of total catch, including

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

11. DATA PROCESSING

The production of meaningful fishery statistics requires processing of the data that results from the various field surveys. Modern data processing now requires the use of computerized systems. This section outlines the following:

- Need for automated procedures
- Basic system functions
- Data flows
- Computerized survey standards
- Processing of primary data
- Data checking and monitoring
- Estimation process
- Basic reporting functions
- Training and operational guidelines

11.1 Need for automated procedures

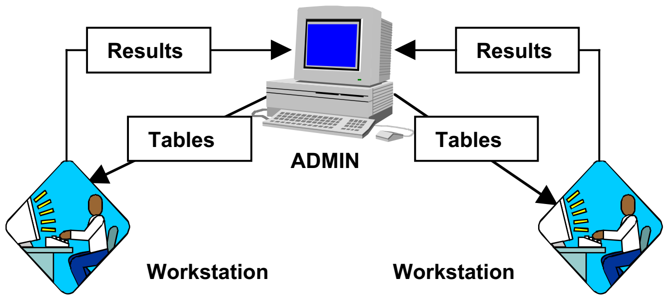
Computer systems and software have become inseparable components of fishery statistical systems, and should respond to a wide variety of functional needs. Their design should be:

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

Typical functions of a computerized system for basic fishery data are:

- Organization of survey standards.
- Organization and input of sample data collected from the field.
- Data quality reports.
- Automatic computation of estimates.
- Basic reporting of estimated data.
- Exchange of estimates with other user groups.
- Export of results to other application environments.

11.2 Data flows



The above diagram gives an example of a simple system architecture that provides data flows between data processing operators and central administration of the fisheries statistical programme, which includes.

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

This or similar structures offer the following advantages:

- Survey standards are the responsibility of an ADMIN central unit, thus ensuring overall conformity with set up standards or when changes to these are required to be distributed to workstations.
- Handling of primary data is nearer to their source, enabling better and quicker corrective actions when necessary.
- Input of primary data is distributed, thus reducing bottlenecks that sometimes occur in centralized operations.
- Decentralized users are the first to view, check and use the estimates produced.
- Data integration based on decentralized results is generally an easier task for the ADMIN central unit.

11.3 Survey standards

Well-defined survey standards help to streamline field operations, produce consistent reports and integrate survey outputs with those resulting from other analysis and reporting applications.

11.3.1 Validity of survey standards

Survey standards are usually valid for a complete operational cycle of a survey programme (usually 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.**11.3.2 Strata and geographical areas and locations**

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

- Lists of administrative or reporting strata (major strata), homeports and landing sites that will participate in sampling operations.
- A list of logical strata that will be used in an estimation context such as a minor stratum, a month and a boat/gear type.

- Associating minor strata to a major stratum where minor strata do not overlap major strata.
- 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.

```
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.

11.3.3 Boat/gear types

The second step is to set up a table of all possible boat/gear categories, which should be easily recognizable by the recorders in case pre-printed lists are used in data collection forms.

```
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.

11.3.4 Frame surveys

The next task is to establish a table containing Frame Survey data, which requires associated tables of homeports, landing sites and boat/gear types.

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 the 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.

11.3.5 Species lists

The next step is to set up a species table containing all possible species. Species names should be easily recognizable by the recorders in case pre-printed lists are used in data collection forms.

```
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.

11.3.6 Standard units

It is important that measurement units involved in a sample-based survey are consistent throughout the statistical programme. In this handbook the following units are considered:

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. (The same concept applies to currencies.)

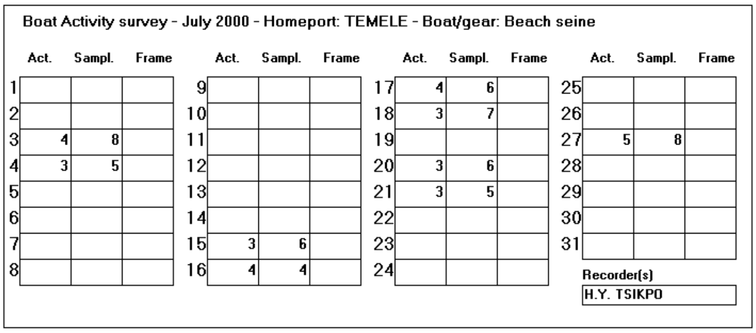
Effort: by definition effort units differ among the various boat/gear types and fishing methods. However, in surveys dealing with basic fishery data there is a need to easily integrate catch and effort estimates deriving from different boats and gears. For statistical purposes it is generally accepted that the boat-day is a reasonably good way for uniformly expressing fishing effort.

11.4 Processing of primary data

The primary data for processing are the individual samples on boat activities and landings, collected from the field. Designing and implementing a computer system for these data can be a complex task, which requires considerable effort and can only be reviewed briefly here.

11.4.1 Input of data on boat activities

The computer procedure must be flexible enough to handle data that are collected by means of different sampling schemes. Data input is done directly from documents organized by month, by homeport or by boat/gear type.


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

The figure above is an example of a general-purpose computer screen used for entering data on boat activities. Numbers of active boats are recorded together with the total number sampled at a homeport on a given day, although provision is also made for Frame Survey data if that is required.

11.4.2 Input of data on Active Days

Active Days data provide time raising factors for estimating fishing effort in an estimation context of a minor stratum, a month and a specific boat/gear type. Therefore, the computer table would contain all combinations of minor strata and boat/gear types. These can be created automatically by the computer system. For a particular month these 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

11.4.3 Input of data on Landings

Landings data input is done directly from documents that have been organized by month, by stratum and homeport or by boat/gear type. The figure below is an example of a general-purpose computer screen used for entering sampled landings.

Landing survey - July 2001 Form: 0034

Stratum: SW Coast

Boat/gear type: Gillnet

Landing site: Denu

Date: 23 July 2001

Units: 1
Duration: 2 days

Sampled: 147 kg

Recorder(s)

Yelowomi Paul

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 Unspe	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 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:** providing summary lists and reports will give quick indications as to the availability of samples on boat activities and landings in each estimation context.
- **Data range checking:** providing lists showing “extreme” values (the range of values) for catch, sample effort and prices. These must be automatically linked with the forms used for data entry. Suspiciously high or low values can be verified against these lists.
- **Sample size checking:** providing lists showing expected sample size and accuracy level for boat activities and landings. These have been decided on an a priori basis and have been discussed in Sections 9 and 10.

11.6 Estimation processes

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

11.6.1 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) ***BAC***s 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) ***BAC***s are combined with Active Days and Frame Survey data to produce estimates of fishing effort.

(g) Effort variability and confidence limits are computed.

11.6.2 Estimation of catch and value

Sampled landings data are directed to the appropriate estimation context of a minor stratum, a month and a boat/gear type.

(a) Overall ***CPUE***s are formulated in each context.

(b) The accuracy of ***CPUE*** estimates is computed.

(c) The overall ***CPUE*** variability and its confidence limits are computed.

(d) ***CPUE*** variability is explained in space and time.

(e) Sample species proportions are formulated.

(f) Sample prices are formulated.

(g) Estimates of average fish size (in weight units) are produced.

(h) Estimated ***CPUE***s are combined with estimated effort to produce estimates of total catch.

(i) Variability of catch estimates and related confidence limits are computed.

(j) Sample species proportions are combined with estimated total catch to produce estimated catch by species.

(k) Sample prices are combined with catch by species to produce estimated values by species.

(l) 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:

11.6.3 Data grouping

(a) Catch, effort and values are grouped at major stratum and grand total levels.

(b) Average ***CPUE***s and prices are formulated at major stratum and grand total levels.

11.7 Basic reporting

There are many ways for the preparation of basic reports on estimated data. Generally, in the reporting functions of monthly catch/effort estimates, which constitute 'first generation' statistics, the following points should be considered:

(a) The first reporting level should be the estimation context (the stratum) where all computations and related statistical indicators and diagnostics are produced.

(b) Prior to analyzing the results, users should check the system messages to determine the level of completion of each estimating context.

(c) All data involved in the estimation process must be reported to allow manual verification of the results, if needed.

(d) The reporting sequence should generally follow the computational steps discussed in 11.7.

11.7.1 System diagnostics

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

The messages displayed for different estimation contexts inform users that:

(a) Accuracy for ***CPUE*** is below 90%. Estimation continued.

(b) No active days and no frame data (so, no raising factors). Estimation failed.

(c) No landings or data. Estimation failed.

(d) Limited geographical coverage. Accuracy levels for ***BAC*** and ***CPUE*** are below 90%.

```
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
```

11.7.2 Estimated effort

In the example figure below, the 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 raising factors. Confidence limits for estimated effort are also displayed.

```
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
```

11.7.3 Estimated total catch

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

(a) 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.

(b) 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.

(c) 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.

```
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
```

11.7.4 Catch by species

In the example below, 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.

A summary total value of all landings and their unit-value is given at the top of the report.

```
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
```

11.7.5 Grand totals

The example below illustrates grand totals computed for a specific boat/gear type (drifting gillnet). These figures have resulted from grouping all statistics for this boat/gear type from the different minor strata.

```
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.            CPUE         Value
                                        Effort            Aver.W       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
```

11.8 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 of all system functions by data operators.

(b) Preparation of regular backup copies of data.

(c) Availability of quick start-up guides for system operations.

(d) Methods for accessing catch/effort estimates for further processing.

(e) Effective monitoring of data entry, estimation and data submission procedures.

SUMMARY

In this section general aspects concerning automatic processing of basic fishery data was introduced, including:

(a) The need for automated procedures performed by robust, modular and sustainable computer systems

(b) Basic system functions

(c) Data flows. Advantages of a decentralized system structure

(d) Computerized survey standards, including strata, sites and associations; species and boat/gear classifications; Frame Surveys, Active Days and standard measurement units

(e) Processing of primary data on Boat Activities and Landings

(f) Data checking and monitoring

(g) Estimation processes, the data involved, statistical indicators and diagnostics

(h) Basic reporting functions

(i) Importance of training and operational guidelines

12. DATA STORAGE AND DISSEMINATION

The previous sections reviewed the various steps in designing and implementing fishery surveys involving basic fishery data. They also presented practical approaches to 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 data processing concepts on accessing and using basic fishery statistics are discussed, including:

- Setting up databases for general purpose use
- General functional characteristics of general purpose databases
- Transferring data to commercial applications software
- Principles in developing sub-regional and regional databases for shared use

12.1 General-purpose databases

After completing an operational cycle (usually a year, it is useful to integrate monthly estimates into a single database 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 12.1 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).

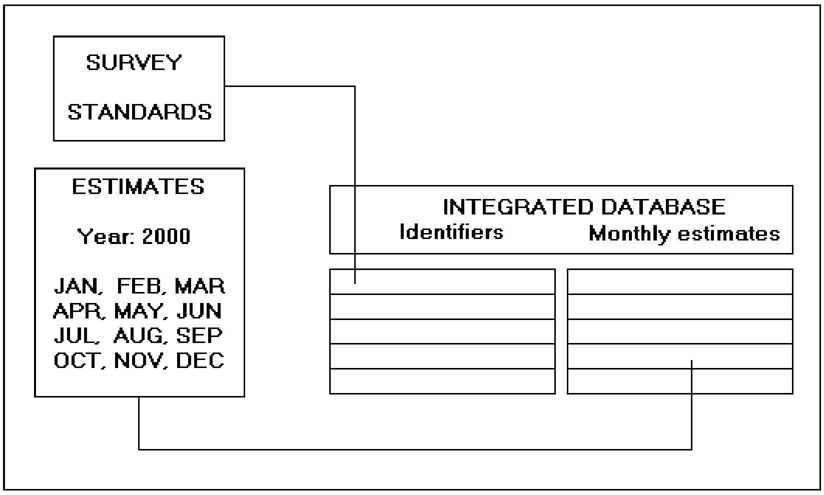
(b) Monthly figures of estimated catch, effort, CPUE, prices and values.

(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:



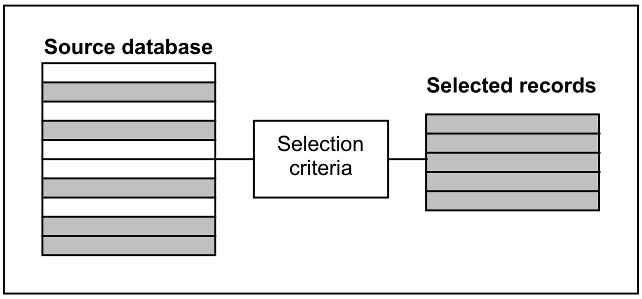
12.2.2 Flexible data selection

Users should be able to work on the entire database or on selected sub-sets. The figure below illustrates a flexible selection function, whose selection criteria could be:

(a) Select for major stratum A and shrimp for trawlers

(b) Select for gillnets in all strata and for all species

(c) Select for trawlers in all strata and for all species, etc



12.2.3 Data grouping

Data grouping functions use selected sub-sets or the entire database to produce sub-totals and totals at various grouping levels, such as totals by boat/gear for each species, by species for each boat/gear, by geographical major and minor stratum level, and/or 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 example, the following ranks are often useful to demonstrate in reports:

(a) Species with highest values

(b) Boat/gear types with highest overall CPUE

(c) Boat/gear types that account for more than X% of total

(d) Species that account for more than X% of total value

(e) Minor strata ranked according to total production

(f) Major strata ranked according to total fishing effort

12.2.5 Use of commercial applications software

Customized computer systems that are built around known and standard application and user needs, however flexible, cannot respond to all user requirements. Commercial software applications (such as Word, Excel, Access, etc.) are useful tools that can support statistical and other studies and reports, provided that the required data can be made available. Therefore, an essential function of an integrated database system is to allow users to extract the required information from the database and transfer it to a commercial software package for further analysis and presentation. This is usually a straightforward process involving:

(a) Use of flexible selection criteria (discussed in 12.2.2).

(b) Use of data grouping functions (discussed in 12.2.3)

(c) Use of ranking functions (discussed in 12.2.4)

(d) Formatting the processed database records for easy transfer to an external application environment

12.3 Regional databases

The establishment of a regional database (RDB) is required when there is a need to conduct studies on shared resources of transboundary fish stocks (in lakes, rivers, between exclusive economic zones and extending onto the high seas). Development of an RDB is essentially a matter of standardization and harmonization. The following stages are usually involved:

12.3.1 Regional needs and stanardization

(a) Identify the data scope for the short- and medium-term, (e.g. catch, effort, CPUE, prices, values, etc.).

(b) Determine 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) Prepare a checklist to examine the feasibility of obtaining such data from contributing countries.

(d) Standardization of geographical, boat/gear type and species classifications.

(e) Prepare country-orientated lists for comparing national standards in use against the standard RDB classifications.

(f) Establish commonly accepted formats and operational modalities for data submissions (fishing boat logsheets, survey forms, etc).

12.3.2 RDB development and implementation

(a) Design of a basic RDB architecture and preparation of technical specifications on the types of outputs, access to data and RDB maintenance requirements.

(b) Select appropriate database engine and programming tools.

(c) Develop and test the RDB applications with data from contributing countries.

(d) Prepare operational guidelines.

SUMMARY

In this section, data processing concepts concerning access and use of basic fishery statistics were outlined, including:

(a) Setting up 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.

13. FURTHER READING

Banerji,S.K. (1980): The collection of catch and effort statistics. *FAO Fisheries Circular*, 730.

Bazigos,G.P. (1974). The design of fisheries statistical surveys. Inland waters. *FAO Fisheries Technical Paper*, 133.

Bazigos,G.P. (1975). Applied fishery statistics: vectors and matrices. *FAO Fisheries Technical Paper,* 135.

Bazigos,G.P. (1976). Guidelines for the production of fisheries statistics. *FAO Training Courses in Fishery Statistics*.

Bazigos,G.P. (1983). Applied Fishery Statistics. *FAO Fisheries Technical Paper*, 135.

Bonzon,A. and Horemans,B. (1988). Socio-economic data base on African fisheries. *FAO Fisheries Circular,* 810.

Brander,K. (1975). Guidelines for collection and compilation of fishery statistics*. FAO Fisheries Technical Paper,* 148.

Caddy,J.F. and Bazigos,G.P. (1985). Practical guidelines for statistical monitoring of fisheries in manpower limited situations. *FAO Fisheries Technical Paper*, 257.

Cochran,W.G. (1973). Sampling Techniques. John Wiley & Sons, New York.

Deming,W.E. (1960). Sample Design in Business Research. John Wiley & Sons, New York.

FAO, (1993). Report of the Working Group on Artisanal Fisheries Statistics for the Western Gulf of Guinea, Nigeria and Cameroon.

FAO, (1999). Guidelines for the routine collection of capture fishery data. *FAO Fisheries Technical Paper*, 382.

Hansen,M.H., Hurwitz,W.N. and Madow,W.G. (1953). Sample survey methods and theory. John Wiley & Sons, New York.

Sparre,P. (2000). Manual on sample-based data collection for fisheries assessment. Examples from Viet Nam. *FAO Fisheries Technical Paper,* 398.

Stamatopoulos,C. (1996). Report on the use of a fisheries statistical software (ARTFISH). *FAO-IDAF Project Technical Report.*

Stamatopoulos,C. (1999). Observations on the geometrical properties of accuracy growth in sampling with finite populations. *FAO Fisheries Technical Paper*, 388.

Thompson, S. K. (1992). Sampling.

The purpose of this handbook is to summarize experience gained over recent years in fishery statistical development by the Fishery Information, Data and Statistics Unit (FIDI) of 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 marine and inland capture fisheries and are presented in a manner that is generic enough to make them adaptable to most 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 the statistics and related indicators collected, 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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