HANDBOOK ON
COLLECTING FISHERY STATISTICS FOR INLAND AND COASTAL FISHERIES

THE SECRETARIAT
SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER

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Foreword

It is with pleasure that I introduce you to this new Regional Handbook on Collecting Fishery Statistics for Inland and Coastal Fisheries, compiled by Theo Visser, Fishery Consultant, under the project on Capacity Building on the Improvement of Fisheries Statistical System in the ASEAN Region, supported by the ASEAN Foundation. Strengthening national fisheries statistical systems and maximizing their use for fisheries planning and management are important issues in Southeast Asia, as it was highlighted during the ASEAN-SEAFDEC Millennium Conference and its main output, the Resolution and Plan of Action.

In implementing this particular Resolution, ASEAN Member Countries must consider ways to improve their national fishery statistical systems. This will include how accurate and timely data can be collected and analyzed, and how information can be utilized in policy formulation and decision making to support governments' priority issues.

Too often, unreliable or untimely statistical analyses have provided inadequate information to key decision makers. This has led to dwindling support from these important actors for fishery statistics and data collection systems, causing a vicious cycle affecting production of reliable and timely national fishery statistics.

We hope to this handbook will provide you with a clear framework on the collection of fishery statistics for the Southeast Asian context, and effectively support the four national workshops hold in Cambodia, Lao PDR, Myanmar and Vietnam, and the subsequent on-site trainings.

In this occasion, I would like to express once more my appreciation for the indispensable support produced by the ASEAN Foundation, without which these workshops and in-country trainings would have been impossible to organize.

On these few words, I wish you pleasant reading, and wish that this handbook will provide you with clear references when developing your own national fishery statistics collection programs in the near future.

Niwes Ruangpanit
Secretary-General
SEAFDEC

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CHAPTER I
INTRODUCTION

1. Introduction

1.1 Scope of this document

Fisheries are a major activity for many people living in inland and coastal areas and are considered to be the major source of protein for rural populations. Information on actual levels of consumption and catch are scant, but research data suggest that for example the inland capture fisheries in the Mekong basin may produce over 3 Million MT per annum (Bush and Hortle, 2003). The official catch estimates, where available, do not even come close to this huge amount and may underestimate the actual fish production with a factor of 2 to 3 times. For example even the reported inland fisheries production from all SEAFDEC countries combined for 2000 is only around 1.3 million MT (FAO 2002). Although the estimate for the Mekong is mainly based on consumption studies conducted over a number of years and therefore also includes non-fish aquatic organisms (shrimp, frogs and water insects), it is a conservative estimate for the average capture fisheries production for the whole Mekong basin (Hortle and Bush, 2003). This is a good indication that the official information based on fishery statistics is lacking. Although in some SEAFDEC member countries the coastal fisheries is well covered by a statistical system, the general situation for the statistical coverage for coastal fisheries in many SEAFDEC member countries is very similar to that for inland capture fisheries.

During the millennium conference it was concluded that the capacity of certain member states were insufficient in respect to many aspects of fishery statistics, but especially methodological and analytical capacity. Four countries (Lao PDR, Cambodia, Viet Nam and Myanmar) were identified as the initial recipients of training under a Human Development project to be executed by SEAFDEC for which the main focus would be on inland and coastal fisheries.

As a first step for this human development project a set of methodologies that are appropriate for inland and coastal fisheries need to be compiled. There is increasing emphasis on economic and socio-cultural data collection, necessary to answer many management, policy and planning questions which biological data alone cannot address. Most of these socio-economic data are *not* considered to be part of regular fishery statistics and they are rarely included in a comprehensive manner and thus these should be prominently featured in the guidelines.

This document tries to provide the building blocks for setting up a statistical data collection system by providing elements for:

1. *basic statistical training*: basic statistical knowledge, and units
2. *sample survey design*: methods to select the coverage and size of a sample (including stratification)
3. *selection of methodologies*: what methodologies will obtain the required statistics with least possible cost and highest reliability with a comparative description of most commonly used methodologies and potential field of use (with suggested further reading and source material)

SEAFDEC will use this document as the basis of training events in a number of SEAFDEC member countries, initially in Cambodia, Lao PDR, Myanmar and Viet Nam. The training intends to familiarise counterparts from the fisheries line agencies with the available approaches and to set-up a number of pilot schemes for the collection of fishery statistics.

Obviously, each fishery is unique and therefore it is impossible to prepare a ready made set of do-it-yourself handbook that can be universally applied to any fisheries situation. Therefore this handbook is kept general, with a focus on appropriate methodologies for different fisheries to obtain meaningful information. Use of the step-by-step approach contained in section 5 of these guidelines should facilitate designing an appropriate fishery statistical system under different circumstances.

An important objective of this document is in awareness building. It is never mentioned in any specific way in the text, but the main message of this document is that statistics should be used to the full extent and for that to be possible, a statistical data collection exercise should be well planned and executed. If after browsing through this handbook people remember anything, let it be this. It may be basic and obvious, but judging from the many fishery statistical systems I know of it is not widely applied to the full extent.

This document was not written to be read from cover to cover. Instead different parts are intended for different users and therefore it should be considered as a menu from which different parts can be selected. Reference can be made to the table of contents at the beginning of this document. The main structure is formed by three separate parts:

1. *Fishery Statistics and Statistical Design*: discussion of variables, indicators as well as statistics and sample survey design with guidelines to design a statistical system or review an existing one. It also contains recommendations for a minimal statistical system.
2. *Data Collection Methods*: general methodologies available with a detailed discussion of the methodologies for catch assessment (catch and effort) and collecting appropriate economic data and livelihood (socio-economic) information as well as non-routine data collection including data collection in a co-management setting;
3. *Approaches for Processing and Analysi*s: GIS as a tool for survey planning, analysis and extrapolation, survey planning, data processing, training and a glossary with terms used in this document.

1.2 Rationale for the Handbook

This handbook is written under the assumption that no similar resource is currently available. If some of the information is already available it is spread out over many different sources scattered in time, that do not provide enough focus to be practical useful in the South-East Asian context.

Several documents exist that provide basic guidelines for collecting biological data under different circumstances for marine and inland fishing operations. These tend to focus almost exclusively on sample surveys for catch and effort. Although this may be appropriate for some sectors of the fisheries, the small-scale and fragmented nature of a large part of the inland and coastal fishery calls for some alternative approaches. All methodologies that are described in this handbook are also covered elsewhere. Lack of a document with a comprehensive coverage with practical advice data and methodology makes it worthwhile to try to merge the different source material into one document.

An important document on fishery statistics was produced by a FAO-DANIDA Expert Consultation in 1998, guidelines for the routine collection of capture fisheries data (FAO, 1999). These guidelines are very important in providing the framework for setting up or redesigning an existing fishery statistical system, but fall short in providing practical approaches. In addition the focus is quite heavily on the larger scale marine fisheries whereas inland fisheries are mainly ignored.

Under these circumstances it is appropriate to produce comprehensive practical guidelines. This document does draw from other published sources, but in doing so it not simply merges but also synthesises the appropriate material for the South-East Asian fisheries context.

1.3 Scope of the fishing operations

This section will try to rationalise the different fishery sectors, that are mainly separated based on the scale of operations. The main issue for this document is the differences and similarities between inland and coastal fisheries.

1.3.1 Inland and coastal fisheries

Combining coastal and inland fisheries into one document is open for discussion. In most SEAFDEC member states both sectors are treated as separate entities and are managed by different departments or sections.

Inland and coastal fisheries cannot be considered to be a homogenous collection of fisheries, as there are many different levels of operation, down from collection by hand by family members to almost industrial sized operations. Both inland and coastal fisheries are in general small-scale operations, often family business or small enterprises. Although a few localized commercial fisheries of middle to large-scale can be observed, most of the operations are small one man/household sized operations that are scattered in space and time, using a mind boggling array of gears and habitats for catching a wide variety of species. The fishing activities often have a large subsistence component, with many fishers active only for part of the year. The similarities of fishing activities on a coast line and for example reservoir fisheries and even river fisheries in the main river channels are quite obvious, including fixed fishing grounds, landing sites and license systems. Fishers in both environments have a close relationship with their environment and are therefore the prime focus of recent participatory management approaches.

Whatever the similarities, inland and coastal fisheries also have vast differences. This is mainly a matter of scale, i.e. the size of fishing operations and the associated structure of the fisheries sector. In general the amount of subsistence fishing is far greater in inland waters, especially where floodplain fisheries (including rice-fish ‘culture’) exist. In many areas commercial catches only amount to 25% (or less) of the total catch. The seasonality of fishing activities (intensity) and involvement of part-time fishers is of far greater importance in inland waters. This is especially true for the highly productive floodplain fisheries that still form a major contribution to the fisheries sector in Cambodia, Viet Nam and Myanmar and to a lesser extend in Lao PDR, where fishing operations are spread out over a vast area, without fixed landing sites.

Even though some commercial fisheries exist in inland areas, the proportion of total catch taken by this sector is far less than in the coastal fisheries. Because the water-land interface available for fishing activities in inland areas is huge, especially there where extensive floodplains exist, the amount of people involved in inland fisheries is far greater than in coastal fisheries. In general the coastal fisheries is more commercialised and of a larger scale, i.e. most of the catch is landed by small to middle scale commercial fishing operations. In contrast, in inland fisheries the commercial fisheries consists mainly of small-scale one person fishing operations, in addition the catch by this commercial sector is only a small part of the total fishing production.

Due to the inherent dynamics of inland waters, the heavy dependence on floodplains in river fisheries, either directly (floodplain fisheries) or indirectly (much of the catches, i.e. biological production, in rivers and reservoirs is actually produced on the floodplains), there may be huge fluctuations in production from one year to another, that are largely unrelated to the fishing pressure. River channels may be compared with the coast line of a sea, lake or reservoir, however the length of all the fishable river channels combined is far greater then that of any coastline.

The complex relationships between habitats, fish and flooding create a far more complex fisheries system in inland areas than in coastal fisheries. Participation, gear use and catches fluctuate between seasons and years, as well as in response to economic factors. Although this generally holds true for both inland and coastal fisheries, many more people are involved in inland fisheries in a far larger area. As a consequence inland fisheries is far more complex, dynamic and more difficult to monitor than coastal fisheries and care has to be taken not to simply transpose marine methodologies and concepts to inland fisheries, as has been done so often in the past.

For example a major use for data collected for coastal fisheries is often stock assessment. This places certain requirements on the data that have to be met and this has implications for the data collection system. Although stock assessment works well in marine environments, and can also be applied to lakes and reservoirs without too many problems, it cannot be used in riverine environments, especially rivers with extensive floodplains are problematic for stock assessment models. Therefore some of the variables that are routinely collected for coastal fisheries (e.g. length composition of the catch) may not be particularly useful for most inland fisheries.

Fish stock assessment is not the subject of this handbook, a large amount of books and practical guides have been written on that subject. The reader may decide for themselves whether certain variables are required under the specific circumstances of a fishery.

Some would argue that a complicating factor in describing coastal and inland fisheries together is that different departments are often in charge of statistics (and management) of these sectors. Would this separation at the national level then warrant a similar separation in the current handbook? This physical separation of responsibility makes it perhaps difficult to co-ordinate development of the statistical system between the two sub-sectors; however it is not required for the statistical systems of both sub-sectors to be developed in tandem. The main reason for describing inland and coastal fisheries is that there is considerable overlap in the methodologies that can be applied; similar data collection methods can be used in both fisheries. However differences in scale and type of fishing operations, as well as in economic importance makes the data requirements for both sectors different. Some methodologies are

more appropriate for coastal fisheries and others will be better for use in inland fisheries. This does not mean that it would be better to separate the description of statistical variables and methodologies. The handbook is equally suited to guide development for the statistical systems for inland and coastal fisheries and a certain amount of cross-pollination of concepts and approaches can only benefit the design of a better statistical system. Besides separating the two sectors over two separate handbooks would lead to considerable repetition.

1.3.2 Fishery Sectors

The differentiation between coastal and high seas fishing is based both on geographical coverage and considerations of scale. Coastal fisheries are often limited to near-shore operations, i.e. within the Exclusive Economic Zone (EEZ) and more often within 12 miles from the coast, although there are a multitude of legal definitions in use based on tonnage, or operational distance. High seas fishing are almost always outside the vicinity of the coast, but more importantly of decidedly much larger scale. As with any definition there is considerable overlap, some small-scale operations do fish far away from shore and in some instances large commercial vessels do fish near shore (to much dismay of coastal fishing communities).

Inland fisheries are bound by geographical limits and only in estuary areas there may be considerable confusion about the extent of inland fisheries. Under the influence of ebb and tide and seasonal discharge fluctuations, the border between true freshwater and true marine environments shifts longitudinally along the river branches of the delta area. Marine fish are regularly caught in inland areas; therefore the location of a fishing operation, not the species of fish, is the only important consideration to include it in coastal, estuarine or inland fisheries. In addition, some species may seasonally be found in fresh or marine waters, or migrate from different environments during different development stages.

Classification of any sort is always artificial and never comes to a satisfactory separation of the constituting parts in a logical and mutually exclusive system. Many are the ways in which the fisheries sector can be divided over different sub sectors and confusion (between different countries/systems) is often the result. Different countries use different definitions for the different fishery sectors and although they may make sense in a local legal (law enforcement), management and operational framework they are never quite logical or systematic. This is not the place to introduce a new separation which would be incompatible with most countries practical separation of the fisheries sector. However, in general the geographical location of a fishery is less important *for the methods*[1] that can be employed to collect fishery statistics, than the level of operations, therefore for the purpose of this handbook it may be better to distinguish fisheries sectors based on the scale at which they are conducted. This is the approach that has been taken when preparing this handbook and this philosophy fits well with the structure of this document.

Following this capture fishery in inland and coastal areas falls broadly into three sectors:

[1] This does NOT mean that geographical location is unimportant, on the contrary it is extremely important to know where fish are caught. The point here is that the location fishing takes place does not influence the use of the methodology to obtain information as much as the size/scale of the fishing operations, out of practical considerations of coverage and sampling effort. This means that for example the method to assess involvement for a commercial fishery is normally different than for family fishing operations. The first can be approached through a general population census, asking for occupation, whereas the second could best be tackled using a sample survey with extrapolation to the total number.

1. *Large-scale commercial fisheries*, fishing with large vessels and gears, which often are highly mechanized and can fish far from their home port, data can be collected using logbook systems, census or sample based or sample surveys for catch and effort; Several regional trawl fleets fall in this category. Includes also large stationary fishing operations, like the Lot and Dai fisheries in Cambodia.
2. *Small to middle scale commercial fisheries*, commercial fishing with both motorized and non-motorized boats for which a sample approach is most appropriate. Fishers are full-time fishers, or fishing is their main source of income. Fishing operations are normally near the coast. Annual production may be as high as 50 MT. The number of fishers involved and the number of operations is relative low; and
3. *Family fisheries*, which is small-scale fishing in which the fishermen are mostly fishing part-time and catch may be sold but where the prime objective often is to obtain food for the own household. For these reasons, this sector is often defined as part-time 'subsistence' fishing. It consists of one person or family operations, using a variety of gears and may be only a seasonal occupation. Often an (important) part of the catch is consumed by the own household. This category does include commercial fishers that fish the whole year using small-scale fishing gears. Annual catch may be as high as 5 MT, but normally is much lower in the range of 100 kg per annum and could even be as low as 10 kg. Despite the low production, the number of people involved in part-time small-scale fishing is quite high. Involvement, gear use and catches are covered by household and consumption surveys, sometimes through the use of the results from agriculture or population census.

A fourth category is formed by *recreational fishing*, but this presently plays a very minor role in South-East Asia, although locally this can be very important for the economy.

Note: although family fishing is often referred to as subsistence fishing, in most circumstances 'real' subsistence fishing is extremely rare and there is considerable overlap between commercial and subsistence fishing. Subsistence fishers often sell or barter part of their catch and most commercial fishers do eat part of their own catch. This is the reason to avoid using the term subsistence, whenever a more appropriate term is available.

The bulk of all fishing operations in inland and coastal areas can be regarded to be covered by, the small/middle scale and family fishing categories. The small/middle scale fisheries display a wide size range for fishing operations; it includes one-person operations, self-employed commercial fishers, with or without a boat or canoe, to larger multi person operations like some coastal fisheries or beach seine and giant lift net operations in inland waters. A small part of the operations fall in the large-scale category, like some trawl fleets, as well as the Dai fisheries in Cambodia where individual operations may have over 50 workers employed.

Industrial scale fisheries are effectively non-existent in inland and coastal fisheries and are generally confined to high seas fishing for large pelagics. Fisheries like the Dai Fisheries in Cambodia are large-scale in inland fishery terms, but not compared with large-scale marine fishing. National definitions used will be largely incompatible with the proposed fishery sectors; therefore the importance of the above division is mainly to understand the underlying philosophy of the current document. The survey methodologies that are appropriate to collect statistics for a fishery are mainly governed by the size and intensity of the operations as well as the level of involvement, i.e. the number of operations. In effect the methodologies

discussed in this document are separated by size of the fishing operations, not by the location (freshwater or marine).

The main issue for local implementation of different methodologies will be to establish what general category local fishery sectors belong to, either the small to middle scale commercial fishing or family fishing sectors. It is expected that this is relatively straightforward and should not compromise the system to define and separate fishery sectors at a national level.

CHAPTER II
FISHERY STATISTICS AND STATISTICAL DESIGN

2. Fishery Statistics

2.1 Introduction

Fishery statistics are data and information that describe the current and past status of the fisheries and show trends on the development of the sector that can be used for policy, planning and management.

Statistics refers both to the methods applied to collect data and the (partially) analysed data themselves. Without applying statistics, the raw data collected cannot be changed into something managers, planners and policy makers can understand, let alone want to look at. Indeed statistical analysis can be very complex, but for most purposes the statistical tools required for fisheries are rather straightforward and easy to understand.

This handbook take a very broad view on statistics and some variables are included that in many cases are considered to be outside fisheries or regarded as research rather than statistics. Research can also supply statistics, and contribute valuable information on the fishery sector. Fishery statistics comprise of a large number of parameters that can be recorded. These variables and indicators (calculated values based on statistics) will be covered in considerable detail in section 2.3.

The scope of fishery statistics is quite wide and includes livelihood data, socio-cultural information and economic data besides production (biological) data. Obviously a choice has to be made about what will be collected. Statistics are relative expensive to collect, so what is collected should be usable and reliable. What exactly is collected depends on what information is required and since this depends on policy and management decisions often taken at a national level, the requirements and thus the statistical system will differ from country to country. In all cases it is important not to be too ambitious and to limit the statistical system to a certain minimum requirement. This will be discussed in considerable detail in section 5 of this document.

Fishery statistics can serve many goals, but in most SEAFDEC member countries, inland and coastal fishery statistics are only used to indicate the importance of the fishery sector in the national economy. The reliability and/or coverage often is such that the there is not much use to try to use it for other purposes, even then economic importance based on the official statistics is almost always under estimating the actual importance, that can be obtained from the results of research surveys into fishery socio-economics. Fishery statistics are also widely used for tax and licensing purposes, and in some countries for the management of the fishery. It is rare to find examples where the fisheries management is actually based on the available statistics. Instead a mix of statistics and auxiliary information (as well as policy considerations) are used to arrive at a certain level of management that often says more about the status of the fishery in the national economy than about the status of the fishery resources.

Statistics for inland and small-scale coastal fisheries are often considered extremely unreliable. This is true for both developed and developing nations alike. It is not just a

question of the available budget, as the fishery statistics for many 'rich' countries are in particular bad shape, especially inland fishery statistics are of poor quality world-wide. The main problem with inland and coastal statistics is two fold:

1. The amount of detail required to make them useful need to be higher than of those for high seas fishery, therefore the quality of the statistics needs to be higher. For example, there is rarely exact location information available for high seas fishery, whereas exact locations (habitat information) where fish are caught, is often essential for coastal and especially inland fisheries, if the information is to be used for integrated resource management;
2. Collecting statistics for inland and coastal fisheries face several (methodological) problems:
    a. due to the nature of the fishing operations, that are mainly small-scale scattered in space and time ;
    b. Use of inappropriate methodologies, designed for medium to large-scale *marine* fisheries;
    c. Focus on the most visible components: large-scale fisheries with 'easy-to-collect' parameters;
    d. Inappropriate management focus, that requires classical catch-effort and stock information;
    e. Lack of funds/attention, for certain sectors; and
    f. Little or no evaluation of statistical system design.

Not all of these issues are typical for inland and coastal fishery, but the combination of all factors together is unique especially for inland but also to a lesser extend for coastal fisheries. For all sectors the matter of timeliness is an important issue. It is not uncommon for statistics to become available only two years after collection. Since the main purpose for a statistical system is to provide relevant information to policy makers and managers this is completely unacceptable. Information should be available almost immediately. The solution is mainly a system design matter, unless the information is relying on reporting or questionnaires that can delay timely collection of data.

The main purpose of fishery statistics is generally mentioned to be to monitor the status and trends of the fishery. Therefore the variables that are collected should be used as indicators for changes in the fisheries or support calculation of composite indicators, like Catch per Unit of Effort (CpUE) that do so. Although biological indicators can be used to monitor the state of exploitation of the fishery, they are inadequate to assess the performance of the fisheries sector as a whole. Other indicators are required:

1. Economic indicators are designed to measure the relative importance of the fishery to the nation or region at the macro- or micro-economic level.
2. Socio-cultural indicators take into account the diversity of needs and practices of different groups of people within the fisheries sector.
3. Compliance indicators are needed to monitor the effectiveness of management measures and reduce conflict.

Fisheries assessments should ideally combine biological, economic, socio-cultural and compliance indicators to be able to guide management decisions, policy and planning. This is often not practical or affordable and in cases where choices have to be made to limit the coverage of the statistical system, at least the core statistics should be collected: biological information on catch quantities and applied fishing effort where this is used for management purposes.

In addition for fishery statistics to be useful it is often necessary to have time series available over a long period that are comparable and compatible, they should be collected in a consistent way, using the same methods and approaches. This has been done for biological data for considerable time; time series for economic and especially livelihood (socio-cultural) data are either non-existent or consist of largely incompatible data.

2.2 Fisheries Management: considerations and practical approaches

The main use for statistics, at least the one frequently mentioned in discussions with fisheries officials, is for management. Although certain sub-sectors, especially (inland) river and floodplain fisheries and small-scale fisheries in general are very seldom managed in South East Asia, at least management should be one of the main focus points for the use of statistics.

Managing fisheries solely through catch and effort restrictions does not work in inland and small-scale coastal fisheries. Most of the fishing operations, indeed the bulk of the catch is in effect unregulated, mainly due to practical constraints of enforcing catch/effort based management interventions. Although at a local level enforcing may work, the costs are quite high, and are often in no relation to the value of the resource in economical terms. Besides, over fishing is not the largest treat to sustainable use of the fisheries resources.

Although fishing pressure does have an impact on fisheries, environmental change, in particular loss of fish habitats will in general be much more important for the status of the fish stocks. The concept of environmental management taking precedence over fisheries management is not new. Especially in floodplain driven river fisheries it has long been recognised that the only way to understand the fluctuations in fish production is by looking at environmental fluctuations, e.g. mainly the flood-pulse concept. Environmental management still does need information to steer management interventions, but normally does not need the type of classical fishery statistics, used in stock assessment based management. This could mean that for certain sectors no regular catch statistics will be collected, instead socio-economic or resource use indicators may be used to steer multiple use environmental management.

The only feasible way of management is to transfer ownership of the resources to the resource users and allow them to manage it themselves. As long as the local fishers can limit access to the resources, with a good institutional support and a ‘reward’ for those who participate in the scheme, this decentralized management approach where the power is transferred to the resource users themselves works well, both in inland and coastal fisheries.

The process of putting these (co-) management systems in place is a never-ending tedious task, albeit essential in order to maintain a healthy fishery and sustained benefits from the resources. The advantage of this type of management is that it is relatively cheap and that it does not just look at fisheries, but takes a holistic view and effectively works on management of the environment of a community. An added benefit of community management is that it can work in a data poor environment, and that it can also be used to produce data (see section 10.4). This bottom-up approach of data generation can be used to obtain valuable information on the state of the fishery and resource use.

In terms of management it is important to make management decisions transparent and explain the policies and management measurements to the people involved in a way that they

can understand. In general the relationship between fisheries staff and fishers needs improvement and this is the main challenge: building of trust and mutual understanding. Only when fishermen can understand the reasons for management interventions, i.e. why there is a closed season and why they cannot use a certain gear there is a chance they will implement and enforce management measures themselves. There is no good alternative to active participation, enforcement will not work if fishing activities are scattered in space and time. It is much more efficient to involve fishers themselves. Especially when there are clear advantages like higher catches, bigger fish or the return of higher valued species fishermen, will co-operate. Co-operatives and reforming the marketing structure, improving the living standards and creating alternative livelihoods all play an important role in restructuring and managing the fishery sector and this is part of the reason why co-management is such a humongous task.

2.3 Fishery Statistical Variables

As mentioned in section 2.1, there are a large number of variables that can be included in a fishery statistical system. Before deciding what variables are essential for a minimum statistical system, it is good to describe in general terms the many variables that may be[2] included in a statistical data collection system. This will explain the use of different variables and put them into context. It is not intended to list here all essential data variables, as this will be covered in section 5, merely to give an overview and describe variables that can be collected.

There are basically three types of fishery statistics that are of interest, in order of importance:

1. *Catch assessment data* this includes catch and effort, species composition, length frequency and other variables associated with catch (and stock) assessment.
2. *Economic data* this includes data on fish price, employment (both within and related support industry), processing, marketing, trade (import and export)
3. *Livelihood data* this includes data on involvement, habitat use, importance of fishing related activities for livelihoods, (fish) consumption etc.

The following section is largely based on contents from Guidelines for the routine collection of capture fisheries data (FAO, 1999) with some elaborations for the inland and coastal fisheries.

2.3.1 Catch Assessment Data

Catch statistics can give useful information on fish production from year to year and can show trends for individual species or species groups which may be used to decide on management measures. This data, which includes catch and effort statistics are essential to be able to assess any fisheries and should be amongst the first variables to include in a statistical system.

If it is clear that catches for a certain species or the average size is going down, while the effort is the same or is increasing, there is a strong indication that maybe this species is over fished and the fishing effort should be reduced. Over fishing means that too many fish are being caught to early in their life cycle, leaving in-sufficient fish for reproduction. In the end this can make that a species disappears from the catches and that the population numbers become so low that it is being displaced by other species. This could make that restoration of

[2] Note that this is not a listing of all required variables!

fish stocks after over exploitation has stopped can take a long time, and that some species may never come back in large enough numbers to be exploited commercially. This means that it is best to prevent over fishing or over exploitation and this is generally achieved by reducing the fishing effort. By imposing closed seasons and closed areas, together with banning of certain gears or gear sizes the fishing effort is reduced, and fish populations get the chance to recover.

Although this type of management works well in some marine fisheries, for the open access fisheries, both in coastal, but especially inland waters the situation is quite complex. In many inland systems annual fluctuations in species composition are quite normal in response to environmental changes, therefore long time series are required to be able to separate the impact of fishing pressure. Not only is there a lack of good-quality time-series, the correlation between fishing effort and standing stock is not all that straight forward. In addition even 'simple management' like enforcing closed seasons or closed areas is extremely difficult, not too mention banning gears or trying to restrict catches by reducing effort. Although impacts due to over fishing are evident, especially with the current population pressure, this has only become an issue in many inland waters after considerable destruction of fish habitats.

For inland fisheries it is interesting to note that governments insist implementing fishing bans in the spawning season when, due to high water levels and fast currents not much fishing is going on anyway. Under co-management, the fishers themselves often opt for a fishing ban in the dry season when fish are most vulnerable and are easily caught.

Increased fishing effort in itself has not (yet) impacted the total production in for example the Mekong basin. Although the production per fisher has decreased, the total production has in many cases increased over the years. At the same time the species composition, in particular the major economic species, in catches is influenced by the increasing fishing pressure. Instead of slow growing big species that used to dominate catches 40-50 years ago, the bulk of the catch now consists of small fast growing, early maturing species. Some of the large species have all but disappeared and the few individuals that are caught are much smaller than they used to be. This process is called fishing down the ecosystem. In fact the catches are dominated by species that can spawn within a year of their birth, as long as there are sufficient floodplains, breeding and feeding grounds, it would seem as if at least the biomass that is extracted from the system can stay stable even under extremely high fishing pressure.

For fishery statistics the amount of fish caught, the biomass extracted from the system, is probably the single most important data item, especially since it provides an easy macro-economic measurement for the 'value' of the fisheries. This should be collected with as much detail as feasible, including species details (catch by species) and where possible information on habitats and fishing grounds. This is especially important for inland fisheries, where fish production from lakes/reservoirs, floodplains and different parts of rivers (mainstream, tributaries including order stream) can give important information on the local state of fish and fish stocks. Information on catches is not complete without information on the fishing effort.

In this respect some clarification is required:
Catch: is the weight of fish that was actually caught, and always is the weight of the fish at the moment they are taken from the water.

Landing: is the weight of the catch as it is brought ashore, because there is always weight loss between the moments a fish is caught and the moment it is brought ashore, due to

dehydration, gutting, drying or salting the fish, the landed weight is NEVER equal to the catch weight:

1. Sometimes fishermen do not take all the fish they catch to the landing site, this is quite rare in small-scale fisheries, where everything that is caught is normally used. For some fisheries, especially large-scale fisheries small fish or fish with a very low value are often discarded. Shrimp fisheries are a notorious example where often non-shrimp catches are discarded. Also in inland fisheries discards do occur, for example in the Dai fisheries in Cambodia, although this is a special case. In general discards will be low and can effectively be disregarded, except in specialised fisheries like the Dai fisheries or shrimp trawls. For those fisheries it may make sense to estimate the average amount of discards for each gear type in different seasons to correct the landing data; and
2. If fish are salted, dried or gutted they will have lost part of their weight. It is important that the original catch weight used as the measurement of fish production. Most countries use the weight of the fresh weight of the catches as the weight to be used in national catch statistics. Therefore it may be important to know how to convert the weight at landing into the original fresh weight of the fish. These conversion factors can be taken from books or can be assessed in experiments, weighing fish before and after gutting, salting and drying them. Since weight loss by different preservation methods is different for different species and even size classes within the same species, ideally this must be done for each species separately. Conversion factors are known to change over the years, due to changes in average length of the fish, but also due to the quality of the fish. The fat content and dry weight is also not constant and varies by season, year and cohort. Conversion factors are generally more important for landings from industrial fisheries or when marketing surveys or consumption surveys are used to assess catches, since marketing and consumption of processed fish is quite widespread the use of the incorrect conversion factors has quite a big impact on the final estimates.

Fishing effort: is the time fishing gear, or more precise a gear unit, has been used to catch a certain amount of fish. There are several measures for the fishing effort, in the simplest form it simply refers to fishing days, without any specification of gears used, or the size or number of gears employed. This is a useful simplification when effort is not used as a management tool, as is the case in many open access (small-scale) fisheries in South-East Asia. It then becomes more a measurement of the time commitment by fishers and hence can be used in both economic and socio-cultural (livelihood) analysis.

For most fisheries that are important enough to be monitored it is useful to collect catches and landings by species and in some cases where gear restrictions are being employed as management intervention the catch by gear can also be collected. The fishing effort is always important, the exact detail required depends on the management interventions (planned or implemented). Effort is often used to assess the efficiency and performance of the fishery and it is a very important multi-purpose variable. The catch should be expressed in weight (fresh weight) and number of individuals. The length frequency can be indicated as the range (minimum and maximum length); anything more fancy should be the subject of a separate Length-Frequency survey.

In some fisheries it is worthwhile to not only know which species are being caught by which gears, but also the catch rates or the efficiency with different gears catch fish. This is especially useful for single gear fisheries, where these catch rates can be used to calculate an independent catch estimate and in some cases can be used to replace the estimate based on surveys for catch and effort. This makes some sense since effort can be estimated very

reliably based on samples whereas catches are very variable. Single gear fisheries can be found both in small to middle scale commercial and family fisheries, but needs reliable (and detailed) effort estimates to be able to calculate the catches. This means that it will only be sensible for medium to large-scale commercial fisheries. Normally these catch rates are obtained from experimental fishing, but this often leads to misleading estimates for catch rates in comparison with real catch rates by professional fishers, that are often higher. Catch rates need to be re-established on a regular basis as they depend on seasonality and changes in the target fish population. For most fisheries catch rates are not appropriate, since the required detail and sampling effort for multi-gear fisheries and problems establishing the catch rates themselves will make the results useless.

Catches show a natural fluctuation and therefore it is necessary that fishery statistics are available for a number of years. The collection of data should be an ongoing effort. Many countries (in the 'developed' world) have data on catches and landings for more than 50 years. Even then management has not prevented the collapse of some important fisheries, perhaps partly because of ignoring environmental aspects. Past trends and future prospects for the fisheries can only be derived from fishery statistics with sufficiently long time-series. This can help explaining the influence of fishing on fish and to understand what needs to be done to manage the fishery.

Although the catch assessment statistics provide one of the most important inputs for stock assessment analysis, stock assessment is not the subject of this handbook and therefore will not be covered here. Many detailed texts are available on this subject and although the applicability in river fisheries is close to zero, some approaches are valid for tropical lake/reservoir fisheries as well as coastal fisheries.

2.3.2 Economic Data

The main current use for inland and coastal fisheries statistics seems to be to show the importance of the sector as compared to other sectors. The importance can be expressed in several units: monetary value of the fishery of catch, exports, or replacement cost of the protein provided by the fisheries. Alternatively the value of the fishery sector may be expressed in the job opportunities or livelihoods provided. For most fisheries statistical systems in South-East Asia economic variables and indicators are not at all included, except at the most basic level, i.e. value of the fish and fish products obtained from the fisheries sector. Economic variables beyond these basic variables are at best a luxury in most cases, and can best be implemented for sectors with high economic value or shelved until more money is available. Fisheries departments do not normally consider collection of economic variables to be their responsibility, but economic departments often do not spend enough attention to fisheries. Information on employment and marketing may well be considered to be the most useful economic variables, but are seldom included in routine data collection. Instead they are often included in one-off research surveys.

There are several indicators that should be taken into account, most are not fishery statistics in the true meaning of the word, but can be regarded as auxiliary information. For example consumer demand in shrimp and tuna fisheries is an important factor in influencing the value and hence the profitability of a fisheries.

These indicators provide the basis of the understanding of the economic importance. One of the most important variables that should be collected (assumed that a reliable estimate for the

fishery production in terms of weight is available) is the price for fish and fish products at several levels (point of first sale, whole sale, market, shop prices).

Obviously to completely understand the economic value of a fishery, information on associated industries (fish processing, gear suppliers, transport companies, import export firms etc. is essential. Therefore to be able to formulate effective policy, information on the structure and economic indicators should also be available. An instant indicator for the (possible) importance of a fishery is given by the gross value of production (GVP) this is obtained by multiplying total production by the price received.

Below some of the main variables are discussed that are often collected for economically important marine fisheries. As mentioned before, most of the variables described are not priority areas for fishery statistics in the South-East Asian context, with the possible exception of employment and fish price information, it is not recommended to include any of the mentioned variables for a basic statistical system. The reason to include them here is to provide some background information on the type of variables and indicators that can be considered for collection. The coverage is far from complete and many other approaches can be taken, economics is a complex and diverse field.

A division into macro and micro-economic indicators can help to indicate the importance on a national (or regional level) or at the local level, respectively:
Macroeconomic indicators include the gross value of production, the gross value added, the level of subsidies, the level of employment, the balance of trade and foreign exchange earnings. Often these statistics may be already available from other sources and can be considered to be 'outside' fisheries.
Microeconomic indicators include the level of resource rent, the economic performance of fishers and changes in the level of investment. These indicators are evaluated at the level of the fishery or the individual fleet segments within a fishery. These include some very specialist variables and surveys and are not normally included in routine collection, but can be done as one-off studies for certain fisheries of special interest.

2.3.2.1 Costs and earnings

In order to assess the economic profitability of fishing operations and ensure that enough money will be invested in the sector it may be necessary to perform financial analysis. For this it is necessary to have access to financial data on costs of fishing operations. This means fuel, gear and labour costs etc.

It will normally be required to include stock assessment and even socio-cultural assessment in this assessment, as the availability of under exploited stock is needed to ensure future profitability. It is clear that there are very little or no under-exploited stocks in the South-East Asian region, the economics of fishing operations is thus in effect mainly geared towards stock depletion. Social cultural factors may be important in cases where family fishing operations are the norm, in these cases some cash costs may be deferred for a longer time than what would normally be expected.

Information on costs and earnings can normally be obtained from the fishers themselves, or from support industries that provide fuel, gears or services.

Governments are normally interested in the rate of investment in fisheries, in view of the current state of resource exploitation, increasing the fishing capacity is in most cases not desirable.

Investment of interest will normally be into new gears, engines or vessels and therefore the support industry providing these are the primary source of information on this.

2.3.2.2 Cost of Monitoring and Management

The costs incurred by companies and industry to comply with fisheries (management) regulation should be monitored, to be able to assess the benefits of policies and regulations against the cost of implementing them. If for examples companies are required to report on sales of fishing equipment, this will have a certain administrative cost (staff need to be employed to prepare reports). In general any benefits from policies should outweigh the cost for implementing them.

Similarly the costs for monitoring, collecting fishery statistics on which management and policies are (ideally) based should be known. This includes staff at different levels of government involved in collecting statistics as well as enforcement and funding for research.

The main source for information (statistics) on these costs is the departments in charge of collecting statistics and monitoring/enforcing the policies. This will include Fisheries Department, but perhaps also forestry, irrigation, coast guard/police/army or wildlife services. In some countries the management and monitoring of water bodies and coastal areas may be divided over four or more different departments, this is true for Viet Nam and also Thailand where different departments are in charge of management of reservoirs. They all may incur costs for management and monitoring of fisheries, as well as costs of training.

It is expected that most departments will have a fairly good administration and accounting system that will be able to provide the required information. A thorough assessment of the costs involved will often lead fuel a discussion how to optimise the benefits of the resources used, for example by investing in other management approaches. It is clear that accurate information on budget and resources should be available to enable detailed planning for collecting of statistics and management of the fishery.

2.3.2.3 Gross value added

Gross value added (GVA) is the total amount paid as returns or rent to labour. It is based on the gross value of production (GVP) by including all costs except labour and capital. It represents the contribution or value added to the economy by the fisheries sector. GVA provides a measure of the economic importance of the sector in the national economy in relative terms and is eventually is incorporated in Gross Domestic Product (GDP). It may be calculated from the raw data used to calculate the Agricultural GDP or estimated from cost and earnings data. In addition data on licensing fees and subsidies are required, which may be available from the Fisheries and/or Finance departments.

2.3.2.4 Subsidies

In many countries subsidies are used to support the fisheries sector. They can be highly visible subsidies to modernise fishing fleet or for certain fishing gears, to tax incentives or a general subsidy on fuel prices. Although subsidies can be used effectively to steer development of the fishery sector, many negative impacts have emerged, mainly over exploitation of the limited coastal resources. Even though inland fisheries normally are not the beneficiary of subsidies, the general subsidies on fuel and tax arrangements may be regarded

as subsidies. In many cases the monitoring and management costs are not paid for by the fishery sector and this may also be regarded as a subsidy.

It is essential to be aware of the existing subsidies to enable policy and planning for the sector. Information on subsidies can be obtained from the Fisheries and Finance departments.

2.3.2.5 Resource rent and economic profits

A number of economic indicators that is of particular interest to indicate the level of economic benefit of the fisheries sector to the national economy are Resource Rent and Economic Profits:

Resource Rent: the returns (profit) to the capital inputs (fishing) provided by the resource (fish stock) itself. Since fish stocks are normally not owned, there is a tendency for over exploitation. Fisheries management and fisheries policies should ensure that the fishing activities are restricted at a level that ensures a certain level of resource rent (profit or revenue). Effective fisheries management should attempt to maximise the resource rent, the factual resource rent relative to the maximum sustainable rent is therefore an excellent measure of the economic performance of fisheries management. Establishing the level of resource rent to be extracted from a fishery is a policy issue and is determined by looking at stock assessment and cost and earnings data, using bio-economic models.

Setting up these bio-economic models is quite tricky and in view of the sorry state of stock assessment and cost and earnings data, would not make much sense before this data has improved drastically. Unfortunately the costs for setting up cost and earnings studies is quite high and therefore it is unlikely that this indicator will play an important role in fisheries statistics.

An alternative to resource rent is *Economic Profits*, the difference between revenues and all costs (including opportunity costs) involved in the fishery operation. The problem here is that economic profits include both resource rent and skills of individual fishers. The latter is difficult to quantify and separate from the resource rent. If it is assumed that the general skill level of fishers does not change, then changes in economic profits are indicative for changes in resource rent.

The gross economic profits can be calculated by deducting subsidies, management, labour and capital costs (including license fees) from the Gross Value Added.

For some fisheries a cheap alternative is available, when a limited number of licenses or quotas are auctioned. The price paid for individual license or quota will be influenced by the expected future profitability. In many cases, the existence of subsidies or hidden costs (bribes) may limit the usefulness of the value of a license as economic performance indicator, as the price paid may not constitute the real value of the resource.

The source for information for resource and economic rent is the same as for aforementioned indicators; therefore the Fisheries and Finance departments should be able to provide most of the data required from existing records.

2.3.2.6 Domestic food supply and fish consumption

Food security is not just a health and livelihood issue, availability of affordable protein is also an economic issue. There fore the supply of fish and consumption of fish at different levels is of considerable importance for the formulation of policies on fish trade, import/export to ensure food security.

To be able to calculate the per caput fish supply, a number of variables should be available:

- Data from fish landings should be separated by use (i.e. food for human consumption and non-food purposes) the same goes for fish imports and exports.
- Conversion factors for different fish products (from gutted or dried fish to fish oil)
- Food consumption (including fish) by food type
- National population census figures

The amount of auxiliary information required is quite large, some information may be available from the national census bureau and in some countries consumption or expenditure surveys are performed at regular intervals. A compilation of the available data for comparison at an international level is made by the FAO who updates the food balance sheets based on data submitted by several national departments.

2.3.2.7 Employment

A measurement for the relative importance of the fisheries sector is provided by the number of people involved in fisheries and related (processing, trade and transport) activities. A major problem with inland and coastal fisheries is that the formal employment, i.e. wage labour in fisheries, is often quite limited. In contrast involvement in fishing activities is very wide-spread, although this is mostly integrated with other livelihood activities.

Most available statistics concentrate on the main profession. For several reasons this is seldom fisheries. Fisheries are considered to be a low status activity and therefore most people will not mention this as the most important activity for income or food, even if it is. If people own land, farming will be mentioned as there primary occupation. Most fishing is done part-time and the only measurement that would make sense in the informal economic setting of much of the inland and coastal fisheries is to ask for time investment or importance in terms of food or income during different seasons.

Even the number of self-employed full-time fishers is limited. For example in the Songkhram river basin, in North-East Thailand a survey amongst 477 villages concluded that of a total of 61069 households only 1270 households had at least one full-time fisher. On the other hand over 35000 households were reported to be involved in part-time fishing. Well over 58% of the households are involved in part-time fishing against only 2% in full-time fishing. Even though in the survey fishing and non fishing areas were lumped together this clearly indicates how many people are involved in fishing but mention fishing or fishing related activities as the second or third activity.

In inland areas, especially in rural areas, people are often involved in many activities and fishing (in the widest sense) is only one of many activities that are important seasonally as part-time activities. The use of employment statistics to show the importance of the fishery sector for small-scale fisheries is rather meaningless. Part-time involvement in itself does not have a large

predictive value, unless other activities are taken into account in a livelihoods strategy analysis. This will be discussed in some more detail in section 2.3.3.4.

Official census information often will include information on profession or wage labour status and this will often include fisheries. In most cases the economic importance of fisheries is not reflected by the official statistics, but should be inferred from socio-economic studies or specialised studies.

2.3.2.8 Trade balance of fish and fishery products

The difference between the value of imports and the value of exports of fish and fish products gives the trade balance. It shows foreign currency earnings and losses as a result of international fish trade. It basically shows the performance of the national fisheries sector as opposed to foreign fisheries sectors. In some cases establishing the trade balance will lead to studies of national fish trade and policies.

Import and exports (provided they are official) are normally well documented and several departments or specialized agencies may be able to provide information on the official trade. In respect to grey import and export, some information may be obtained from transporters, who may be willing to provide information, or by visiting whole sale markets or middle persons. This kind of information can often be obtained when collecting marketing and trade information and drawing up market flow diagrams. Although the quantities are normally not very exact, this can give a good sense of the marketing flows and the relative importance of marketing hubs. This is not only important at a national level, where knowledge of the marketing network allows better planning and facilitates anticipation of impacts from policy and management measures, but also at a regional level to establish international market flows and possible ways to improve trade. More information on trade networks and marketing studies is discussed in section 8.3.

An unknown but large part of the inland fisheries production of Cambodia is illegally exported to Thailand, similarly a small proportion of the fish catches in Lao Mekong river, along the shared border with Thailand is sold for consumption at Thai markets or directly to restaurants or middle persons in Thailand. In some cases coastal catches from neighbouring Myanmar, Cambodia and Viet Nam are also exported illegally or caught by foreign vessels and landed abroad.

2.3.3 Livelihood Data

Under livelihood data a wide range of variables and indicators are included; this also covers so-called socio-economic or socio-cultural indicators that describe the effect of policy and management not just in economic terms, but in terms of involvement, distribution of consumption, income and activities over age groups and gender.

Even though these indicators are critical for any balanced evaluation of policy and management, these are not normally routinely collected. Objective assessment for socio-cultural data is essential and cannot be replaced just by one-off surveys. However this is exactly what seems to happen: surveys are often commissioned at uneven intervals, implemented by research institutes and universities and the results seldom have an impact on the design of the statistical system, nor on policies and management. Departments of fisheries often do not have the internal capacity to design, implement and analyse these types of

surveys and are often not capable of using the results of any surveys commissioned to outside organisations. Capacity building for socio-economic work should be a main component of any survey commissioned, with department of fisheries staff involved in all aspects of the survey, from the design to report writing.

One reason for the lack of attention for socio-cultural variables and indicators is the difficulties to establish rigid targets or limits. Socio-cultural indicators describe the fisheries in terms of equitable benefits or the social value of fisheries. Many fisheries scientists feel at least a bit squeamish about this kind of fuzzy language and the lack of common ground with economics or biological indicators, which can often be expressed in quantifiable mathematical expressions. This indicates for many that socio-cultural issues are not quantifiable and therefore unimportant.

It is unlikely that socio-economic surveys will be an integral part of the routine statistical system in any of the SEAFDEC member states, especially when the budget currently is hardly sufficient for covering the catch and effort statistics. Therefore treating these surveys as research is permissible, as long as there is proper planning and co-ordination with the regular statistical system. Of the several variables discussed here, the one with the most potential and multi-use potential is fish consumption, that can be used both for food security and quantification of small-scale fisheries catches (section 2.3.3.2). Fish consumption studies are widely regarded as the only practical way to obtain accurate production estimates for small-scale (family) fishing. The other variables and indicators are more esoteric, i.e. they are less practical and more socio-cultural in nature.

2.3.3.1 Distribution of income

The distribution of income out of fishing activities over different socio-cultural groups is an important indicator of equity. Managers and policy makers can analyse the income distribution and try to tweak policies to give a larger share of the wealth from fisheries to some groups. It can also tell if some group is profiting more than other groups and may give clues how to influence the distribution of income.

It may also show to what extent certain groups are influenced by certain policies, and whether some groups are hurt more than others. In this respect it can provide a valuable feed-back mechanism to assess the performance of management and policy in socio-cultural terms.

To be able to analyse the income distribution, the earnings (monetary and otherwise) have to be available at the level of individual crew member and for fishing households. This information may be obtained through interviews with individual fishers, but it makes more sense to collect this through household interviews in fishing communities. Demographic data is required to describe the composition of the household in terms of age and gender and is normally available from the national census bureau.

2.3.3.2 Distribution of fish consumption

In terms of food security it is important to know what groups are depending on fish, and if there are any alternatives, in case the fish supply would decrease. It is a fact, not just in South-East Asia, but in the world as a whole that fish is essential as a cheap source of protein for large parts of the population. In many places it is the only source of animal protein people can afford or is still available ‘free’ for anyone to catch. Even if the fish protein could be replaced

with other sources of protein this would normally be more expensive, too expensive for many people currently relying on fish for their protein intake. Therefore there is a question of replacement cost or additional cost to the economy if part of the fish production would have to be supplied from another source.

By including different social and age groups in the assessment it is possible to look at the consumption patterns of children, pregnant mothers, elderly people etc. In addition if reliable estimates for the species (and size) composition can be obtained, the reliance on certain species can be assessed, and also which species are mainly consumed by some groups. This may be of crucial importance as some species or fish products may be consumed with preference over other products and any change in the supply side could disrupt the social structure.

Any policy should ensure that enough protein is available at all times, and as such distribution of fish protein is a measure of food security and of social stability within fishing communities. It is common practice to share fish production amongst the extended family, and this factor should be taken into consideration.

Detailed catch and landings data are required, with species detail, demographic data as well as money available at a household level; this is often available from national expenditure and consumption surveys. The conversion ratios of different fish products to grams of protein per kg of product should be available, if possible by species and should be as accurate as possible, since the results of the extrapolations are heavily influenced by the conversion factors, since rural populations in South-East Asia rely heavily on processed fish and fish products and fresh fish only constitutes a small part of the total fish protein intake.

2.3.3.3 Management assessment

Any change in management should take into account existing management practices. Existing social structures will indicate if new management approaches could actually work. If there is little or no trust between managers and the community, than co-management approaches are difficult to implement.

To be able to propose changes the existing management structures and practices both formal and informal linkages should be known as well as the extent of membership to different community bodies. In order to assess the status of fisheries knowledge the degree of use of local knowledge should be assessed

In fact this requires a full institutional analysis for the whole fisheries sector, including issues of resource ownership, co-management practices and multipurpose resource management, in particular to the process of making policy and management decisions. This analysis is very labour intensive and time consuming and should not be regarded as a routine survey, although updates can be obtained on a routine basis, in practical terms this will normally not be done more often than every 5-10 years.

A cheap alternative is a desktop study and consultation with national fishery experts with all stakeholders (including fishers). This will be able to generally describe the relationships and management arrangements, but will fail to provide much detail.

2.3.3.4 Dependence on fishing and related activities

The combination of demographic data and patterns of fishing activities can help to find dependency relations between certain social groups and certain activities. This will show if certain groups are more influenced by certain policy or management interventions than others. This knowledge will assist in assessing impacts of management interventions on different stakeholder groups.

This is a very complex analysis that requires a large amount of data on households, activities and community structure and decision making processes at all levels.

The main aim of this information is to be able to predict what individuals, households or communities are likely to do under changing circumstances. In view of the many variables that need to be considered this is not an easy task and is way beyond the scope of this handbook. However it is important to be able to predict the impact of policy and management and attempts should be made to incorporate these and other indicators into decision and planning processes.

2.3.3.5 Social status of fishing

In many places fisheries is regarded as a social security net, an activity that is done as an activity of last resource. Although this is clearly not true for capital intensive fishing practices, the large amount of subsistence fishers especially in inland areas testify that, many people are depending on fisheries. Entrance into fisheries, for employment is often governed by considerations of profitability as well as the social status, especially if there is a choice of other jobs with similar enumeration. In many countries in South-East Asia, commercial fishing is done with foreign crews, whereby Thais work on Malaysian vessels, and People from Myanmar and Cambodia on Thai vessels.

Involvement of fishers in non-fishing institutions at a community level will indicate the degree of integration of fishers with the rest of the community, or the degree of (social) isolation within a community.

Data are usually obtained from fishers, fishing communities, government agencies, fisheries agencies (see Annex 6)

2.3.4 Environmental 'statistics'

Although estimates for the biological fisheries variables (catch and effort) describe a large part of the fish mortality, this is only part of the picture. In many fisheries, especially those depending directly or indirectly on floodplains, close to mangrove or sea grass areas or on (coral) reefs, and also in up welling areas in the marine environment information on the environmental parameters are critical in understanding the fluctuations in the stock.

The state/health of habitats fish need during their life cycle is essential for predicting status and trends. For example information on flooding, flood duration and timing of flooding is essential to predict recruitment and often displays a very close relationship with the fishery production thereby providing an additional method for obtaining fisheries production, by assessing the flooded area by means of remote sensing (see also section 11). This approach has been tested on a limited scale in Cambodia where a clear relationship was found between

the extent of flooding and the total fish production for any given year. It is not entirely clear what plays a more important role, big floods (increased duration of the flood) by themselves increasing productivity or extended exposure to fishing pressure by the large population of part-time fishers on floodplains. This likely depends on the species and more research is required to establish the complex relationship between aspects of flooding (timing, duration and fluctuations) and the fish production.

Natural fluctuations of populations in response to fluctuations in environmental parameters such as temperature, water levels, rainfall etc. are not well understood and long time series of data are required to be able to assess these relations and obtain reasonable estimates for fish production. In many cases environmental parameters are already collected by various departments, like Meteorological department, and departments responsible for different aspects of water management, or irrigation. In some cases data is available from buoys, Vessel Tracking Systems or remote sensing. Research data is an important source of environmental data.

Many variables can be listed that give information on the various habitats or ecosystems. For inland and coastal fisheries two areas are of special interest: floodplains and coastal zones (mangroves and estuary):
For *floodplains*, water level, area flooded, timing and duration of flooding are important characteristics, as well as topography (land cover) of the floodplain;
For *coastal zones* and mangroves, salinity and temperature gradients as well as seasonality (monsoon influence) are important variables, as well as area and different kinds of chemical measurements to assess pollution levels.

2.3.5 Scientific data

In addition to regular fishery statistics, some supplemental information may also be useful to understand the fisheries, this is scientific research data. Although these methods will not be covered in this document, it is important to mention it and put it into context.

2.3.5.1 Fish sampling

Ecological research methods are undertaken independent from commercial fishing operations and can include experimental fishing (to assess catchability) or scientific sampling of fish stocks or environmental parameters. The data collected can be biological (abundance, occurrence, size composition, migration and spawning) or environmental (salinity, conductivity, temperature etc.).

In a similar way socio-cultural research methods (household surveys, Rapid Rural Appraisal (RRA) or Rapid Fishery Appraisal (RFA)) can be used to obtain information on fishery related topics, of interest for management.

As with fishery statistics this type of research should be conducted at regular intervals, although not on a routine basis, and should form part of infrequent data collection where possible.

2.3.5.2 Interview

Interviewing of key informants can provide very useful information. A basic set of questions form an introduction to more open ended discussion of certain topics of interest. Key informants can be academic experts, community leaders, fishing industry entrepreneurs or expert fishers. This methodology is widely used to obtain Local Ecological Knowledge (LEK) from fishers and can provide valuable insights in ecological information on spawning and migration, biology of fish and fishing practices.

2.3.5.3 Observation

Participant observation is a technique where a researcher spends a long time in a community, conducting open ended interviews/discussions and in general observing the behaviour of the community members and how they interact in times of conflict. This method provides important information on the actual decision making processes as opposed to the formal procedures. The actual practice can deviate substantially from the cultural and institutional rules. This observational method is often the only way to obtain information on the informal standards.

3. Basic Statistical Theory

Although this document is not intended to be used as a reference work for basic statistics, it is good to cover at least the basic units and concepts.

Statistics is a methodology to describe a number of values, i.e. the classification, tabulation, and study of numerical facts. Statistical descriptions can be brief or elaborate, and can consist of graphs, tables, or frequency distributions. In most cases statistics consist of only a few selected values that describe a certain characteristic of a group of values. What measurement is selected depends on what we want to show, be it a trend, the proportion of values above a certain value, a measurement for the middle of the data or the variation.

Two key concepts are:
Population: the collection of all possible values
Sample: a subset of a population

The term ‘population’ arose when statistics only referred to descriptions of human populations, i.e. census counts. These days the word has got a much broader meaning, including all gears used in a certain area, or all sizes of fish caught for a given species.

When describing a population by taking a sample, an important and often used measurement is the mean, or more particular the **arithmetic mean** or average that is defined as:

$$\frac{\text{sum of a number of values}}{\text{number of values}}$$

In formula form:

$$\bar{x} = \frac{\sum x}{n}$$

Sometimes a number of values contain a few small or a few large numbers that are not 'typical', i.e. they do not fit with the other data. These data are called outliers. Although outliers should not automatically be excluded, the arithmetic mean may not reflect the typical value, the middle of the values may be better described by other measurements.

Median the middle number (for an odd number of values) or the arithmetic mean of the two middle values (for an even number of values) for a set of numbers arranged (sorted by size)

The medians for different samples of the same population have in general a larger variation than the values for the arithmetic mean for the same samples; however a median can be obtained from ordinal data (data that is ranked, but does not have a numerical value) like ranking the importance of fishing activities according to their importance for a household. Whereas the average can be obtained by using the median, an arithmetic mean cannot be calculated from ordinal data.

Fractiles (also **quantiles**) are derivatives of the median, in that they divide a group of values in two or more parts, like quartiles (25%).

It is sometimes used to show outlier values, or simply to display the range of values encountered.

An important concept in statistics is variation. All measurements vary, and in each collection of values the amount of variation is an important measurement to fully describe any set of data. There are two main measurements that can be used:

Variance is defined as the average of the squares of the differences of a number of observations from the mean.

Standard Deviation in a frequency distribution, the root of the variance

Normally the summed differences are not divided by n (the total number of observations in the sample), but instead by n-1 for samples, to obtain a better estimate for the variation. Normally the standard deviation is used, in formula:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

The application of the standard deviation is quite straight forward: if the standard deviation is small then the values in a sample are concentrated around the mean. Alternatively if the standard deviation is large, the values are scattered wildly around the mean. The nature of the standard deviation allows us to make predictions to what percentage of the data is between certain limits.

For any set of data, the proportion of data that must lie within k standard deviations, on either side of the mean is at least:

$$1-\frac{1}{k^2}$$

This means that at least 75% of the data is within 2 standard deviations from the mean and at least 96% is within 5 standard deviations on either side of the mean.

The disadvantage with the standard deviation is that it depends on the unit of measurement, and this has always to be kept in mind. For example the standard deviation may be 5 grams when measuring something. This may be huge when measuring fingerlings at a fish farm, but not when estimating the monthly catch for a commercial fishing boat. The solution is to obtain a measure for relative variation, by removing the unit. This is generally know as the coefficient of variation and is calculated as:

$$V = \frac{s}{\bar{x}} * 100\%$$

This expresses the standard deviation as a percentage of what is being measured.

The amount of fluctuation of estimated means from samples around the 'real' mean of the whole population is dependant on the size of the sample and the size of the standard deviation of the whole population. It is good practice to always write down the mean, together with the number of values in the sample and the standard deviation to give a complete picture of the sample.

To make it even clearer a measurement for the reliability of the estimate of the mean can be added. This is normally in the shape of **confidence intervals**. This is given in formula form as:

$$\bar{x} \pm z_{\alpha/2} * \frac{\sigma}{\sqrt{n}}$$

The end points at either side of the interval are called **confidence limits** and the (1-α)*100 % is called the **degree of confidence**

A noteworthy fact is that when the degree of confidence is *increased*, the confidence interval becomes *wider* and thus tells us *less* about the quantity we are trying to estimate!

Above formula is valid for large samples, at least with 30 observations, if there are less than 30 observations a slightly different approach is taken where z is replaced with t (from the student-t distribution) and σ is replaced with s (the standard deviation of the population). The value of distribution of t is dependant on the number of observations, or the **degrees of freedom**, this is normally denoted as f.

The quantity $\frac{\sigma}{\sqrt{n}}$ or $\frac{s}{\sqrt{n}}$ is the standard deviation of the estimate of the mean and is also called the standard error. It is clear from this formula that with larger samples the estimate for the mean ξ will be more reliable.

More complicated statistical concepts may be required when analysing and interpreting the raw data, especially to establish the validity of the sampling approach and to enable extrapolation of results, and testing for significant differences. However this is more in the realm of analysis, for the first tabulations, it is rare to use more than above measurements.

Recommended further reading

There are a large number of text books available on general statistics. These tend to concentrate on theoretical statistics and are often intended to be used by students at university level. These textbooks are often (too) general and are not very practical focussed. A

Fowler, J. and L. Cohen, 1995. Statistics for ornithologists. 2nd ed. British Trust for Ornithology Guide No. 22.150p.

Freund, J.E., and G.A. Simon, 1997. Modern Elementary Statistics. Ninth edition. Prentice-Hall International, Inc. New Jersey, USA, 612 pp++.

4. Census and Sampling Approaches

4.1 Introduction

There are two ways of collecting statistics:

1. census, a complete enumeration or count of all elements in a population
2. sampling, selecting only a few measurements and using these to estimate the average value

A census approach is only appropriate for national population/expenditure surveys. Even then often sampling approaches are used in census surveys when the total population is too big to be covered completely within reasonable time. For most parameters that are of interest to inland and coastal fisheries it is normally not possible to collect them cost effective (nor reliable) by using a census approach, except where logbooks or questionnaires can be easily implemented.

4.2 Sampling

Many people feel uneasy about sampling and think that it will always be better to count everything. Try counting or weighing a big pile with fish, you will find that the results of different counts are never the same, slightly more or less, but seldom exactly the same. Sampling will never be 100% accurate, but that goes for a census too, in real life sampling is the only practical way to collect information.

For inland and coastal fisheries a census or complete enumeration of landings and fishing effort is not possible, not even if reporting of catches using catch logbooks could be implemented. Landings are normally not concentrated in a few big ports but are dispersed over a large number of sites. Maybe there will be 100 or more landings for small to middle scale commercial fisheries at any particular landing site, concentrated in only a short period in the day. For any given landing site (and there will be many different landing sites for small to middle scale commercial fisheries) it would be necessary to have large numbers of data collectors to be able to perform a census every month! A census approach can result in very accurate results. However, the costs

both staff and money will be very high. In complicated fisheries, and where in inland or coastal fisheries is the situation not complicated, with many gears, fishermen and landing sites a census practically impossible.

The alternative for a census is to measure only a few landings and use the average weight from these landings to estimate the total landed weight. This is called sampling and it means to measure some of the landings only at certain landing sites and on certain days. This method will be far cheaper and easier to implement than any census approach. To collect enough information to make our estimation of the total fish production only a few staff members will be necessary for each district or even province.

It is not necessary to take many samples, since even when recording less than 1% of the total number of landings, the result of the **estimate** for the total fish production can be very close to the **actual weight** of the total fish production. This depends mainly on the variation in the landings, i.e. the differences between the catches landed by different fishers and the level of error that is still acceptable. This is where it gets iffy. Although there are certain fisheries where sampling of catch and effort can be easily implemented and indeed are, the amount of fishers involved in simple gill net fishing in inland areas on a commercial basis is so large and the number of landing sites so vast that also the sampling of catch and effort becomes too much. Similarly in many small-scale coastal fisheries the amount of effort that is required to obtain even the minimal number of samples is simply too much.

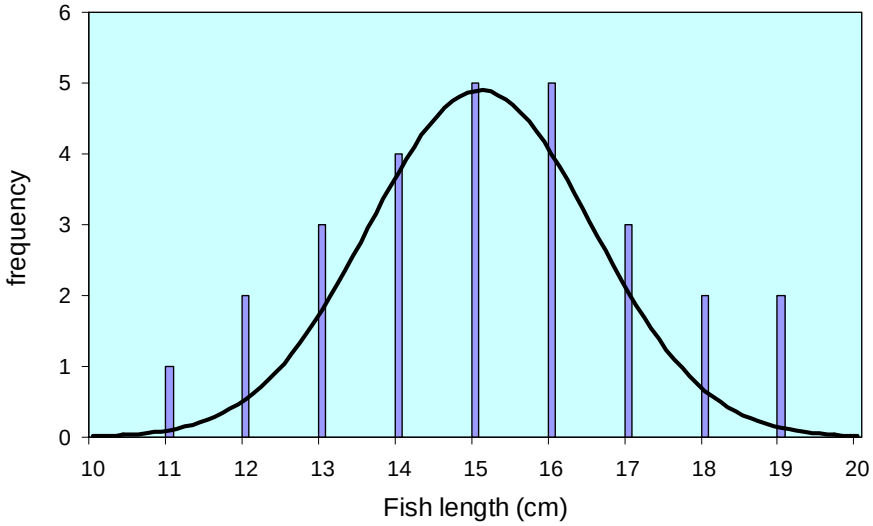

Figure 1. The normal distribution curve, with a real-life length frequency example (μ = 15.07 cm).

A useful concept in statistics and one essential for the concept of sampling is that of the normal distribution. Although this is mainly a theoretical concept for a population with infinite number of values, surprisingly in many cases measurements follow the same bell shape as the normal distribution. An example of such a distribution is shown in figure 1. Here the frequency of the number of occurrences of all possible values is plotted against all possible values, ordered by an x value (fish size, number of gears etc.). The position of the normal distribution curve along the x-axis depends on the value for the mean. However the width (or the shape) of the curve is only defined by the variation of the population, that forms the basis of the curve.

The normal distribution is the best known and most important of all distributions. There are a number of other distributions that may be of interest but these are beyond the scope of this handbook. Skewed distributions can be regarded as normal distributions and tests are available to calculate the normality or the skewedness of any given distribution. Many variables will produce a normal distribution curve when they are plotted as frequencies of a measurement. Others are easily transformed into normal distributions, by taking the logarithm of the measurements. The normal distribution plays a central role in statistics and is a fundamental element in sampling theory. It forms the basis of many assumptions and approaches in statistics.

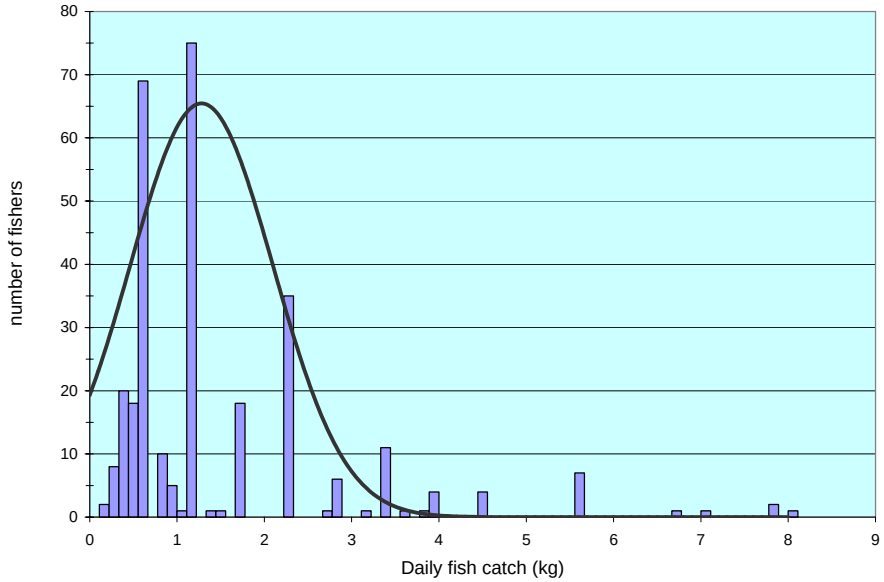

Figure 2. Catch frequency for individual fishers (μ = 1.28, sd = 1.25, n = 304) and the normal distribution curve.

In practice many results may result in a skewed distribution, for example the frequency distribution of daily catches will show a preference for smaller catches (figure 2), even though the distribution does not follow the curve precisely, the general shape of the frequency bars does coincide with the normal curve.

Everyone working with fishery statistics is familiar with skewed distributions, in some circumstances this is caused by bias in the sampling in many others it is only a seemingly skewedness, i.e. the length of fish plotted against the frequency for each length interval will probably result in a very skewed distribution, as there are many more juvenile fish than adult fish for most species. However the distribution of length frequencies within an age cohort is normally distributed.

For large enough populations any collection of measurements will form a normal distribution when plotted as a frequency distribution of ranges. If sampling is at random, the values with the highest frequency have most chance to be sampled. This means that since the values are evenly distributed around the mean the chance that the estimated mean, based on the sample is close to the population mean, is large.

The theoretical normal distribution curve has a surface of 1.

4.2.1 Random sampling

Random sampling means that any member in a given population has the same chance of being included in the sample. In real life it is often impossible to truly sample at random, in most cases practical constraints make that we have to take a less stringent approach. In fact for sampling to be at random all members of a population should be known, from a sampling frame (census), before initiating any sampling. This is not possible in most real life circumstances. Therefore normally an approximation is used in which the dictionary meaning of random is used: 'haphazard, without aim or purpose'. This means that we must not select or reject any element of a population because of its seeming typicalness or lack of it, nor must we favour or ignore any part of a population because of its accessibility or lack of it.

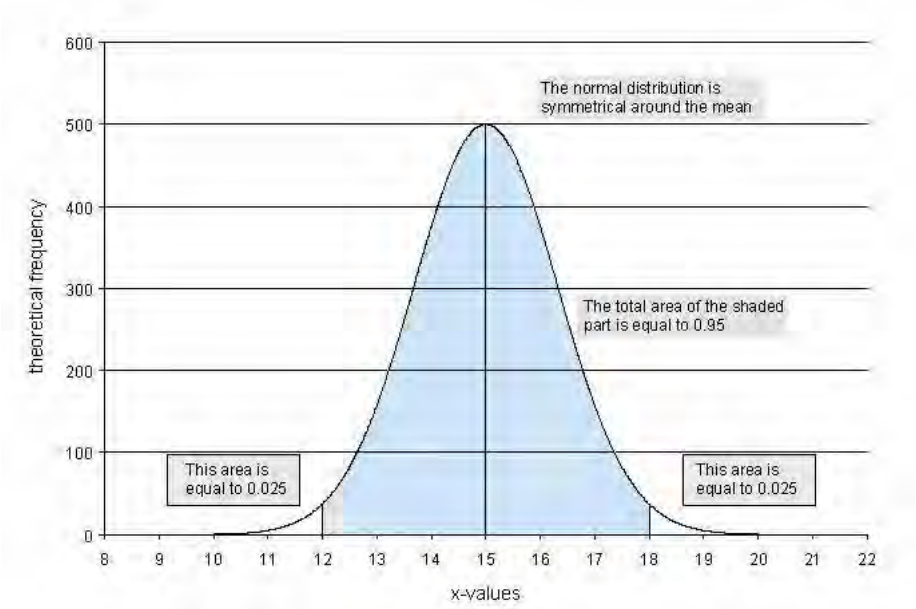

Figure 3. Representation of the theoretical Normal distribution curve.

In practical terms, when choosing certain villages, house holds, individuals, or other collections to be sampled/interviewed we have the problem of replacement of pre-selected elements with others, due to unavailability or unwillingness to co-operate. Certain households may refuse to be interviewed, certain individuals may be unwilling to give answers; certain villages may simply no longer be there. In the end it may sometimes appear that the sampling is non-random, as in certain instances someone will predetermine who or what is covered in a survey, for example a market master or village headman may decide that only some people are fit to be sampled or interviewed.

Another problem in sampling is the existence of bias. The catch that is sampled may be landed from different sites at different times, so that when sampling only during part of the day only part of the population is sampled. If different gears are used in different sites, or when different species or size ranges are the result, this would seriously influence the estimates based on these samples. Where possible bias should be avoided, for this it is important to have some background information on the fishery and practices to allow the sampling to be designed properly.

4.2.2 Systematic sampling

Systematic sampling provides a practical solution to implement random sampling. In systematic sampling every 10^{th}, 12^{th} or 50^{th} member of a population is sampled; the randomness is introduced by using a random number for establishing with which unit to start sampling. The reliability may sometimes improve compared with truly random sampling as the samples are spread more evenly over the total population.

Even though systematic sampling is not truly done at random it is reasonable to treat the resulting samples as if they are taken at random. The only real danger lies in the presence of periodicity, which could be inherent in manufacturing or city planning (for example city or apartment blocks), but normally less so in fish landings or other fisheries parameters, establishing a sub-sample of villages to be sampled, or a sub sample of households to be sampled in each village.

4.2.3 Stratified sampling

Only if we have information on a certain population that is relevant to the data we want to collect can we improve on 'random sampling' by stratification of the population. The aim of stratification is to divide the populations in non-overlapping groups that internally are more homogeneous, thereby reducing the variation and cutting back the number of samples required.

In catch assessment separating boats according to size classes, gear classes or into motorised vs. non-motorised often makes sense as size, gear or the presence of a motor influences which fishing grounds are fished, and thus what species or what sizes are caught. Similarly, separating households over income classes or fishing vs. non-fishing households may decrease the required number of samples and increase the reliability.

For stratification to work, some information about the fishery is required, on gear use, number of boat-gear combinations or on location of fishing grounds. This information should be collected separately, by talking to key informants, by conducting a frame survey or by using existing census or sample information.

Stratification of the fishery to be covered by the statistical data collection programme will include decisions on:

1. Administrative strata
2. Logical strata (estimation contexts)
3. Sampling locations (homeports and landing sites)
4. Classification of the units that will be measured, including:
    a. Boat and gear categories
    b. Species and species groups
    c. System units (i.e. weight, currency and effort units)

This standardization will greatly assist in assuring the data collection and processing will process smoothly and will ensure that the results can be compared with other fisheries or strata. For any given fishery two types of strata are identified:

Major Strata
These are defined by administrative boundaries. Data collection will have to follow administrative boundaries as the fisheries staff at a local level will have to be mobilized; this stratification is only for practical organizational and reporting purposes, not from an statistical point of view.

Major strata often conform to district or provincial boundaries and are in fact a bit of a nuisance as natural strata, sub-basins or ecosystems normally do not conform to any administrative division. If statistics are required for these ecological units then a complex estimation process is required (often using GIS) to fit part of the existing data from administrative units. A fine example is the Mekong River that forms a prime major strata for which catch assessment estimates have to be made and that relies on national statistics organised by province.

Minor strata
Within each major stratum there are sub divisions that are logical, i.e. they make sense from a sampling point of view and can be either spatial or temporal. These sub-divisions are called *minor strata* and they form the basis of the estimation process.

Minor strata are not limited to geographical areas. They can also refer to any other 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.

However, as the required sampling is established at the minor strata level, increasing the amount of strata too much (i.e. adding too many boat-gear categories, increasing the level of detail for which separate estimates are available) also will increase the amount of sampling required to be able to obtain reliable estimates.

General rules for the optimum allocation of sampling effort to each stratum are to assign more sampling effort to those strata that:
- are larger
- have a larger variation
- for which the cost to sample is low

The number of elements in each stratum to be sampled can be decided according to the total number of elements in the population, according to proportional allocation:

$$n_i = \frac{N_i}{N} * n \qquad \text{For i = 1,2,…, and k}$$

n_i being the number of samples in stratum i, N_i being the total number of elements in stratum i and n being the total number of samples to be taken.

Alternatively the number of samples in each stratum can be assigned according to **optimum allocation**, which means that not only the size of each stratum but also the variability between strata is taken into account taking the population standard deviation σ instead of the sample standard deviation s:

$$n_i = \frac{n * N_i \sigma_i}{N_1\sigma_1 + N_2\sigma_2 + ... + N_n\sigma_n}$$

The variability refers to the characteristic on which the stratification was based. This could be the size of villages in each stratum, or area of rice paddy, but unfortunately not something vague as the habitat type (fishing ground), unless these can be assigned a numerical value.

4.2.4 Cluster, area or sub sampling

Another technique that greatly enhances the reliability per unit cost, not necessarily the overall reliability is the approach to make a census in a sample. The total area of interest is sub-divided in a number of smaller areas and from these a number are chosen at random and all the elements in these areas (or a sample of them) are then covered. This is a special case of what most people consider to be sub-sampling where a small part of a sample is chosen at random to be taken representative for the whole sample.

Selecting some discrete landing sites or villages from the whole population is the standard approach, when dealing with a large area that is covered.

4.3 Sample size

An important decision to make is on the number of samples to take, both in terms of planning and of estimating the survey costs. The only way to estimate the necessary number of samples from a statistical viewpoint is on the basis of discrete data items. If we know for a certain question the amount of error we think is acceptable and the expected variation of the answers and the confidence levels we want to have, it is possible to get an indication for the necessary sampling effort. Since statistics does not pretend to be exact (statistics does not promise better results than the data can guarantee), the advice on the number of samples to take will err on the careful side. Although this may not be much comfort, it is better than that the number of samples will only be determined by what can be handled or by 'what others are doing'.

Although in many cases the available manpower is an important factor, it should not be the *main* argument for determining the sample effort. Cost of data collection, the perceived benefits and the required reliability should be carefully balanced. As the graph in figure 4 shows, there is a point beyond which taking additional samples does not increase the reliability much.

The sample size depends on the margin we accept, the certainty that we need that the resulting estimate falls in the margin of error we have specified and the variation in the parameter to be estimated. In formula form:

$$n = \left\lceil \frac{\lfloor t_{n-1} * s \rfloor}{\varepsilon * x} \right\rceil^2$$

n	number of samples
t_{n-1}	student-t value for n-1
s	standard deviation of sample
ε	maximum relative error
x	mean of the sample

The main disadvantage of this formula is that it is necessary to have a reasonable idea of the population standard deviation. In cases where no reliable estimate can be made, it should be either over estimated, or the sample size is determined while collecting the data by monitoring the estimate for the sample standard deviation. It is also necessary to have an idea of the mean of the population while the population should be normally distributed.

From the previous section it is clear that many populations do not follow a normal distribution. Sometimes this can be changed by using a logarithmic transformation or some other 'trick' to influence the scaling of the horizontal x-axis.

For example if we want to estimate the number of monthly samples in a beach seine fishery, we need to know the number of beach seines, the proportion that is active each day (or night) and the average catch per day (or night) operation.

When we allow for a 5% margin of error (ε), for a set of values that have a mean of 14.25 kg per 'trip' with a variation (s) of 5.6, then we would select a high value for t of 2.1 to get:

$$n = \left[\frac{\lfloor 2.1 * 5.6 \rfloor}{0.1 * 54} \right]^2 = 68$$

In this case we would need 68 samples each month to be able to estimate the average value within a 90% reliability. If the reliability needs to be 95%, the number of samples should be 272.

The relation described by the formula for the sample size for the above example is displayed in figure 4. It is clear that after an initial large improvement of the reliability, the gain in reliability per increase of sampling effort quickly decreases. After a sampling size of 100 the error only very slowly gets lower, to a point where a small gain in increased reliability becomes hugely expensive in terms of effort and manpower.

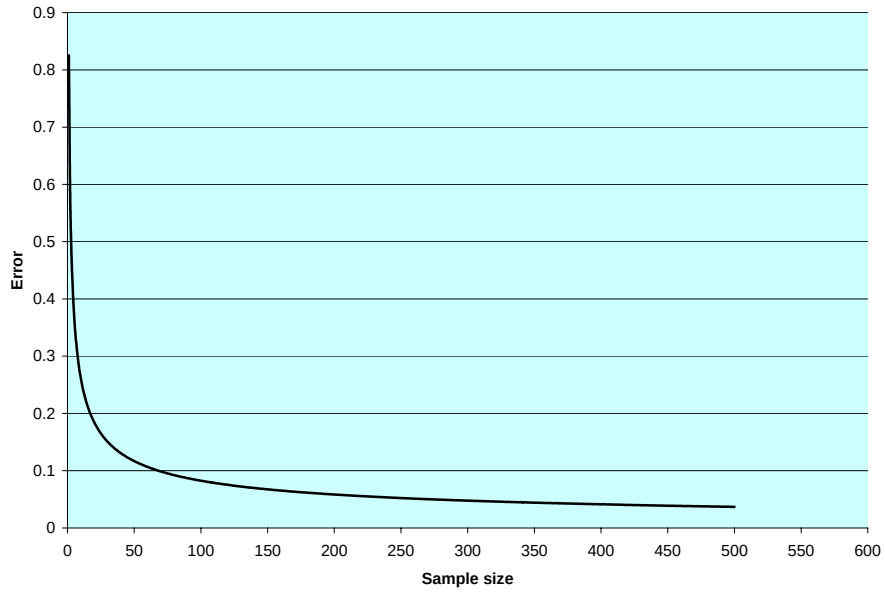

Figure 4. Sample size and maximum relative error for the estimation of average catch.

Having to train and supervise large amounts of data collectors may in fact decrease the reliability and counter any benefits from adding more samples, mainly due to human errors and data fabrication.

As said before it is only possible to estimate the number of samples if it is clear what the maximum error is we find acceptable, and what confidence level we want to get, to be sure that the error will not be higher than the value indicated. For simple yes/no questions, we can use a simple relationship of proportions:

$$n = \frac{1}{4}\left(\frac{z_{\alpha/2}}{E}\right)^2$$

n number of samples
$z_{\alpha/2}$ value for z equivalent to the area under the normal curve
E Maximum error of estimate

The value for z is depending on the required reliability and this can be taken from standard statistical tables, for example z0.025 (which equals to a probability of 95%, or 0.05/2) = 1.96.

For instance if we do not want the error to exceed 0.10 (10%) with a probability of 0.95 (95% confidence limits) than the number of samples needs to be 97, if the error should be less than 0.05 the number of samples needs to be 385!

The required reliability depends heavily on what the data will be used for and also what the parameter is that we try to estimate. In general it makes a big difference whether the data is analysed for a country, province, district, landing site or village, and whether the estimates need to be based on a yearly, monthly, weekly or daily time frame. Although the sample size for a single parameter is easy to calculate, for surveys with many different questions, the sample requirements for different parts may be quite distinct.

For the statistical sampling error to be calculated and to assume that our estimate for the mean of our samples (x) can be taken to be an estimate for the mean of the population (μ), n the sample size needs to be sufficiently large, meaning equal or larger than 30. For classical catch assessment this means that we need to take at least 30 samples for each sample period for each boat/gear type for which a separate estimate has to be made. At the same time the population under examination should be infinite or a large enough finite population so that the finite population factor need not to be used. So if we use x (sample mean) as an estimate for μ (population mean) then the probability is 1-α (in this context α is the area under the standard Normal curve, i.e. the confidence level) that this estimate will be wrong either way by at

$$E = z_{\alpha/2} * \frac{\sigma}{\sqrt{n}}$$

most:
This assumes that the sampling is random and sufficiently large from an infinite (or large) population so that the sampling distribution of the mean is approximately a Normal distribution, according to the central limit theorem. The above formula, for the maximum error of the estimate, can be re-written to indicate the number of samples needed:

$$n = \left(\frac{z_{\alpha/2} * \sigma}{E}\right)^2$$

Note: *The above formula, to establish the sample size for estimating μ, is depending on $z_{\alpha/2}$ the value of z for which the area under the standard-normal-curve is equal to $\alpha/2$. We are interested in $\alpha/2$ as this refers to the area to the right of z on the x-axis of the Normal distribution. It is good to remember that the total area under the Normal distribution is 1, hence the area under the curve to the right of z = 0 is 0.5. Tables only represent half of the Normal distribution (since it is symmetrical). If α is 0.05 (95% confidence limits), $\alpha/2$ is 0.025 and we need to look for the value of z corresponding to 0.5 – 0.025 = 0.475, which is z = 1.96. Substituting appropriate values for E and σ then gives the appropriate number of samples to be taken…*

In general we do not know what the standard deviation, σ of the population will be. Therefore we can either replace it with a large but plausible guess just to be on the save side, or start with a small sample and let the observed value for the standard deviation (s) determine whether more data are required.

When talking about individual catches the standard deviation depends on many factors, not the least of which are the gear, gear use and the skills of the fishermen operating the gear. As a rule of thumb the variation is proportional to the average, i.e. s is equal or larger than the average. This implies that we may need to assess first which averages we want to describe.

Note: *On the other hand there is a distinct difference between σ and s, or between the standard deviation of the population and that of the sample. This is essentially similar to the difference between the population mean and the sample mean with which we try to estimate the population mean. As long as the sample is large enough, the bias will tend to be small (given a proper sampling design) and s will be a good estimator for σ.*

It is clear from the above that estimating the required sampling is as much an art as science and that in order to plan a survey it is necessary to have at least some basic understanding of critical information like the range of the mean and the expected variation. If this is not available this could be the subject of a pilot survey to establish the mean catch and variation by measuring a random selection of landings.

Using any of the above formulas will normally give a conservative estimate for the number of samples that needs to be taken. The estimate for the sample size may well be larger than actually required.

In practice many statistical systems apply rules of thumb or use empirical established sample sizes. For example for catch assessment using sampling for catch and effort at landing sites and home ports, that will be described in section 7, a minimum sample size of 30 is often advised spread out over 5-6 days per month. This can be adjusted upwards if the variation in the landings within one strata and boat/gear combination proofs to be high.

Planning a survey requires considerable effort. After the sample size has been established the logistics of the survey need to be decided. This should address the number of data collectors and supervisors required and selection of staff that will be involved. The costs and general requirements for all steps of the survey including those for data processing and publication of the results should be established in advance. All steps of the survey: objectives, background information of the survey area, methodology, sampling design, survey formats and logistical arrangements should be included in a survey manual, that forms part of the training.

Recommended further reading

There are a large number of text books available that deal with sampling. The standard work in this sense is:

Cochran, W.G., 1977. Sampling Techniques. 3rd edition, London. John Wiley and sons inc. 428 pp

Other valuable books, besides the ones already mentioned in the reference list are:

Green, R.H., 1979. Samplíng design and methods for environmental biologists. New York, John Wiley & Sons. Inc. 257p.

Thompson, S.K., 1992. Sampling. New York, J. Wiley-lnterscience.

Thompson, S.K. and Seber, G.A.F., 1996. Adaptive sampling. New York, J.Wiley-interscience.

5. Statistical System Design

Methods for collecting statistics are well established. This means that in most cases the main task at hand is to design the statistical system, using the available methodologies and adapt them to the local circumstances and data requirements. This can be a very complex process depending on the exact fisheries situation, and far beyond the scope of the current document.

Several documents are available that cover this subject matter. A useful document was prepared by the FAO: Guidelines for the Routine Collection of Capture Fishery Statistics (FAO 1999). This recent publication forms an excellent basis for evaluating or designing statistical systems.

5.1 General approach

In essence the design of a new data collection system or re-evaluation of an existing one is merely a question of applying a few general guidelines to establish the requirements and based on this select the methodologies and combine them into a statistical system. In short above mentioned Guidelines and other documents focus on a few key questions:

Why? Why are statistics required, what will they be used for?
What? What statistics are required, what information is necessary?
How? How will the statistics be collected, processed and used?

It follows from the first question that there should be a clear objective for collecting statistics, as opposed to the view point that they can be collected just for the sake of having them available. In other words:

If there is no good reason to collect statistics, then don't!

If there are good reasons to collect statistics these reasons, or data requirements will influence the answer to the second question. After the objectives for the data collection are established then comes the difficult choice what parameters to collect to be able to reach the objectives of the data collection system. This is a very important consideration, since what should be collected (and in what detail) will in turn decide on what methodologies can be used.

This document mainly covers abovementioned what and how questions, listing several appropriate methodologies and discussing the possibilities in considerable detail. The 'how' question is only partly covered, i.e. only the data collection methods are described that are thought to be appropriate, only limited coverage is given for data processing, while analysis and presentation is almost completely left out. These are as important, if not more important components of a fishery statistical system than the fishery statistics themselves. Perfect statistics in itself are of no use whatsoever if they are not being used by policy makers and planners.

Asking above three questions can be helpful in establishing the statistical requirements, both when designing a statistical system from scratch, and when redesigning an existing system.

> **It is essential to evaluate the statistical requirements regularly, and design or adjust an appropriate statistical system to meet the information requirements.**

Fisheries line agencies do not operate in a vacuum and often other departments are involved in collecting fishery statistics at various levels. Either in a supporting role, for example to maintain the statistical standards or advising/assisting in the system design, or taking a leading role, whereby the fisheries line agencies sometimes merely receive the final statistics, without any active involvement in collecting them. In almost all countries the central government statistics bureau at the very least influences how statistics are collected and sometimes collects nearly all statistics for different sectors. However fisheries line agencies normally have the opportunity to influence what is collected. As they should know the sector best, at least they should be able to steer the survey design process, and hence need to know what methodologies are available and be aware of the pros and cons of each method.

5.2 Planning and preparatory work

Each country and fishery is different and will need a different approach for collecting fishery statistics, differences in policy emphasis and preferred approaches and differences in staffing and budget will make it almost impossible to formulate a 'minimum' set of parameters to cover the fisheries that is applicable to all SEAFDEC member countries. Each fishery will need a slightly different approach, possibly use the same general methodology, but with small differences in the actual implementation. This is the main reason why it is impossible to write a do-it-yourself, step-by-step manual. It is however possible to indicate the different steps that need to be followed for the evaluation and design phase.

5.2.1 Step-wise approach

When considering designing any new statistical system, or redesign of an existing system there are a certain number of steps that need to be followed to enable designing/evaluating a statistical system:

1. *collect information on the existing statistical system (objectives, data needs, methods used and information produced)*

All countries have already a statistical system in place. It is essential to understand how the current system works, or more precisely what information is expected to be produced by the system and what doesn't work. A new fishery statistical system will need to be built with the available staff and expertise present, so the existing structure, resources and capacity of staff should be known and evaluated. This needs to be done on a regular basis, and is in fact done in several of the SEAFDEC member countries. This information on the system should be readily available if the planning process was performed properly and documented; this should be an integral part of any planning process.

2. *collect information on who is involved in policy and planning in relation to fisheries*

It is necessary to be aware of who the targets are for the information produced by the fishery statistical system, partly to be able to answer the why question. This will influence what type of information is required, what should be collected and how it should be packaged. This will not be limited to the fisheries department, but will involve irrigation, agriculture, forestry, environment and other departments that may have conflicting policies that impact fisheries (resources and habitats) and therefore should be aware of the status of the fisheries in order to make balanced decisions on the sector. Policy and planning are seldom directly influenced by the state of the fisheries, unless it is a policy of the department of fisheries; however fishery statistics are (sometimes) used to assess the impacts of policies, as a measurement for changes in the fishery situation.

3. *formulate the objectives of the fishery statistical system*

It is necessary to clearly specify what the fisheries statistics will be used for, or more to the point, why is there a need for fishery statistics. This may seem a stupid question, but without proper objectives it is impossible to define the data needs that the fisheries statistical system has to fulfil. If there is no good reason to collect statistics, then simply don't. If for example the only information requirement would be an overall production estimate for aquaculture, reservoir fisheries and river fisheries, then this can be done without any surveys, based on previous research, Morphological Edaphic Index (MEI) or adapted estimates from previous years.

4. *define the data needs*

Before collecting any data the data needs have to be formulated, only then can the appropriate methods be selected. Each method needs to be fine-tuned and can provide data of different degrees of accuracy. It is useless collecting statistics if they are not required. For most statistics starting to collect them means a long-term commitment.

Some of the countries targeted by the SEAFDEC training programme have almost no statistics for certain sectors, except for information almost entirely based on '*guestimates*'. In the absence of any policy or management for the capture fisheries sector, this is very cost effective. Nothing is collected that would not be used anyway and what is produced is only there to show the relative importance of the fishery sector.

5. review all existing information pertaining to fisheries

Before rushing out to perform all kinds of surveys it may be an excellent idea to assess the currently available information from within and outside the fisheries sector. Often it will become apparent that already a vast amount of fisheries related information is available. An important step in formulating or redesigning a fishery statistical system is to assess what is already there. This can be used in the survey planning process, but also to evaluate if the current information is sufficient, or that additional information is required. If the available information is sufficient for initial data requirements, it will not be necessary to initiate a survey for getting this information.

Using available information may be a very sensible first step in improving the available information on the fishery sector without spending any money on relative expensive surveys.

The amount of fisheries related information that is collected by non fisheries agencies is often surprisingly large. General statistical surveys on employment, expenditure and demographics may sometimes contain fisheries related information. Obvious sources for fisheries information may be forestry departments, environmental, irrigation and agriculture departments. Trade or economic departments may have information on marketing, transport or even production estimates. Institutes and universities sometimes have excellent research on fisheries issues and although this information may be not routine, it can provide valuable insights in the fisheries.

Aid organisations may have done fisheries surveys, and if these have been done at a local level, the results may not have been distributed to the central government level. Of particular interest are socio-economic surveys, which in rural areas cannot avoid having some kind of fisheries focus.

This review of existing information is often done as a desk top study and is an ideal target for external (donor) funding.

6. find appropriate methods to collect the required data that is missing from existing information

These guidelines should form an excellent basis for reviewing available methodologies and decide whether or not they are appropriate to the local fisheries situation.

7. train staff in using the methods

Training is an essential component of any statistical system; considerations for training are covered briefly in section 13.

8. apply the methods and collect statistics

Collection of statistics may seem routine, but it seldom is. There needs to be close supervision of the enumerators, some surveys may need continuous feedback to assess the level of reliability and any statistical system should be constantly reviewed.

In general there are a number of steps that need to be taken for any particular survey. Most of these steps will be covered in more detail for the different methodologies that will be covered later in this document, but will be presented in summarised form below.

1. Identify the survey area and target population;
2. Identify what will be monitored and in what detail, for example for catch assessment surveys it normally does not make much sense to collect data on all species of fish and shrimp that will be caught. Some species are especially important, because of their high value or because they form the bulk of the catches, during periods of the year. Other species may be grouped, although the obvious approach is to use local market groups, this may not work out to be a viable approach if the results of the survey need to be compared over the whole country or for a basin that covers two or more countries. As with all standardisations, this has to be implemented for the whole area that has to be covered. In the case of South East Asia this will be no small feat;
3. Establish the units that will be used and standardise these;
4. Establish the sampling design, how the population will be sampled and how many samples are required. This is a bit more complicated than is described here, and is covered elsewhere in this handbook in greater detail. The sampling design should result in a field manual with exact guidelines on the practical sampling, i.e. selection of which villages, fishers, markets, households etc. will be sampled, as well on the composition and tasks for each survey team.;
5. Perform pilot surveys to test the methodology and train the data collectors and supervisors. It is likely that in the initial stages many problems will surface. This is the main reason for performing pilot surveys, both as training and as final check of the methodologies and procedures used; and
6. Implement the full scale survey.

9. process and analyse the data

Processing and validating the survey data is an essential part of any statistical data collection exercise. Fast data entry and analysis is crucial to be able to assess the survey methodology and to provide feedback to enumerators or participants in logbook surveys. It is also important to analyse the results of the survey as-fast-as-possible. For standard surveys that will be conducted on a routine basis, the data processing, data handling procedures and database should be well established before the survey starts. Data processing should be routine and the data should be almost instantly available for analysis. In fact for catch assessment and other basic surveys, the database should be capable of producing all required standard outputs automatically to facilitate use of the data. More details on data processing and software requirements are covered in section 14.

10. produce relevant information for policy makers, planners and managers

This is the most important stage of the statistical system and a test for the applicability of the data that is collected. Does it provide the information that is required to make policy decisions, can it be used for effective planning and does it allow formulation of management plans?

Statistics by themselves are worth nothing, if the information that can be obtained is not used and brought to the attention of policy makers and planners. Publication of the tables in a

yearly statistical yearbook is not the objective of a statistical system; it requires skill and persistence to make those in charge notice. This is both a publicity war, as well as one of the few tools available to fisheries authorities to influence the impact of other sectors on fisheries.

11. *Analyse the system at all stages of implementation and provide feedback to improve the system.*

Like mentioned earlier, it is essential to critically evaluate all elements of the statistical system on a continuous basis and discuss problems and suggestions for improvements to adapt the system to function more efficient.

5.3 Recommendations for a minimum statistical system

Experiences in the past, which cover both successes and failures of data collection systems, have led to a renewed emphasis on sustainability. Rather than trying to set up an 'all encompassing statistical system', the main aim is to keep things to a bare minimum that can be maintained and managed over a long period, producing high quality statistics. Although it is quite easy to add surveys to a statistical system, it is generally almost impossible to remove certain components from the statistical system after a number of years out of fear of breaking the time series already acquired. This leads to the question what is meant by the bare minimum, this is dealt with in some detail in this section. There is some overlap in content with previous sections, but to make this section self-sufficient some repetition is unavoidable.

5.3.1 Introduction

The complexity or extent of the statistical system depends on the data requirements, but also on the available budget, resources and existing capacity with fisheries staff. Since every country will be interested to get more information for less money, this section will probably be of interest for all SEAFDEC member countries.

In many countries the available staff, both in numbers and capacity is insufficient to cover all aspects and tasks required. This is both a reflection of the priorities of the central government and the overall budget situation. There are relatively few countries in South-East Asia with a sufficient budget for the fisheries sector, even in those countries where fisheries are deemed extremely important. This means that in many cases statistics will only be one of the tasks that need to be performed by local fisheries staff and often statistics will be regarded as one of the least important tasks. This is a general problem that can only be tackled from top-down, meaning that at the central level and by local supervisors the importance of collection of statistics should be emphasised.

Under the current (financial and capacity) constraints it will not be possible to implement a large all encompassing and very detailed statistical system, so certain choices have to be made on the scope and contents of the required information.

For those SEAFDEC member states that can afford it more in depth statistics can be collected on a routine basis. This section will suggest a minimum basic statistical system. It should be emphasized that **one size does NOT fit all** and that some countries will have special requirements that need to be accommodated in a statistical system.

5.3.2 Considerations for information requirements

The main purpose of statistics in practical terms is to describe the fisheries, show the importance of different sub-sectors (either relative to each other or to the national economy) and provide inputs (information) that can be used in policy, planning and management. Whatever the structure of the fisheries sector the main objectives of any statistical system will focus on these issues.

It is clear that the statistics that are collected should be based on what is required and the available resources (staff and budget). The information requirements depend on many aspects of the fishery and the institutional structure and relationships between departments in charge of the fishery resources. In addition the issues that are high on the (political) agenda need to be taken into account. In many countries concerns about food security and the availability of cheap protein is top of the list, while issues of economic profitability, bio-diversity and conservation are a much lower priority. In view of the current crisis in fisheries, extra effort should be taken to adjust the statistical system to effectively tackle management and policy questions on how to optimise the benefits from the available resources.

Collection of statistics is essential for well-informed policy decisions taken by government or the fishing industry. This information may be used by policy-makers, or in performing detailed analysis. In this section the types of information that may be required at a national level will be discussed.

5.3.2.1 State of the resources

It is clear that the main priority for fishery statistics is to obtain indicators for performance of the fisheries in terms of catch and effort, or simply put: catch assessment.

One of the main information uses of fishery statistics is to assess the health of the fisheries in biological terms. In all cases the data collected should support (fisheries) management and policy decisions. Ideally fishery statistics should be collected to allow sustainable exploitation of the fishery resources by providing the basis for appropriate fisheries management actions. This does not specify what information is required, but clearly states the need for an objective for the collection of fishery statistics. The exact information requirements should be established for each fishery separately. In some cases it may be prudent to collect catch and effort statistics, for other fisheries this may not be required.

The single most important statistic, the total catch, should be available by fishery and for the economically most important fisheries also by species. This means that catch assessment should be the first priority of any fishery statistical system.

Catch assessment should be done separately for different sub-sectors of the fisheries that can be distinguished by gear or scale of operations. This is mainly a national issue, but for coastal fisheries some individual fisheries that are easily distinguished as separate entities like trawl fisheries or shrimp fisheries could be covered, whereas the small-scale commercial operations could be lumped together into one unit. In inland fisheries it makes sense to separate riverine and reservoir fisheries and separately estimate catches for commercial fisheries and family fishing operations. During the flooding season, floodplain fisheries should also be separately covered, but as this is mainly family fishing (in most cases), this would be easily covered by the existing surveys for catch assessment for the family fisheries.

Effort estimates should be collected only for those fisheries that can be managed based on gear and effort restrictions. This will in general be for middle-scale commercial fisheries that have a relatively low number of fishing units. The other fisheries are better managed through co-management approaches that would implement a general closed fishing season during the breeding period, or for inland fisheries the peak of the dry season, or ban fishing in critical habitats like spawning and nursing grounds. Therefore these latter fisheries would not need any effort measurements.

Species detail can be collected during sampling for catch, but for other approaches additional surveys are necessary to collect species composition in different seasons.

5.3.2.2 Economic performance

In cases where government intervention is strong in the shape of fuel and other subsidies, transferable quotas or price regulations it is important to know how the economic performance is assisted or otherwise affected by various actions of the government and private sector. The capacity of the fisheries sector to attract investments is important to ensure a healthy fisheries, therefore ratio of returns to inputs of private and government investment in the fisheries sector should be established. For this information on fish prices (at different levels and for different grades and species) is required, as well as information on how prices are established/influenced.

5.3.2.3 Food security

Especially for inland and coastal fisheries, issues of food security are essential. For this, information on fish consumption is required, with details on origin and type of fish product consumed.

5.3.2.4 Contribution to national economy

Comparison of the importance of the fishery sector to other sectors is crucial to ensure sufficient attention and budget by the central government. Simply put the monetary value of the fish production and involvement/jobs provided by the fishery sector, both directly and in support industries.

5.3.2.5 Structural Information

Besides basic catch and effort statistics it will be necessary to have some structural fisheries data. This mostly refers to the middle-scale commercial fisheries that per unit have a large production and for who the number of boat-gear units and landing sites and ports will have to be collected in a frame survey to be able to make estimates of the total production. For other sectors that do not depend on sample surveys for catch and effort for catch assessment structural data are less important and can in general be left to infrequent fisheries census, that can be performed every 10 years to obtain an idea of the number of gears, fishing units, processing sites, supporting industries, transport companies, whole sale points, other marketing units etc. This data is used to describe the fisheries and look at involvement and spatial distribution of fisheries related activities.

5.3.2.6 Continuity

What is collected is largely dictated by the requirements for policy, planning and management. In many countries, the wish to retain an uninterrupted time series also influences what is collected. In most cases an intensive information requirement analysis is not done and even when a list of required data is produced this is not based on a thorough analysis, but mainly built on the premises that 'everybody else is collecting this'. If the information is not used, then it is a waste of valuable manpower to try to collect it, therefore assessing the information requirements is essential. This can take the shape and form of stakeholder analysis, with involvement of stakeholders at various levels (from other departments down to the information requirements of fishers). Information generated by the fisheries sector may be used both within and outside the sector.

5.3.3 Considerations for statistical indicators

There are some considerations that can be helpful to select what data variables and indicators should be collected:

1. *Select indicators that measure the performance of an aspect of the fisheries and influence of management, policy or planning.* It is crucial that effects of these three can be measured (unless this is not desirable because of lack of effect). Management, policy and planning try to steer development of a sector, be it decreasing involvement, increasing catches or maintaining species diversity (or the occurrence of certain species in the catches). It is crucial that the effectiveness of management to reach the objectives stated can be measured, to provide feedback to correct the interventions required. Due to the complex nature of fishing operations and interaction of fishers and environment it is unlikely that management can be implemented without adjustments. The objectives of interventions can often be stated in simple terms and the effect can easily be verified by looking at the trends in the variables that are influenced. This can be done through monitoring the appropriate variables, like standard catch/effort variables, over time. This means that trends are monitored not one-off results from individual surveys.

2. *The nature and structure of the fisheries* (organisation and practices of the fishery) *will influence what exactly can be collected and what* (survey) *method is appropriate*. If catches are landed pre-sorted, then logbooks or interview forms should take this into account and sub-sampling to establish species composition can be implemented as a separate survey.

3. *It is sensible to select variables that can be used for more than one purpose in order to use available resources as efficient as possible*:
    a. Catch and effort data are critical to construct the most generally used indicators in most fisheries. When designing a fishery statistical system, the first priority should be the harvesting component, i.e. operations, biological, economic and socio-cultural. If more resources are available, then coverage for other sectors can be added if there is a clear need (management, policy and planning) to do so; and
    b. Multipurpose variables should be collected with potential other uses in mind, i.e. attention should be given to recording data in a manner that allows their use for different purposes. To stick with the previous example, effort may be used as economic indicator (cost of fishing, travel distance, number of fishing days) and for biological purposes the effort data may need to be available per haul. If these different

data applications are kept in mind then this reduces the cost and increases the data usefulness as well as data use.

4. *Frequency of data collection* depends on their rates of change of variables and the costs of measurement. Data should be collected at small enough intervals to capture the variation in the variable, required for the purpose of the data collection, be it management or otherwise. In case of a stocking programme in a reservoir or natural lake, data on release of fish should be complemented with detailed information on recapture on a continuous (monthly) time frame, while household data on resource use, involvement in fishing activities or consumption can be collected at much longer time intervals. Where possible fishers and other information providers should be involved in supplying the required data for frequently required data (catch, effort etc.). Less frequent data can be collected using enumerators since the costs of collection are much lower. In most cases there is an obvious interval, governed by the dynamics of the fishery, be it seasonality or the lunar cycle of operations:
    1. *routinely collected data*: catch and effort, fish prices, species composition etc., i.e. *production data* (weight, price and effort) is normally collected on a daily to monthly basis and aggregated for a final estimate every month since it changes rapidly even from day to day;
    2. *structural data* for medium to large-scale commercial operations (additional information: boat/gear counts, involvement, number of fishers, fish consumption etc.) are normally collected on an annual or less than annual basis, since the number of boats, fishermen, or gears normally does not change fast for those sectors. Although this is true for most commercial operations, for small-scale fisheries, especially with small gears and traps this is not a valid approach as gear numbers can change overnight and gear restrictions often will not form the basis for management in small-scale fisheries:
        a. *Daily*: usually provided from industry records (e.g. logbooks, processing records) covering catch, effort and processing rates;
        b. *Fishing trip*: this will in many instances be equal to one day, however some coastal operations and migratory fishers in inland area will sometimes fish over a number of days or even weeks before returning home. For example peak fishing in the Tonle Sap River (Cambodia) attracts many migratory fishers who may stay up to a few months on site before returning home with their part of the processed fish. Data collected at the end of each trip could consist of landings, effort summary, fishing grounds[3], prices, fishing costs (gear, fuel and labour), and other data;
        c. *Monthly:* Seasonally changing variables, which change more slowly, like fish and fuel prices or flooding and other related meteorological data;
        d. *Annual*: For slowly changing variables, like number of gears, licenses or employment; and
        e. *Less frequently collected data*: includes household data (and consumption), general population, agricultural or other census data, that is normally collected on a less than annual basis, depending on the resources every 5-10 years.

5. *Concurrent Collection* It will often be possible to collect multiple variables simultaneously, to reduce cost and sampling effort this should be taken into account when designing the data collection programme. For example while collecting catch and

[3] The location where the fish was caught can be important in relation to habitat use (inland fisheries) or stocks targeted, it is clear that this information will be highly sensitive for some fisheries where it is customary to fish illegally in other countries territorial waters.

effort at a landing site, length frequency data could be collected as well as species composition and price at first sale. Catch/consumption logbooks handed out to households can be accompanied by socio-economic questionnaires or surveys. Agricultural, population or other general census approaches can be used to obtain some general information on fishing and fisheries, that can be used to plan and design more detailed surveys. Especially consumption and expenditure surveys can be very useful and efforts should be made to insert fisheries questions into these data collection exercises and to make them multi-departmental.

6. *Data quality and quantity*, for truly complex multi-species multi-gear fisheries the amount of data required for effective management and planning is quite large. That is the main reason why at the moment any existing management is often not based on the existing information, as that is insufficient to be used to manage the inland and coastal fisheries. Although for some fishery sub sectors with a large impact (on the resource) true *fisheries* management may be required, like for coastal trawl fisheries, or for the Dai and Lot Fisheries in the Great Lake and Tonle Sap area (Cambodia), in most circumstances there is no effective management only policies. In these cases the information requirements are almost solely for policy and planning, that have more modest requirements.

7. *Data Detail*, it should be kept in mind that although the data may be used at different levels, with varying degrees of aggregation, it should be collected and stored with the highest required detail. The level of detail should be assessed using careful assessment of possible data use. Even if it is not immediately necessary for the current information requirements, it may be useful later on. However more detail means a higher budget requirement and survey effort. If the catch is aggregated by household without details on where the catch was obtained, any patterns of habitat use would be lost. This may be essential to obtain importance of certain habitats, and hence the vulnerability of the fishery to changes in habitat availability (extraction for other uses). It is easy to aggregate, but impossible to disaggregate data once aggregated.

   In all cases the required degree of precision is important. It is no use to record fish catches in grams, if the catch estimate will be expressed in kg or Metric Tons (MT). The amount of precision will influence the data collection method, data collection form and analysis practices. Fishers age can be recorded in years, or separated in age groups. Similarly importance of a fishery related activity or the extent of involvement can be recorded in hours spent (on an activity), or percentage of time used for certain activities per day, week or month, or subjective (qualitative) quantities, like little, medium and high. In these cases, and every time where data values may need to be represented by codes (e.g. comparison of catch with typical catch), these should be standardised.

   If more precise measurement is required, interview or reporting is not appropriate then direct measurement by enumerators is the only alternative. As this is relatively expensive, this should only be done when absolutely necessary.

8. *Standardization* of the methodologies and units used; is required to be able to exchange and use data collected in other (fisheries) sectors. In most cases there are a number of common variables that will be collected in all fisheries. The system should be flexible enough to accommodate changes in data requirements and hence should address both the current and future needs.

5.3.4 General selection of appropriate methodologies

It should be emphasized that at this point in time, there is no clear consensus what mix of approaches forms the best choice for collecting statistics for inland fisheries. For coastal fisheries the situation is relatively simple. The fisheries are in general covered by a combination of landing site sample surveys for catch and effort, a census for the structural parameters (boats and gears) as well as surveys for marketing, processing and some livelihood parameters.

If a fishery is conveniently located, split up in only a few large units, and on top of that is economically very important, i.e. it provides employment to many people, or it pays for licenses, then the money spent on collecting statistics is (at least potentially) paid for by the benefits the fishery is generating. In addition, the government has a vested interest in monitoring these fisheries, if not to maintain the production, then at least to optimise the revenue from licenses. If on the other hand, the fishers do not pay license fee, are largely self-employed, then the economic benefit for this particular fishery is not immediate clear. If on top of that a large sampling effort is required to cover this fishery, then this normally is viewed as a waste of money.

Several approaches that have proved their worth for collecting statistics for marine fisheries (landing-site surveys, license based data collection, catch and effort surveys) can also be applied to certain sectors of inland fisheries, mostly the middle-scale commercial operations. Likewise for aquaculture, methods are fairly standard and implementation is depending more on available budget and capacity of the DoF staff involved. However for the bulk of the inland capture fisheries (both in terms of involvement and production) other methods need to be employed, like trade or consumption data or even use of GIS.

For inland fisheries the situation is much more complex due to the large production of the small-scale family fisheries. Most of the inland fisheries and a substantial part of coastal fisheries cannot be covered by sample surveys for catch and effort. This is often ignored by planners and fishery scientists alike, who often strongly believe in the universal applicability of the catch and effort sampling survey and fail to see the value of alternative approaches to collect information on the fishery. At a general level, agreement has been reached on the use of a combination of sample surveys for catch and effort for those sectors of the fishery that can be managed through gear and effort restrictions (reservoir and lake fisheries and the larger-scale commercial fisheries). Consumption (household) surveys are very important to assess fish production/consumption and involvement for the small-scale family fishing sector. In addition surveys and censuses performed by other departments are used as a vehicle for obtaining fishery statistics.

For both inland and coastal fisheries the use of participatory or co-management arrangements is also on the increase, both as a way to devolve management to local authorities, but also as a way to obtain meaningful information on the fisheries, involving fishers and other stakeholders. However at this stage the field is still in flux, not in the least because there is no final agreement on what statistics are exactly required.

The type of data to be collected influences the choice for the appropriate methodology. In many cases the preferred method is obvious, which method is selected is influenced by a number of factors:

- information and type of data required;
- source for the data (or location from which the data must be obtained);
- the skill of the enumerator; and
- resources available to collect the data

In different fisheries, the same variable may be collected using different methods. For example catch data for small to middle scale commercial, fisheries, sample surveys for catch and effort are appropriate, whereas for small-scale family fishing operations interviews or questionnaires (for catch and/or consumption) would be the best approach.

Sometimes middlemen or traders keep catch/sale records and these can be used where available as the basis for the data collection. In many cases middlemen buying fish from fishers keep records for their own administration, likewise especially the larger traders at retail and wholesale markets keep records.

In general there is not just one method that can be used to collect a certain variable, neither is there only one source of information. Where feasible, data should be collected from several sources, using different methods. This will allow for crosschecking the results of each approach for errors. For example, catch data collected through logbooks can be cross checked against reported landings based on sales slips, data collected by interview at landing sites and even consumer or trade data. In general it will be extremely hard due to operational and budgetary constraints, to collect data from different sources.

Statistical departments are (as all other departments) continuously complaining about the budget allocated for collection of statistics. Statistics are normally collected for the economically most important sectors, where they can be collected with the least effort (= budget) and with the largest accuracy. Inland and small-scale coastal fisheries do not often seem to be considered important enough to spent sufficient money for data collection. Since it is unrealistic to assume an increasing budget, for increasing information demands, this means that other approaches need to be taken to achieve a better coverage with more meaningful information than currently available.

Instead of relying solely on comprehensive sampling surveys for catch and effort for the whole fishery there are some alternatives available:

1. Indicator surveys for pilot areas or fisheries using sampling surveys for catch and effort on a small-scale can be implemented to get an idea for the production and associated effort. This can be extrapolated over larger areas or other fisheries to obtain an overall estimate; and
2. Other approaches concentrate more on estimation for total fish production, with less emphasis on effort, and more emphasis on involvement and auxiliary information to gauge the status of the fishery, this can be done through socio-economic, consumption or fish trade surveys.

While using sample surveys for catch and effort for small to middle scale commercial fisheries is possible, albeit impractical for some small-scale sub-sectors, they cannot be used for obtaining meaningful estimates for catch and effort for the family fisheries sector unless a disproportioned amount of staff is employed to conduct the surveys. The seasonal/monthly/daily fluctuations in participation, catches, gear use, habitats targeted, the fact that in many cases the catch is landed in the household and the highly informal open access nature of most fisheries make it all but

impossible to obtain reliable estimates for this sector through the use of sample surveys for catch and effort.

Table 5.1 Different types of data that can be collected from the various data sources. (after: FAO, 1999)

Main Data Types	Sources					
	Harvest	**Post Harvest**	**Market (including retails)**	**Consumers**	**Government related agencies & institutions**	**Support Industry**
Catch	●	●	○			
Effort	●				+	+
Vessel / gear data	●				●	+
Operations data	●					
Compliance data	●	○	+		●	○
Biological data	●	●	●		●	
Environmental data (4.3.2.4)	○				●	
Market data	○	●	●	○	○	+
Costs and earnings data	●	●	○	+	+	+
Trade data		+	+		●	
Fisherfolk data	●	●				
Household data	○		○	●	●	+
Institutions data	●	●	●		●	

Table 5.2 Different data collection methods that can be used for the different sources (after: FAO, 1999)

Method/sources	Harvest	Post Harvest	Market	Consumers	Government	Support Industry
Registration	●	○			●	○
Questionnaires	●	●	●	●	+	○
Interviews						
Open-ended	○	●	●	●		
Structured	●	●	●	●	+	+
Reporting						
Harvest	●					
Post harvest		●	○		+	
Sales		●	●		○	
Trade		●	+		●	+

● Major source
○ Secondary source or important validation source
\+ Possible source or secondary validation source

Table 5.3 Different types of data that can be collected by the various data collection methods (after: FAO, 1999).

				Interviews		Reporting			
		Register	Questionnaire	Open ended	Structured	Harvest	Post-harvest	Sales	Trade
Complete enumeration	Catch		●			●	+	●	
	Effort		●			●			
	Vessel-gear data	●	●			●			
	Operations data		●			●			
	Compliance data	●				●			
	Biological data					○	+		
	Environmental data					○			
	Market data		○				+		
	Costs and earnings data						○	●	
	Trade data								●
	Fisher folk data	●				○			
	Household data								
	Institutions data		○						
Sampling	Catch		●	○	●	+	+	+	
	Effort		●	○	●	+			
	Vessel-gear data		●	○	●	+			
	Operations data		●	●	●	+			
	Compliance data					+			
	Biological data					+	○		
	Environmental data					+			
	Market data		●	●	●		○		
	Costs and earnings data		●	●	●		●	+	
	Trade data								
	Fisher folk data		●	●	●	+	○	+	
	Household data		●	●	●				
	Institutions data		●	●	●		+		

It is widely recognised that the family fisheries sector where fishing is an inseparable part of the social structure, is extremely important for food security. Therefore statistics for these fisheries are important even though are often not collected on a routine basis. Management for these small-scale fisheries (if any) is seldom based on routinely collected statistics and the only reason to include these fisheries is for the purpose of policy and planning. For this some parameters need to be monitored at a national and local level. It is useful to have estimates for total production, involvement in fishing activities, importance of fish protein in the diet etc. Total fish production is normally estimated from information provided by socio-economic house hold surveys, often based on consumption studies.

In table 5.1 and 5.2 the relationships between the main data types and data sources and the methods and main sources are indicated. These and table 5.3 were adapted after tables included in FAO (1999). The data sources that can be distinguished are the following:

Harvesting: this is the level where fish are caught and landed for first sale.
Post harvest: after landing fish are prepared for marketing, sometimes processed. Several sources of information may be available middle person, fish auction, cold storage, processing farms and transporters of fish products.
Market: this refers to all situations where fish are commercially transferred. It may include the fish market at landing site, secondary (whole-sale) marketing of fish products among brokers, processing farms and retail (consumers) market.
Consumers: the level where the products are finally consumed, most often at household level.
Government-related agencies: government departments or- institutes including external agencies (i.e. non-fisheries) like tax departments, agriculture department, customs.
Support industry: industries which provide materials and services for fisheries, but are not directly involved in fisheries business.

Table 5.4 Proposed standard methods for basic variables and indicators.

	Register	Question naires	interview	direct	logbook
Catch assessment					
Small/middle scale commercial fisheries					
Catch and effort			x	x	x
Frame data	x	x	x	x	
Length frequency				x	x
Catch composition			x	x	x
Family fishing					
Consumption			x		x
Catch composition			x		x
Economics					
Fish price index		x		x	x
Employment		x			x
Trade and marketing		x		x	x
Livelihoods (socio-cultural)					
Fish consumption			x	x	x
Household data			x		x

Table 5.3 shows the different data types that can be collected by applying different methods both using census and sampling approaches.

Table 5.4 lists the data variables and associated proposed methodologies that will be covered in considerable detail in the second part of this document in section 7 and beyond. This covers more than what is regarded as the minimum system. This has been done on purpose to provide scope for expansion of the statistical coverage.

5.3.5 Proposed minimum fishery statistical system

A minimum statistical system should provide:

Catch Assessment giving estimates for catch and effort for different fishery sectors, with *appropriate* detail on species and effort:

- For *family fishing* and *small-scale commercial fisheries* an overall *annual catch estimate* needs to be based on consumption surveys, logbook surveys can be used for the small-scale commercial fisheries, average *species detail* is provided by separate species composition surveys. Effort is not collected, except for selected important small-scale fisheries in terms of involvement (fishing days).
- For *middle scale commercial fisheries* classical sampling surveys for catch and effort should be performed, providing catch/effort estimates by boat/gear type and catch estimates by species.

Catch assessment for inland and coastal fisheries can be done in a number of ways. Due to the small-scale nature of the sector, direct measurements of catch and effort is only appropriate for well defined middle-scale commercial fisheries. Alternatives for this sector include logbooks or interviews of fishers on catch related variables. The middle scale fisheries should be monitored on a routine basis, with *monthly* estimates for catch and effort by species and boat-gear type.

For most small-scale fisheries and the family fishing component the main methodology that can provide a reliable estimate for the catch are consumption studies, or habitat area production estimates (by length of river, or surface area of flood habitats). Interview method for household catches may also be appropriate, although relatively labour intensive. These statistics require complex surveys and are relatively difficult to collect. Depending on the available resources this could be done *every year* or alternatively *every 5 years*.

Economic Data should at the very least cover data on fish prices, export and statistics on employment in the sector (including involvement). Fish prices should be collected at point of landing, whole-sale markets (middle-men) and consumer prices. While the fish price survey should be done at least *twice a month*, involvement (employment) should be assessed on a regular monthly basis for middle scale commercial fisheries, for small-scale commercial fishing the numbers of fishers should be assessed *annually*, whereas for family fishing the numbers of full-time and part-time fishers can be assessed on a *less than annual basis* combined with regular population census updates.

Official import and export of fish and fish products should also be monitored, but this trade data can often be obtained from customs department and separate surveys will not be necessary. This data should be available *annually*.

The economic importance of separate (licensed) commercial fisheries in macro-economic terms should also be assessed every *5 years*.

Livelihood Data should include at least data on (fish) consumption and demographic data on age and gender related to involvement in fisheries activities. These data can be collected on a *less than annual basis* and can be the subject of research studies.

Structural Data should be available mainly for the middle-scale commercial fisheries:
For family fisheries and small-scale fisheries no structural data is required (for a minimum statistical system)
For middle scale commercial fisheries it will be required to have information on fishing gears, landing sites, markets, processing plants, wharfs, ice plants etc. This information should be collected every *5-10 years* (with between survey updates).

Recommended further reading

There are a large number of text books available that deal with practical collection of Fishery statistical data. Most of these works are written specifically for a specific country, area/fishery and project and therefore are not general enough to be of use. They often start at a level where a decision to collect certain information has already been made and deal with the practical details of collecting specific statistics, mostly catch effort statistics. There are only a few publications that deal with the basic decision making process. The most important publication in this respect is:

FAO, 1999. Guidelines for the routine collection of capture fisheries data. Prepared at the FAO/DANIDA Expert Consultation. Bangkok, Thailand 18-30 May 1998. FAO Fisheries Technical Paper: No. 382. Rome, FAO. 1999. 113 pp.

Another useful publication is:

Caddy, J. and Bazigos, G. (1985) Practical guidelines for statistical monitoring of fisheries in manpower limited situations. FAO Físh. Tech. Pap. No. 257. Rome FAO, 86p.

CHAPTER III
DATA COLLECTION METHODS

6. General description of collection methodologies

Before discussing how to collect specific data under different circumstances it is sensible to provide some background information on the data collection methods that can be used. This section provides general information that needs to be taken into consideration when applying specific data collection methods.

6.1 Introduction

Even though there is a wide range of different methods to collect fishery statistics, these all use one of a limited number of common approaches to obtain the data:

- Register: registers and licenses are particularly valuable for complete enumeration, but are limited to variables that change slowly, such as numbers of fishing vessels and their characteristics. In addition many registers only concentrate on large-scale fishing operations, and are often not up-to-date.
- Questionnaires: forms which are completed and returned by respondents. An inexpensive method that is useful where literacy rates are high and respondents are co-operative, out of necessity the questionnaires should in general be easy to fill out and hence can only tackle relatively uncomplicated variables.
- Recall (interview method), uses forms that are filled in by a data collector in response to questions asked. More expensive than questionnaires, better suited for more complex questions where the target population has a low literacy or is less cooperative.
- Direct measurement (weighing, counting and measuring) is the most accurate method for many variables, such as catch, but is very expensive.
- Reporting or logbooks: as an alternative to direct measurements by enumerators, the target population (fishers, middlemen, household members) may be asked to report their activities. This requires literacy and co-operation, in some situations filling out of log sheets can be a linked to requirements for obtaining for example a fishing license.

6.2 Data Collection Methods

6.2.1 Register

Registers are normally used to store information on companies, licensed fishing gear, boats, or fishers. The information contained in a register is obtained when the unit is registered for licensing or tax purposes. In some cases a register is simply a way to collect and store census information on structural data that can be used to keep track of all units in operation.

In most cases registers are incomplete and not up-to-date, old units (boats, gears) that have been long discarded may still be in the register and some new units may not yet be added. Still the information contained in registers may be valuable for statistical purposes, i.e. for designing and implementation of statistical surveys. Even if registers are unreliable, the amount of error can

easily be estimated by taking a small random sample of the units in the register and compare the information in the register with the real world situation.

The exact contents of registers and the amount of detail may vary, but is normally limited to large-scale commercial sector and for those sectors where licenses are required.

Vessels, information on vessel type, size, gear type, country of origin, fish holding capacity, number of fishers and engine horsepower
Companies, both fishing and 'support' industries (gear manufacturers, processing plants, traders) may be included in a register where the type of business, number of employees, capacity etc. may be included.
Individual gears are sometimes licensed and these may be registered, with information on license holder, size and type. Examples are some trawl gears or the Dai's (bag net gears) in inland fishery in Cambodia and Viet Nam)

Since licenses are normally only issued for a limited amount of time, the information should be renewed regularly.

A well managed and up-to-date register is very useful, but a considerable task to implement. Since data contained in the register needs to be updated regularly and checked, registers tend to be limited to the large-scale sectors of the fishery. These contain relatively few units and these are easily tracked. Small-scale and subsistence fisheries are almost never covered by a registry, mainly because the amount of units (fishers and gears) involved and their associated flux makes it almost impossible to keep the register up-to-date.

6.2.2 Questionnaires

Questionnaires form an interesting methodology and can be very effective in circumstance where there is a large literacy. Questionnaires are survey forms that are filled out by the respondent without assistance from an enumerator.

Questionnaires are widely used where census type coverage is required, but they can also be used for sampling. They are for example used by the FAO to obtain the national fishery statistics for inclusion in the global fisheries statistics and are widely used by governments to collect different types of statistics. Questionnaires are either handed out or send by mail with prepaid addressed envelopes.

Because there is no pressure or support from an enumerator, the best guarantee for a high return rate is to keep the questionnaire both short and simple. Questionnaires should be targeted and only ask for information that is readily available, or in a format that conforms to existing records. Asking for data that needs to be calculated from existing data, and that requires manipulations and regrouping of categories, almost certainly will reduce the response rate and the reliability of the information obtained. It is desirable to reduce the amount of work for the respondent to the absolute minimum, questions with tick boxes and a limited scope of the questionnaire will help both to focus the respondents and tempt them to complete the questionnaire. The writing should be reduced to the absolute minimum, perhaps only asking for numerals, this will also facilitate data processing. In addition the questions should be easy to understand; complex issues can be addressed in questionnaires, but are best handled by spreading them out over a larger number of more simple questions.

Because the questionnaires have to be filled out by the respondents extra care has to be taken in preparing the forms and formulation of the questions. When translations are required these have to be checked thoroughly to ensure that the questions are clear and relay the same information as the original questions. It may be best to test the forms in a pilot scheme to ensure that respondents understand the questions and provide the right information, before going full-scale.

Since it is such an easy and cheap tool to collect information, questionnaires are widely used by government agencies. It is very likely that respondents receive several questionnaires from different sources. It is important to reduce overlap of different questionnaires, to reduce frustration with respondents. Therefore an inventory must be made which questionnaires are already being sent out and to whom, before adding any more. It may turn out that some of the information that is required is already collected by another department, or that a simple change or some additions may be sufficient to cover the data needs from the point of view of fishery statistics.

Questionnaires are great tools to collect almost any information, from monthly industry production reports to catch or consumption data from small-scale fisheries. In general demographic data, fisheries management, gear use, state of the fisheries are often collected using questionnaires.

For example a village fisheries census was performed in the Songkhram river basin in Thailand in 2000 and this targeted over 800 villages. The main objective was to obtain the number of part-time fishers in the village to be able to compare this with the number of full-time fishers from official labour statistics. In addition questions were asked on gears employed and the development of the fishing situation. The questionnaire was returned for more than 70% of the villages. The questionnaires were handed out at monthly district meetings of village headmen and returned in the provided prepaid envelops. The objective of the questionnaire and the questionnaire was explained in detail in the meeting. The return rate is relatively high and the results matched well with available information, the number of full-time fishers was also asked for, to be able to check the other data provided for reliability/consistency. These results were not unexpected as the Thai government uses questionnaires, or reporting by village heads as the backbone of the statistical system, therefore the respondents were used to providing information like this.

Even though catch assessment by means of questionnaires is possible, by combining information obtained from fishers, middle persons, markets, traders etc. Information obtained through questionnaires is not direct measurements and therefore are less reliable than either reporting systems (logbooks) or direct measurements. If using questionnaires for catch assessment and related (measurement) purposes, it is important to have some kind of measurement for the amount of error in the results. This can be done either by obtaining the same information through another method, or by including test questions for which the answer is already known from another source. A verification survey could be done by visiting a small sample of respondents where the answers are verified. Another approach is to plot the size of the companies (in terms of full-time and part-time employees) in a frequency graph to see if the results are normally distributed. If they are not the frequency plot should reveal which part is under represented.

Most questionnaires that are returned will be sent back within about two weeks after receiving them. The remainder of the respondents has either forgotten about them, or does not want to cooperate. It is useful to remind the respondents that have not yet returned the questionnaire after

about 1 month and wait for another 2 weeks before starting to process the questionnaires. It is unlikely that any more questionnaires will be returned after more than two months.

Although the questionnaires are designed to be a census it is rare to get more than 70% return, often it will be much less. The first check is whether the results make sense, i.e. is they representative for the sector surveyed or is there bias in the returns? For example in the case of targeting fishing companies, it is possible that most smaller companies (in most countries this equals with companies that pay no or a very limited amount of tax), did not bother to return the questionnaires, either because they don't have anyone assigned to do so (they are too busy making a living, so what urgency is there to answer some questionnaire) or because of taxation fears. Even if there is a return, it is difficult to assess if the questionnaires were filled out correctly without some data from a different source.
Only if the results are normally distributed can the result for what in effect will be a sample be raised to the whole population by simply applying the same distribution of the returned questionnaires to the non returned questionnaires. This basically comes down to applying the average result to the remaining units to arrive for example at the total number of employees (employed and self-employed, full-time and part-time).

While designing questionnaires thought has to be given how the data will be used, processed and analysed. It may be useful to use Optical Character Recognition (OCR) when large amounts of forms need to be processed and questionnaires can be optimised for this purpose by using multiple choice and tick box questions to reduce hand writing to a minimum. If open-ended text questions are inevitable, then these may need to be coded for certain categories of replies to facilitate data entry and analysis.

6.2.3 Interviews or recall surveys

Interviews are done by enumerators who ask questions and note the responses down. There are two types of interviews:

- **Structured interviews** in which a survey form is used to guide the enumerator and the respondent through the interview and in which the responses are noted down;
- **Open-ended interviews** in which the enumerator simply talks to the respondents and takes notes, although the general focus of the interview is known, nothing is rigidly organised in a survey form.

Interviews can target a wide range of respondents, from children collecting aquatic organisms for family consumption to consumers and industry leaders and can even be conducted by telephone.

Open-ended interviews require more skill from the enumerators, they need to be able to keep the interview focussed, to improvise questions on-the-fly and capable of recognising possibilities for obtaining more or better information by exploring further. The interviewer needs the ability to interpret and 'analyse' the information obtained so far and use this as the basis for further questions.

Although structured interviews can be used to obtain almost any information, the information is based on what people remember or what they want to tell. Especially for areas that are considered sensitive, like all subjects with links to economic value, like income or productivity (catch and effort) large errors can occur either due to bad memories or intentional misrepresentation.

6.2.3.1 Structured Interview

Survey forms are filled in by enumerators/researchers, not by the respondents themselves, like with questionnaires. The use of enumerators is more expensive than using questionnaires, but the advantage is that more complicated questions can be asked. It is also possible to rephrase questions, if the answer is not satisfactory and thus allows for a much higher quality of data, where the answers can be validated during the interview.

Structured interviews are widely used for collection of information for small-scale and family fishing.

The survey forms used need to be carefully designed, it is recommended that a manual is produced that explains all questions in detail. This can be used by the enumerators during initial training. If the survey form is translated this has to be done with the outmost care. If the respondents are literate, they may want to read the questions or look at the survey form, and there should not be any room for doubt about the meaning of the words used or the question asked. If local names or measurements are commonly used, then these should be used in preference over the 'official' measurement system or species or gear names. It is important that respondents can relate to the questions and therefore, alternative phrases may have to be used under different circumstances for the same questions. The manual should contain alternative versions of the same questions, which are allowed to be used when the original question is not understood. It is important to use standardized questions to the extent possible to ensure to get comparable answers.

Even if outmost care is taken in preparing the survey forms, it will be necessary to test the survey forms in a pilot survey. It will not be possible to anticipate all possible interpretations of different questions. In practice, the more complex the survey, the more testing is required.

Survey forms should never be regarded as "questionnaires". They are for recording the data arising from questions asked. Sometimes the questions can be asked directly from the forms; sometimes the questions are not indicated on the forms and guide-sheets (included in the survey manual) for each form must be consulted in order to determine which questions should be asked. In some cases, straight answers may be given, in some cases the interviewer may need to ask a series of questions to obtain the data required. In all cases, the way in which questions are asked is absolutely crucial to the information that is given and its value.

The survey manual should also give definitions for all key terms that may give rise to ambiguity. For example fishing may or may not include all methods to collect or harvest fish. Especially in inland fisheries there are a large number of techniques that may not be regarded as fishing, collection of snails, frogs or crustaceans on the floodplain by hand, or the collection of marine worms or shell fish on beaches. Limiting fisheries to capture of fish may also be disregarding a large proportion of the production. In many cases the interpretation of the term "fishing" is extremely important. For inland fisheries the term "fishing" means trying to capture fish (and any other aquatic animals). Chasing frogs, for example, is regarded as fishing. A person is fishing (or has been fishing) if he or she:

- has any fishing gear set at any time in any place (even if it does not catch anything)
- is involved with (helps) any other person who has fishing gear set, or uses gear, at any time

"*Gears*" can include any method of catching fish including methods where a physical structure is not used (for example, using bare hands to catch fish is fishing, as is the use of poisons, or the draining of water from areas to pick up the fish afterwards). Any activity that results in the capture of a fish (and any other aquatic animals) or is designed to result in the capture of a fish (and any other aquatic animals) is "fishing".

However, this is often not the way people in villages or fishers interpret the term "*fishing*". To them this often means "*professional fishing*" using "real gears" (e.g. gillnets). They often do not regard the casual collection of fish (etc.), with or without less obvious gears, as "*fishing*". The same can be said of the fisheries authorities, who either ignore these other fishing activities or do not regard them important enough (in terms of catch, tax or license fees).

Protein from other aquatic organisms may be locally and seasonally very important. Especially during the dry season, collection of other aquatic organisms may account for the bulk of the protein intake.

A particular issue is the use of 'passive' gears. Passive gears do not require to be actively operated by a person all the time. Examples are fish traps (most types), set hooks (on lines) and gillnets. (Active gears are spears, bows and arrows, trawl nets, scoop nets - which must be physically operated for them to be effective). Passive gears do not require any effort on behalf of the person to operate them (at least not all of the time). A fish trap, for example, can be set and then emptied days later. Gillnets are often emptied once or twice a day for a brief period. A person who has set any kind of gear (or helped anybody else set it) is "fishing" as long as that gear can still possibly catch any fish (and any other aquatic animals). Therefore, it is quite possible for somebody who is tending a rice field, for example - harvesting rice, to be actually fishing at the same time (if, for example, he/she has traps set at that time but does not check them until later). In fact, this is normal practice. It should be noted that the person (in the last example) is still "fishing" even if his/her trap does not catch anything.

Never ask a 'simple' question like "*are you a fisherman*" (99% of people who actually do go fishing may answer "*no*" to that question). You must ask several related questions like *"do you ever go fishing, use any fishing gears or ever collect any fish (etc.) from anywhere at any time"*. It is for these reasons that a survey form may ask the same question in different ways; this is not just repetition, but essential to get the correct information.

There are several issues to remember when doing this type of research with people who may not understand what the objectives are, or who may be suspect of the motives. These issues may seem obvious when sitting in the comfort of an office; they can easily be forgotten after a hot, tiring, unproductive day in the field.

- Start with explaining the survey objectives;
- Introduce each section of the survey by explaining what it is about
- Make the questions clear and simple;
- the interview often takes place in peoples home, so be polite;
- people differ, some will talk your ears of, others will only give the briefest of answers;
- Tell the truth and be honest. Take the time to introduce the team, the project and the survey, make sure to explain objectives clearly and honestly, and don't make promises that cannot be kept;
- Try not to put words into people's mouths.

Often when it becomes clear that the survey is sponsored by fisheries authorities, people get exited believing that they now may get some benefits (free seed fish for their farms) or get apprehensive, because they suspect that this survey spells trouble for their fishery, either through bans, taxes or licensing fees. In many countries contacts between fisheries people are rare and may be limited to the collection of fishing fees or penalties for illegal gear use. This makes it even more important to explain the objectives and scope of the survey, and also what will be done with the data.

- Be polite and respectful. Try not to look down on people – even if they are being uncooperative;
- Allow interviewees to have their say – even if it is not on the form, i.e. show interest in what people tell you, even if it does not answer your question;
- Try not to interrupt – if you want to stop someone talking, try to do it diplomatically and politely;
- Take your time for the survey, do not rush through the survey but make sure the respondents understand the question and that you get the information needed;
- Make sure you are writing down the answers that people are giving, and not the answers you want to hear; and
- Make sure people are not just giving you the answers they think you want to hear.

It is important to consider a number of issues when starting surveys. Most often the point of entry will be at the village level. Villagers are asked to help collect data, and to co-operate. It may be necessary to revisit villages; it therefore is required to build a good relationship. Fishers have a great deal of knowledge and experience, and can make a very valuable contribution to any data gathering exercise.

A great deal of confusion can be avoided if on first entering the village, survey teams spend the time conducting a walk around the village in the company of the village headman and key informants to gain an overall view of the village, and to facilitate discussion. During this time survey teams could informally map main resources (viz fishing grounds, habitats), general layout of the village, and allow village key informants to present their village in their own terms. Survey teams should be encouraged to engage in more general, open-ended conversations in order to provide a context for the more formal structured interviews to be conducted later on.

Before starting the interviews:

- Consider protocol – it is generally required to introduce the team and the survey to the village headman, and ask for permission;
- Allow enough time to explain the objectives and to overcome any suspicion;
- Explain the purpose of the research project, and the importance of villagers contributions to the project;
- Emphasize that it is merely a data collection exercise not checking up on the villages;
- Explain that there may be further visits, and ask for co-operation, don’t demand it;
- Check the timing is convenient – are people too busy to answer any questions in the survey; and
- A relaxed interview will give better information.

While performing the interview, consider that:

- Exact information is often difficult to obtain especially when there are no written records available. Therefore a compromise needs to be reached on the level of detail and accuracy, versus the time and effort invested;

- Surveyors must be wary of over-emphasising the need for 'accurate' responses when these are not possible. In these situations, surveyors must avoid free interpretation of interviewees' responses, i.e. making up data, just to fill in all the boxes on the form;
- Surveyors must spend the time to look around during the interview (for example to discuss gears or processing equipment that might be in evidence), and to ask to be shown gears with which they are unfamiliar. This of course requires training and experience and some basic understanding of fisheries aspects;
- After each survey, interviewees should check that forms have been completed fully and accurately; and
- Be aware of possible tension with government – for example, dams and relocation, fears of tax, illegal gears (or other illegal activities, e.g. money-lending in Vietnam).

It is sometimes possible to calculate the number of interviews per village or stratum beforehand, based on the required reliability and the (expected) variability of the information. Alternatively a fixed percentage of the fishers, households can be interviewed for each administrative unit. It is often not possible to select the households before entering the village. Census information may be out-of-date or otherwise incomplete. It is common practice for people to be registered at a fixed address, while they may be working or living somewhere else. Also squatters or other groups that may be considered migrants, may be living at a certain site for decades and still not being registered (and thus excluded from the census). This means that selection of respondents often has to be done while in the field, with the assistance of the village head, key informants or local organizations of traders or fish processing companies.

Once a full list of the sample units (companies, household, individuals, etc.) has been compiled and a random selection has been made, the next challenge is to find the households/people that have been randomly selected. If someone is absent at the time of the interview, effort should be made to come back the next day and conduct interviews with the selected respondents that had been missed. This is an important consideration in sampling methodology. Surveyors need to ensure that every respondent on the sampling list will be surveyed. A certain level of flexibility should be considered, and alternate choices for missing households determined.

When interviewing household members, their availability is an issue. It is often difficult to find people at their house, without an appointment. During the day, people are working, either they are busy with their rice fields, or they have gone fishing, or they left for the temple/church. During the rice season, sometimes people leave their house and stay near their rice field for the time being. There are two peaks of activity related with rice farming, when planting take place and during rice harvest. It is recommended to keep the farming calendar, or other important busy times (like New Year holidays) in mind when planning surveys.

It is worthwhile to visit the village at least one day prior to conducting interviews to inform the local dignitaries of the impending survey and obtain the necessary information to make the sampling list. During the initial visit, survey objectives should be presented to the village headman. For larger and more 'complex' villages or strata, more planning and additional survey days may be required to complete a 'full' survey.

Household interview should preferably take place in the interviewee's house, this allows for obtaining supporting information from the house and surroundings. For example when listing the gears a household uses, gears that are at the house may not be listed (because they are

used in a different season). However, this should not be considered as a strict rule, instead survey team should be encouraged to show initiative trying to find people. Interviews can be carried out in people's rice fields, at the fishing ground, on a boat, at the temple, or any other unexpected location. By going to places of importance to villagers, the survey team also gains better insight about villager's living conditions.

6.2.3.2 Open-ended interviews

As indicated above, open ended interviews require considerable skills and consist of advanced methods to collect data. Most of the techniques have been developed in the social sciences:

Focus groups are small (5-15 individuals) and consist of a representative group of 'experts' for a certain group of fishers, traders, fish processor, gear makers etc. This group is interviewed using a few general lead-in questions, after which more specific information is obtained with more focussed questions or discussions. This method is used to get information on gear use patterns, fish migration and spawning information, fisheries management practices etc.

Panel survey is a technique where a few members of a group of interest are selected at random. This small group is then asked to be available for an extended period (1-3 years) for regular discussions. The information that can be obtained is quite wide, and the panel may serve as 'the people's voice' on any subject that may be of interest.

The use of open-ended interviews is rarely part of a fishery statistical programme. The main objective is to gather opinions or notions and this is more difficult to analyse than measurements, in addition the type of qualitative data that is obtained does not compare well with the quantitative data collected by 'real' fishery statistical methods. Still, information obtained by this method can be very valuable for obtaining opinions or anecdotal information, as well as ecological information. This information may be very valuable for understanding the fisheries and to be able to develop proper plans and management interventions.

Sometimes the distinction between structured and open-ended interviews can be quite vague and both methods may be combined. A guided interview may be preceded with a participatory session to map fisheries resources, or a more open discussion on fisheries issues may follow the structured interview.

6.2.4 Reporting and Logbooks

When census type information is required this is often provided from 'external' sources, like fishing companies or middle persons etc. This type of data collection does not normally involve fisheries staff. This would be too expensive and too much work, instead reports filled in by companies, middle persons or fishers are used as source of data. This method is very similar to the questionnaire method, the difference is that in the case of reporting it is not voluntarily, it is a legal requirement, and the reporting has to be done regularly: every fishing trip or every month, or at the end of each fiscal year).

This type of (enforced) reporting is most often found in large-scale industrial and semi industrial operations and may only be of limited importance in inland and coastal fisheries. However as soon as licenses are required, reporting could be used as a requirement for obtaining a license. Data collected by this method is often inaccurate this is mainly caused by

incomplete compliance especially with middle scale fleets, transhipment (to smaller vessels) and general under-reporting. Validation from time to time by inspectors or a separate sample survey is important.

For inland and coastal fisheries, a similar method is often used, but then is referred to as logbook method. Instead of forcing all the fishers fishing within a fishery to report all their fishing activities, a sample of fishers is taken who, on a voluntarily basis, fill out daily log sheets for all their fishing activities. This method is widely used and can obtain very reliable information on fishing, marketing and consumption. It is a very cost-effective method to collect data.

6.2.4.1 General considerations for using logbooks

Logbooks can be used for recording catch and effort for small and medium scale fisheries and even for family fishing, as an alternative to random sampling of the landings. Logbooks are also widely used for obtaining consumption data as well as data on marketing and trade. Using logbooks for small-scale family fisheries is often the only feasible way to obtain detailed catch and effort information for these fisheries that would otherwise not be available.

Logbooks require a great deal of effort on preparing and initiating the survey. As it relies on volunteers it poses problems in selecting a representative group of participants that will allow extrapolating the results over the whole fisheries.

The persons volunteering may not be representative for the target population and then additional volunteers for under represented groups may need to be found. For example if the fisheries in a floodplain area needs to be recorded, it is possible that most volunteers will be part-time fishers. They may have fewer problems with providing details on their fishing activities than full-time fishers who may not want to disclose certain activities for tax or compliance reasons (use of illegal gears or fishing in closed seasons). This may make that full-time fishers may be under-represented.

To recognise that a group is under-represented some general information on the fisheries needs already be available, especially for fishing activities, fishing grounds and number of participants. This information needs to be available for planning of the survey and to establish strata (if any) and for small-scale and family fisheries it is customary that this information is collected in a household fisheries survey. In the case that sufficient information can be obtained from existing sources, or when key informants (local fisheries officers or community leaders) can provide this information, the household survey may be skipped. However because it can also provide key information for verification and extrapolation purposes, it may still be useful.

The first requirement for a successful logbook system is literate fishers. In addition it is important to realise that logbooks require extra work for fishers. In contrary to sample surveys for catch and effort where the landings are weighed and recorded by independent enumerators, in a logbook system the fishers themselves record their catches. This means that to ensure that the catches and associated effort are recorded reliably; the participating fishers need to be motivated and remain motivated for filling out the daily log sheets. This can be done in different ways:

1. explain the objectives of the data collection exercise
2. build trust towards the department collecting the logbooks

3. link the data collection with participatory management approach
4. enhance the sense of ownership with the resource users for the data collection exercise:
    a. involve the participants in all stages of planning and design
    b. provide regular feed-back on the results
    c. allow local analysis and use of data

Although in research programmes it may be alright to provide a small incentive for fishers to fill out logbooks, this relatively small cost may become prohibitively expensive when large numbers of fishers would be asked to participate.

As indicated above in some cases it may be possible to implement logbooks in combination with community management systems, in others it might be come a requirement to be allowed to fish to fill out logbooks. This may provide sufficient incentive without having to pay participants or give occasional. However, paying for information or for the time it takes to fill out a form is not as far fetched as it would seem. Using enumerators is costly and when information is essential, using logbooks is cost-effective and a lot cheaper then sending out enumerators.

Whatever the type of incentive (license, subsidies, or in kind), feedback of results to participants is very important, both to show that the results of the data collection is used and to discuss the results of the analysis with the participating fishers. In addition feedback and guidelines for individual fishers on filling out the logbooks can be provided. This will ensure that fishers stay committed and do not loose their interest.

Organising village or district level meetings provide a good forum for exchange of experience and to show that the fishers form an important part of a larger network.

A few recent experiences (in floodplain areas in Cambodia, and a separate survey covering mainstream Mekong) have proved that logbook systems can work provided sufficient attention is given to building of trust with the fishers and sufficient training and feedback is given.

Normally logbook surveys last at least a period of 12 months to be able to catch the seasonality of fishing for a whole year. Long term routinely implemented logbook surveys are perfectly feasible with dedicated and motivated fishers and a good support system of local fishery officers.

6.2.4.2 Harvest

Reporting all catches and landings (in the sense of a legal requirement) is almost never an option for inland and coastal fisheries except at the large-scale end of the fisheries spectrum where the fisheries is highly homogenous, commercial and specialised, like shrimp fisheries. In all other cases it will difficult to implement this on the required (census) scale.

Reporting requires each record identified by the name of the vessel, with information on total weight by species or commercial group, as well as price obtained. If information on fishing ground and level of fishing effort are available this should also be collected, but this is often not available. Instead a rough estimate for the fishing effort in terms of fishing days can be estimated.

For small-scale inland and coastal fisheries, reporting takes the shape of a catch and effort logbook. See section 6.2.4.1, 7.2 and 7.5 of this handbook

6.2.4.3 Post Harvest

Data from post harvest operations can be used for obtaining information on landings, biology, markets, costs and earnings. It can be used as the sole source of information or as supplemental information. In many cases the larger processing factories do not operate for inland capture fisheries and may only obtain fish from large-scale fisheries, mainly because of regular supply of raw material.

In inland fisheries, the supply is less reliable and quantities available may vary from day to day and season to season. The post harvest industry is therefore of a small-scale nature and more likely to consist of part-time operations depending on the availability of certain species of fish in sufficient high quantities. An example is the production of fermented fish and fish paste. Even then, this small-scale processing industry can provide auxiliary information on catches and on the economics of fish processing operations.

In some special circumstance it may be feasible to use market records to estimate catches and landings quite reliably. This is the case when a large fleet of small-scale vessels is operating with a few central landing and marketing locations. This may be the case in reservoirs or lakes, or bays.

The more transactions are involved, the more paper work will be necessary, up to a point where it becomes difficult to process all the transactions, as a census, and a sample survey for market transaction records becomes a better option. It is seldom an option to use voluntary logbooks for traders or companies as the accuracy and consistency is low and the drop-out rate is high even when initial eo-operation is high. Where existing transaction records need to be filled out (for example at whole-sale markets) these can be used instead. It will be essential to standardise the invoices and sales slips, and to harmonise the way in which they are filled out. It is best to keep the paperwork as simple and brief as possible. It is better to sacrifice some detail for a more complete coverage.

6.2.4.4 Trade

In addition to direct reporting of the harvest there are also a few indirect sources of information of part of the landings, through general sales:

- Market
- processing factory
- export data

These sources are best treated with caution, as the information is second hand and has often been aggregated to a large extent, losing species/gear or other details along the way. Because this data is located some distance from the primary source it may include more accumulated errors and therefore should only be used as a last resort, or possibly to cross-check estimates based on more direct measurements.

Trade data normally refers to information from customs or similar sources on trade. These data are used for socio-economic indicators and, in some exceptional cases, support landings

data. However a different type of trade data is formed by domestic trade data, not to be confused with marketing. The pathways of fish from the producer to the consumer can be very complex. The exact routes and the volumes traded can reveal interesting patterns of consumption and consumer preferences.

It is generally known that an important part of the inland fisheries production of Cambodia ends up in Thailand and to a lesser extend in Viet Nam. On a local scale, highly productive fishing areas will send their produce across the country, for example part of the fish production of An Giang province in the Northern Delta region of Viet Nam, is transported as far as Ho Chi Minh City and for some species even to Hanoi in the North.

Information on trade, exports and imports is normally available from trade or tax departments. This data is limited to assess total production as it normally will focus on export of high value products (not necessarily fresh fish) or excess production. If there is no estimate for the domestic consumption then the total production cannot be estimated. Even if there is, the trade data has to be converted from the processed fish product weight to the whole (fresh fish) weight. In addition trade data often has very limited details on the origin, or species and is often highly aggregated, trade categories are often too general to be of any use for total production, with categories as fresh fish, canned fish, frozen fish etc., there is not a lot of information that can be used for planning or management.

Additional information on trade networks can be obtained through specialised surveys targeting markets, traders and transporters. This is covered in some detail in section 8.3.

7. Catch Assessment Surveys

The main focus for catch assessment surveys is to get a measurement for both the catch and effort, where possible by species and boat/gear combination.

The fisheries in inland and coastal areas are extremely diverse. This makes it difficult to formulate a single standardised approach that can be used universally. Small to middle scale commercial fisheries in general and the larger scale inland fisheries operations, like Dai and Lot operations, or trawl and long line fisheries, in particular are excellent candidates for using sample surveys for catch and effort with direct measurement of the catches. Commercial fisheries also have an important small-scale component and as long as this is mainly full-time commercial fishing this can also be covered well using sample surveys for catch and effort. However for most inland small-scale fisheries (even for commercial fisheries) it is impractical to use sample surveys for catch and effort.

Small-scale and family fisheries land the catches rarely at centralised landing sites, instead they are often brought home first, before the catch is consumed, sold and/or processed. Furthermore fishing is highly irregular, although there are full-time small-scale commercial fishers, who go out almost on a daily basis; they are dwarfed in numbers by the huge amount of people who go out on a less regular basis. Fishing is highly seasonal with a wide variety of gears that can change drastically overnight if there is a good opportunity for a certain type of gear.

Limited scope catch assessment surveys for small-scale inland fisheries may be useful to get an idea of the catch and effort of these fisheries. They can even be used to get a rough estimate of the total production of small-scale fisheries.

Another approach is to use a catch estimate to calculate the production per surface area for different habitat types in the survey area. This value can then be used to calculate the production for the whole country, or any other area, including basins that may cover parts of several countries. The habitat areas can be obtained using remote sensing information in combination with ground truthing. This approach works particularly well for floodplain or reservoir/lake habitats. Species detail may be difficult to obtain in catch assessment or consumption interviews but is feasible (to a certain extent) with catch assessment/consumption logbooks. The main problem with this approach is that the calculated value should ideally reflect the production for a certain habitat type. Fish is seldom caught where the fish biomass is produced. Therefore the required calculations are less than straightforward and in most cases not more than a very rough estimate can be obtained. More details on this approach is given in section 11.

For small to middle scale commercial fisheries three main approaches are applicable:

1. **Sample surveys** for catch and effort at landing sites using direct measurements
2. **Logbook surveys** for selected fishers or fisheries
3. **Recall surveys** for catch and effort at landing sites (or in households)

Note that it is possible to implement sampling surveys for catch and effort for coastal family fisheries and even inland small-scale commercial fisheries. However doing this as a routine survey will take a disproportional amount of sampling to obtain reliable results. This approach is taken to be able to verify results from other catch assessment approaches as a limited scope survey for a small area and limited duration.

For small-scale and family fisheries (in inland fisheries) two main approaches are available:

4. **consumption surveys** for catch assessment (see section 9.1)
5. **logbook surveys** for households

The latter two approaches are generally done in small areas, often not bigger than a few villages or districts or a single province at most to reduce the amount of sampling and the cost of the survey. More than one area can be surveyed, but to obtain an estimate for the whole country the results of the surveys have to be extrapolated. This can be done by stratifying the areas surveyed and then identify similar areas in a country to enable calculating a raising factor based on the number of households or alternatively on the village (commune) or district level. In some cases GIS can be used to great effect in the extrapolation of survey results and estimations for large areas, this is covered in some detail in section 11.

In the following each of the catch assessment methods listed will be covered in considerable detail, except for the consumption survey method that will be discussed in section 9.1.

7.1 Sample surveys for catch and effort at landing sites

The sampling approach recommended for the small to middle scale commercial fisheries is based on methods which are used in many countries in the world. In most cases, the collection of data for small to middle scale commercial fisheries is used to estimate total landings, species composition, and fishing effort by boat and gear type, during the period of one calendar month.

The boat/gear types are the basic statistical units and for all of them it is necessary to collect data on catch and effort separately. Therefore it is sensible to try to reduce the number of boat/gear types as far as possible, by combining some of them in one category to minimize sampling effort.

Since there is a large variation in fishing grounds, type of fishing boats and fishing methods, and other factors influencing the catch and species composition, sampling and estimation are done for limited areas, commonly referred to as minor strata. The use of stratification increases the homogeneity of the landings to be sampled and this increases the reliability of the resulting estimate.

Data collection is limited to a *representative* number of landing sites and takes place on pre-selected sampling days which are preferably randomly chosen, when the fishing patterns allow for this. If the fishing is concentrated in only part of the month, and when this is a regular pattern, it may be useful to define minor strata on basis of a low and peak period, for which the catch is estimated independently.

The general sampling scheme which can be used consists of four surveys, which all four need to be done to be able to estimate the total catch:

1. **frame survey**, a census of the number of fishermen, boats and gears in all the fishing villages;
2. **sample survey** for **catch** and **CpUE**;
3. a **sample survey** for (fishing) **effort**, the number of boats, or fishing gears which are used for the catching of the fish; and
4. a survey for the number of **active** fishing **days** in the month.

The frame survey must be a census, in which all the fishermen, gears and boats are counted, while both the survey for catch and effort are sample surveys. For both sample surveys only some landing sites are visited, and only on some days of the month:

- When sampling for catch, only some of the landings are weighed
- When collecting data on effort *all* the boats which are out fishing from that site on a day are counted.

7.1.1 Sample based estimates for total fish production

For a specific boat/gear type, the total catch is defined as the Catch per Unit of Effort (CpUE) multiplied by the actual total effort of this boat/gear. Therefore it is necessary to find reliable estimates for the CpUE and the total effort.

Total catch = CpUE x total effort exerted by this boat/gear.

For the **CpUE** only one sample survey is necessary, this survey will give the average species proportion of the total catch and provide the sampled CpUE by dividing total sampled catch by the associated effort. This is the sample survey for catch and CpUE.

The estimation for the **effort** or more precise the total effort is more complex and needs inputs from two sampling surveys as well as accurate data on the total number of boats and gears in the areas covered by the statistical system:

1. The first, the **sample survey** for **effort** aims at establishing the proportion of fishing units that have been fishing during a sampling day.

2. The second sampling survey is for collection of data on the average number of **fishing days** for a specific boat/gear type per month. Active days can vary for different boat/gear types and for different minor strata. This information is usually based on empirical data supplied by the data collectors.
3. The third survey, is the **frame survey**, is usually conducted every few years and gives total numbers of boats and gears in the area covered by the statistical programme.

Total fishing effort = boat/gear activity ratio x total # boats/gears x # active days

The Boat/Gear Activity Coefficient (BAC/GAC) is calculated by dividing the sum of the sampled effort by the maximum effort over the sampled days at the sites covered. By multiplying the boat/gear activity ratio by the total number of boats/gears (from the frame survey) we obtain an indication of the total number of boat/gear units that are expected to be fishing on any given day. This indicator is then multiplied by the number of active fishing days in order to determine the total fishing effort during the month.

Estimation Total catch, for each boat/gear type is estimated by taking the estimated total effort multiplied by the overall CpUE obtained from the sample-based survey for CpUE. Species compositions are calculated by taking the ratio of each individual species by dividing the total sampled weight for each species by the total sampled weight. Multiplying this ratio with the total estimated catch gives the total estimated fish production for each species.

Estimated total catch = estimated total effort x overall CpUE

The sample CpUE are reliable if the sample design is correct: taking samples from a few but well-selected representative landing sites. Most of the difficulties and problems in sampling surveys for small to middle scale commercial fisheries come from the estimation of total fishing effort. This needs 3 surveys in order to extrapolate or raise the sampled effort to the total effort, which makes errors more likely to occur.

7.1.2 Sampling techniques

Sampling should be representative for the whole population and should avoid introducing bias. Biased estimates are systematically lower or higher than the true population value. Unfortunately bias is not easily detectable and can seem to be absent altogether. This means that those involved in the statistical programme may not be aware of the existence of bias, since the true population value is often not known. In general biased sampling does not influence the precision of the estimate, therefore the variability may not seem to be wrong, however if the variation is often small, this may indicate the existence of bias in sampling. A biased sample contains on average to many values that are either below or above the population mean, and this means that the variation of the sample is consistently lower than the population variation.

It may from operational point of few not always be straightforward to reduce bias, by using more representative sampling; however the best approach to the reduction of bias is through the application of appropriate stratification.

7.1.2.1 Selection of sampling sites

Selection of landings sites (for medium and large-scale fisheries) is the first step in obtaining representative samples. There are two approaches:

1. all landing sites are covered (at least once a month)

This needs sufficient and mobile human resources. When there are operational constraints (accessibility, availability of data collectors, limited mobility, etc.), this may not be possible and the other approach needs to be taken:

2. a fixed selection of landing sites is covered for a longer period

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, or when changes occur in the fishery with changes in the number or importance of landing sites

Frame surveys and map based information are normally used to make a selection of fixed sampling sites:

- The selected sampling sites should provide a satisfactory geographical coverage of the survey area and at the same time constraints on human resources or transport have to be taken into account. This means that the selected sites will always be a compromise;
- The frame survey will indicate the importance of each landing site in terms of the number of fishers, boats and gears, thus indicating potential fishing effort;
- Selected landing sites should cover boat/gear (effort) types; and
- Sampling should focus on sites with larger numbers of fishing units.

Selection of clusters of sampling sites may make sense to facilitate coverage by available enumerators, as long as the coverage for the separate boat/gear types is sufficient.

7.1.2.2 Data collection at sampling sites

As mentioned before random sampling or a close approximation of random sampling (systematic sampling) is the best guarantee for representative and unbiased sampling. This means that data collectors should be thoroughly briefed on this issue. Sampling for the collection of effort data, should always use random selection of fishers without prior knowledge of whether they have been fishing or not.

Practical problems arise when boats land within a short period. It is not more than human for enumerators to try to cover as many landings as possible and thereby concentrating on those landings that seem to have the smallest catches. Also in case landings occur over longer periods, enumerators may only sample the first few landings before rushing of to the next landing site. This kind of selection introduces bias for CpUE, species composition and prices. This should be avoided at all cost. Therefore sampling should be random, both random selection of landings and at random times.

7.1.2.3 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. This is always

the basis for reporting the numbers of fishing boats and gears in frame surveys, and for the estimation of fishing effort:

- Frame surveys are conducted at all homeports, which is the reason why this approach does not work very well for fisheries where there is no central landing-site (unless a village is classified as such);
- Effort surveys are conducted at homeports selected for sampling;
- Locations can be both homeports and landing sites;
- Landing surveys are conducted at landing sites selected for sampling;
- Estimates are produced at minor stratum level; and
- Totals for major strata come from combining results at minor stratum level.

7.1.3 Classifications

7.1.3.1 Boat/gear categories

It is essential that certain boat/gear categories are defined for which separate estimates will be made.
The selection of categories is made on catch characteristics with respect to:

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

It is not required to specify a category for each separate boat/gear type only when significant differences are expected. The level of detail in the categories is based on practical considerations, is it possible to collect all required data (frame survey and effort) or will it be difficult to separate data for different categories.

Standardization is mainly required to ensure uniformity in the boat/gear classifications used for all landing, frame and effort surveys.

It is also required to have a good understanding of the gears and gear use, with detailed particulars for each gear on size, operation cost, habitats where it is used, how it is used and selectivity. Especially for inexperienced staff it is useful to have a gear catalogue available. This can be used for training and can be a valuable reference work for use in the field.

Small-scale fisheries encompasses a huge variety of gears, especially trap types are especially numerous. Some of them are very selective and some may be localized. It is easy to compile a list with over a 100 different gears, in floodplain areas. It is clear that it will be impossible to obtain effort data on all of these gears.

Determining the fishing unit (boat, gear and fisher) that forms the basis of the sampling programme is very important. It will be almost impossible to conduct a frame survey for the gears encountered in inland and coastal fisheries. Changes are extremely rapid and the resulting deviations between the real situation and the frame survey gear count will heavily influence the estimation process.

There are basically 3 possible possibilities for the unit of effort:

1. **Fisher or fishing day**. This is the most appropriate measure for small-scale fisheries, as there are many fishers that do not fish using a boat, especially in inland fisheries. Often

passive gears are used, gears, gillnets and not just in small-scale fisheries, the Lot and Dai fisheries are large stationary gears. Using the fishing day is also the easiest to use but unfortunately contains the least information on the fishing activities. A fishing day may consist of anything between 1-12 hours fishing and it will not be known what gears were used.

2. **Boat approach**. The fishing boat is often used as the unit of choice, especially in the classical sampling surveys this is the commonest approach:
   a. Frame surveys usually are designed to give the numbers of boats by boat/gear type that is subsequently used for estimating fishing effort;
   b. The level of fishing activity is frequently measured by the Boat Activity Coefficient (BAC), this expresses the probability that a boat is active on a given day; and
   c. Catch per Unit of Effort (CpUE) is often expressed as the average catch per day of a boat of a certain boat/gear type.
3. **Gear approach**. Alternatively the fishing gear can also be used as the statistical unit; this is often done in large and middle scale operations that have a relatively low level of involvement. There using units like 100-meter gillnets, or hook line units etc. may make sense and be practical possible from the point of view of collecting the frame survey data. Similar to the boat approach:
   a. Frame surveys may provide numbers of gears by boat/gear type to be used to estimate total fishing effort;
   b. Fishing activity levels may be measured by the Gear Activity Coefficient (GAC), this expresses the probability that a gear will be active on a given day; and
   c. Catch per Unit of Effort (CpUE) may also be expressed as the average catch per day of a gear of a certain boat/gear type.

The amount of detail decreases along the line going from fishers (fishing days) down to gear-units. There needs to be a careful evaluation of what is required (as opposed what is desired) and what is attainable:

1. Frame surveys for 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;
2. 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; and
3. The major advantage of the “gear” approach is that it can better handle cases of multiple gears (whether in sequential or concurrent use).

The amount of detail that can be handled for the statistical system is dependant on the scale of the fisheries. If for some fisheries relatively few units are in operation, then these can be easily monitored and they should be monitored separately. For example the Lot fisheries in Cambodia (figure 5.) uses certain well defined areas that are fenced off and are easily recognizable on satellite and aerial photography. The lots are also registered and therefore can be sampled as a separate fishery.

For most small-scale fisheries however, going beyond the concept of fishing days for a general catch assessment survey is shear madness. Too many gears are being used, with numbers that can change dramatically, literally over night.

7.1.3.2 Species classifications

The number of different species that is landed in coastal and inland fisheries is quite large; it is not uncommon to see 100-200 different species on large landing sites. Although fishers are

often capable of distinguishing over 100 species with ease, marketing often follows certain economical species groups. In most fisheries (with the possible exception of estuaries) around 40 species will probably represent around 90% of the catch in terms of weight annually.

For sampling purposes species groups can be defined for:

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

As for gears it will be necessary to prepare species lists and species identification sheets to be able to describe the species diversity correctly and to be used as identification guide and training material for fisheries officers. FAO has prepared some excellent species guides for coastal areas and the MRC has published the Mekong Fish Database (MFD 2003) that can be used as the basis for a field guide. This database contains most of the species that will be encountered in the Mekong and may also contain most of the commercial species found in other inland areas. The MFD can be ordered from the MRC web-site: *www.mrcmekong.org*. Another well known resource is ICLARM's FISHBASE that contains information and pictures on over 25000 fish species. FishBase is available on line: *www.fishbase.org*.

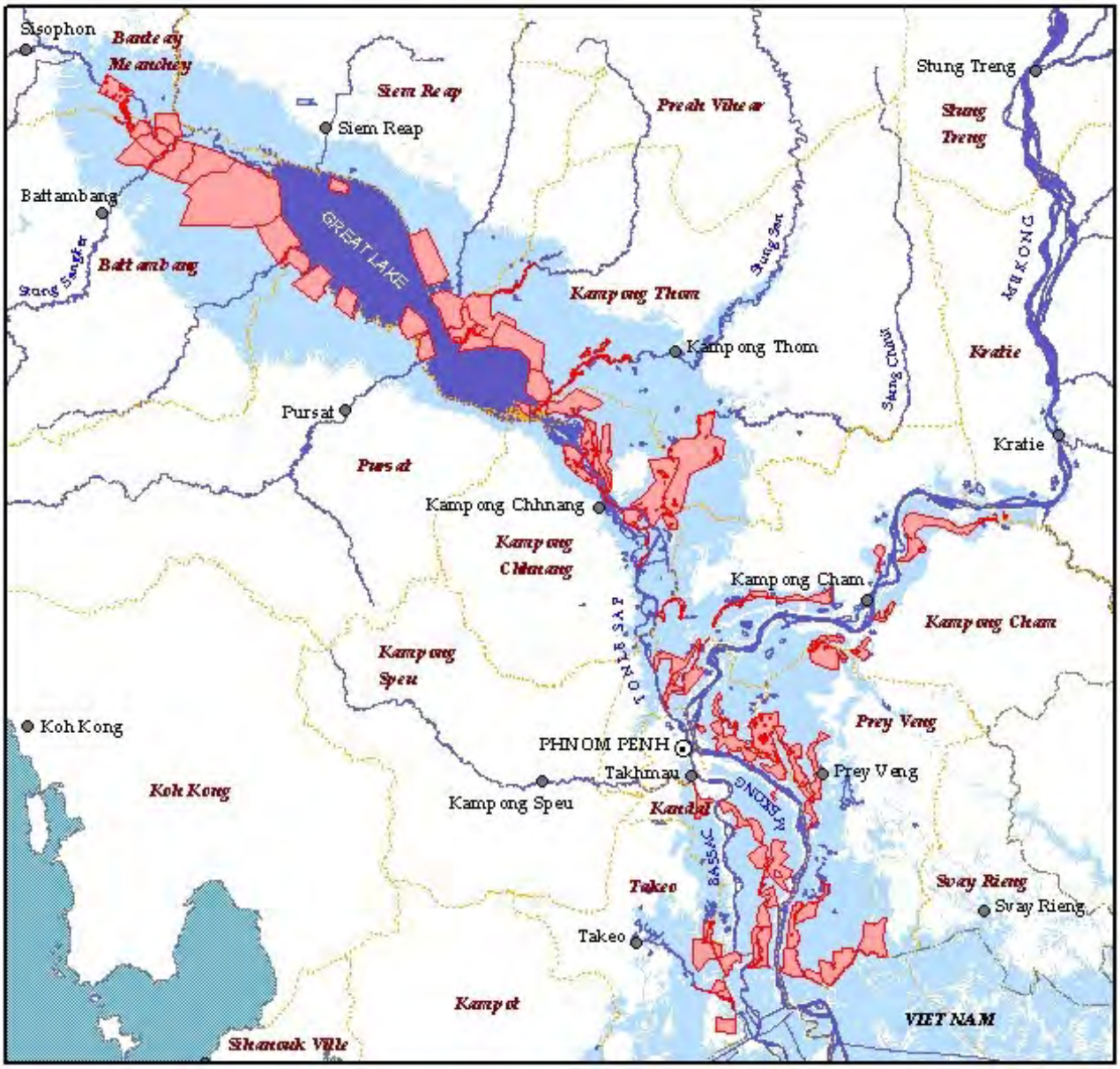

Figure 5. Location of fishing lots in Cambodia in 2001.

If there is a local stocking programme, it makes sense to include the species stocked as separate species for monitoring, so it will be possible to assess the impact of the stocking.

7.1.3.3 Measurement units

The measurement units used must be standardized. Weight should be recorded in kg and length in cm. Measurements themselves should also be standardized, all weights should be fresh weight, or converted to fresh weights and length measurements are normally Total length. Effort may be expressed in different ways; however the same unit should be used throughout the data collection. For commercial fisheries, that operates with fixed, standardized gears the effort may be gear specific or may refer to the surface area of the gear. When fishing is with a mixed number of gears, as is the case in many small-scale operations, then boat days may be a valid unit of effort, for family fishing, fish days may be more appropriate.

7.1.4 Frame survey

Once it is decided to collect fishery statistics in a certain area the first thing to be done is a frame survey, which will form the basis for the following sample surveys. The frame survey needs to be a census where all landing sites are visited and the total number of boats and gears is counted for each boat and gear type.

The records kept at DoF offices are in general not reliable. They do contain numbers of vessels and which gears are licensed, but not only are the number and size of the gears not recorded, it is highly likely that there will be more vessels and gears than officially licensed. Therefore it is necessary to actually visit all villages for the census. The official register can however provide the basis for the planning of the frame survey. It would be best to disconnect the results from the frame survey from the collection of license fees. In many countries frame surveys are done by independent part time staff that in consultation with local DoF staff goes to every village to collect data. An alternative approach is to use local DoF staff at the district level to do the frame survey.

Prior to the frame survey a list needs to be made with the gears which are expected to be found, based on existing knowledge of the fisheries.

Discussions with local DoF staff will provide information on which gears can be expected and information on location of villages and access routes to be used in the planning for the frame survey. The local fishery officers need to be assigned full-time to the collection of the frame survey data. It is good practice to have at least two teams visit all the villages and thereby duplicate the census to be able to cross-check the results from both teams.

Collecting frame survey data just by direct measurement, counting all boat/gear combinations has severe shortcomings. Some gears will be used or may otherwise not be visible in a village. Therefore a mix of counting and interviewing of key informants is often the best approach. When going to the villages some of the vessels will be out on sea, so much of the information needs to be collected by interview method. Fishermen can be of assistance as well as the village headman, but since detailed information on the gear is necessary, it may be necessary to visit a certain village more than once. Annex I shows the form which may be used for the collection of frame survey data.

7.1.4.1 Tabulation

The result of a frame survey is a set of tables indicating:

i. Existing landing sites;
ii. Number and type of fishing boats, motorized (HP-class) and non-motorized and the size (classes) material used;
iii. Number and types of gear with the sizes possessed/used;
iv. Number of fishermen with indication whether they own a boat or are crew members;
v. Fishing and landing patterns, when landings are expected, but also when certain gears are used; and
vi. Access routes to landing sites.

While in a village it can be useful to collect additional information which is not essential for the frame survey but can give useful supplemental information on the structure of the fishery,

like prices of gears, where they are purchased, credit facilities for the fishermen, average catches per month and trade flows (middlemen and marketing).

7.1.4.2 Data collection

A good approach is to visit each house in a fishing village and ask for the number of fishermen, boats and different gear types. This must include both the gears presently in use and the ones which are not being used in the current season. For all the gears the season in which it is used needs to be recorded. It is useful to know if fishermen operate two or more gears simultaneously. Gears like hook and line and traps are excluded from the frame survey since their numbers fluctuate widely. It is good practice to look around the house and inside the house when that is possible to look for other gears which are not being used by the fisherman during the present period. When no-one is at home, a neighbour or the village headman may know details.

7.1.4.3 Practical considerations and implications for estimates

It is clear that the number of fishermen changes, the number of boats and gears can change from year to year and more importantly from season to season. The validity of the sample approach is based on the assumption that the frame data, the list with the number of boats, gears units for each boat/gear type is accurate and reflects the real situation. For small to middle scale commercial fisheries it is usually necessary to carry out a frame survey every one or two years, since changes can be very rapidly. The reliability and accuracy of the frame survey data can be assessed by going to certain important villages and make spot checks to see if the frame has changed. Moreover while collecting data for catch and effort certain villages will be visited monthly several times. On those visits data can be collected on new boats being built or new gears being purchased. This additional information provided by fishermen can be obtained through a good relationship with the fishermen and local VIP's and can indicate whether the frame survey is still valid and to adjust the frame survey where necessary.

When the number of boats and gears has increased then the effort is *over* estimated when using old frame survey data, and the total catch for all the sites combined *under* estimated. This is not so serious when there are only small changes, an increase of 5% in the number of boats or gears will not be a big problem, but changes in the importance of certain landing sites or target species can make an important difference. Experience has shown that data from frame surveys are, at times, one of the weakest elements in a sampling programme, since they are used as extrapolating factors in order to derive general conclusions about total fishing effort (and at a much larger scale) from a rather limited number of sample-based fishing effort parameters

The results of the frame survey, supplemented by species identification guidelines and a species list, should be organized into a set of tables containing the following information:

(i) A table of major strata for reporting purposes;
(ii) For each major stratum a table of associated minor strata. All sampling schemes and estimation procedures will each apply within the context of a minor stratum;
(iii) For each minor stratum a table of landing sites that may be used as primary sampling points, including also the numbers of fishing craft and gear by boat/gear type;
(iv) A table of species that will be used for species composition during the CpUE sampling survey;
(v) A table of all boat and gear types;

(vi) For each minor stratum a table indicating all boat/gear types in the stratum and preliminary estimates as to the expected active days. This table will be due to changes at the end of each survey month in order to include information not known in advance (such as periods of no fishing because of bad weather).

7.1.5 Sample surveys

7.1.5.1 General considerations

The data collection scheme uses the standard approach of conducting three parallel sample-based surveys:

- CpUE survey
- effort survey
- active days survey

These three sample surveys are combined with a census (frame survey) required for raising the results to the whole population.

There should be indicators for sample size, variation in space and time and confidence limits for all produced estimates to help in adjusting the sampling scheme.

The frame survey will give us a list with all the villages/landing sites in an area and the number of fishermen, boats and gears used. On basis of this it is possible to choose those sites which are most important to be included in the sample survey, or better which villages and landing sites are most representative for the whole area. Based on the information of the frame survey villages can be divided into groupings based on size (number of fishermen/boats) or the presence of motorized or non-motorized boats. This can give the stratification to make more homogeneous groups which will increase the reliability of the sampling. It will also indicate which boat/gear types are most widely used and where they are located. This will give the information to decide which gears or gear groups to include in your sample survey.

From the frame survey it should be clear what the most important villages are which need to be sampled. Initially a maximum of 3-4 villages/landing sites need to be chosen for the sample survey. This is mainly because covering more landing sites may not be possible or necessary, but evaluation of the results will show if this is a good set-up. However from the results of the frame survey and the discussions with the district officers it will become clear where and in which season boat/gear types are being operated. Based on that information a decision can be made which villages/landing sites are most representative, for the fishery and which landing sites have to be included in the sample survey. Landing sites need to be chosen to ensure that landings for all boat/gear types are covered by the surveys, in sufficient numbers. It may be necessary to cover the same boat gear types in more than one village; this is especially true for the effort survey, as the effort will be more variable than the (average) catch.

Some gears will only be operated during a limited period every month and that needs to be taken into account when making the sampling schedule. If certain gears are only operated during a certain period and *never* outside that period during a month, all the sampling has to be within that period and in the active fishing day survey for this boat/gear type the length of that period needs to be indicated separately for each month. However if for a certain boat/gear

type *most* of the fishing is done during a certain period in the month and there is reduced fishing with that gear outside that period, the only solution is to sample both the peak and low period for catch and effort. Information on gear use or on fishing and landing patterns (which is boat/gear specific) needs to come out of the frame survey. It is likely that these patterns depend on the season, which means that patterns may be different for different seasons.

Information on **fishing patterns** indicate if fishermen only go out fishing with certain gear types during certain periods in the month, connected to lunar (tidal) cycles. It will also give information whether there absolute no fishing outside a certain period or that there will always be a certain amount of fishing anytime during the month. It also includes information on the seasonality of gear types. The fishing patterns are influenced by many factors, like lunar cycles, seasonal changes, currents and weather patterns and may be very unpredictable.

Landing patterns refers to the time of day when to expect landings, which depends on when the fishermen go out, the size of the vessels, how the catch is traded and preserved, but also on the boat/gear type. If there are traders who collect fresh fish from villages for sale at the some central market, it is likely that at some places the fishermen will try to land their catches early in the morning, to be able to sell their fish to the traders. For salted, dried and fermented fish the time of landing is probably not fixed since the products can be kept for a long time. It is of the outmost importance to know when to expect landings in order to visit certain landing sites to collect data. It may be possible to identify the day on which the data collectors should be at a landing site, although there should be some flexibility here as well, but the data collectors need to find out themselves when they should be at the landing site. With the data collectors actually based at landing sites there are no problems, but this will not be possible for all the landing sites and fishing villages.

The ultimate goal of the collection of data on the fishery production is to try to estimate the total fish production in a given area as accurately as possible. However it is not necessary to include all gears in our estimate, it is possible to disregard certain gears, when their catch is very low and/or their abundance is very low. For these gears it is also possible to use an estimate for the average catch per month, provided by fishermen to estimate the total catch. Alternatively a census for the catch on some days in the month, if the landings are localized with limited number of landings, can be used to establish the average catch per day.

If there are both motorized and non-motorized boats operating certain gears, they need to be separately sampled:

- Do not go to the same places;
- Do not catch the same species;
- Depending on the gear there will be a distinct difference in the catch rate; and
- May be based at different sites.

The surveys for catch (and CpUE) and effort need to be done independently from each other to increase the reliability of the results. Catches and associated effort should be recorded at the landing sites but the census for the fishing effort should be recorded at the places from where the fishermen go out fishing. This need not be the same. There will be fishermen going out from landing sites, but not all fishermen landing at a given site will have their boats and gears based at that site. This is especially true for central landing sites or wholesale markets where traders meet with fishermen. If collecting data on the effort at a landing site, care must be taken to collect only data on fishermen who go out from the landing site and not to count the fishermen who only come to land the fish at a village.

As with all sampling, sampling for catch and effort needs to be random, meaning that all days in the month have the same chance of being sampled. In practice this means that the landings at some well chosen sites are sampled on 5 or 6 days each month. In case there are many boat/gear types that need to be sampled on different sites, the sampling of different boat/gear types can be spread over a number of days. It is important to collect data for catch and effort on the same number of days, but this need not be the same days.

There will be transition periods in which fishermen will change from one gear to another during a month. If fishermen change there gear more or less at the same time, this need not be a problem, it does however require some extra sampling, but when this can be planned for if it is known in which months changes are likely to occur. The information on when to expect seasonal changes in the gear type used can be derived from the frame survey and the empirical knowledge of the data collectors. This indicates that there is a great need for continuous feedback from the data collectors to the co-ordinator in HQ.

7.1.5.2 Sample survey for catch

In this survey data is collected on the landed weight and the effort which produced the catch (the associated effort) which is necessary to calculate the Catch per Unit of Effort or CpUE. The data form for the collection of data on catches and landings is included as Annex II.

Fish are being caught by many different boats and fishing gears. It is important that the estimates for the total fish production are made on a boat/gear basis. Boat-gear types are all the combinations of gears and boats operated in the area. For example motorized boats with a drift net or non-motorized boats with trammel gill net are boat-gear types. The reason to distinguish between boat-gear types is that the catches by different gears and by the same gear used in motorized and non-motorized boats can be very different.

In this survey the following data needs to be collected for each boat-gear type separately:

1. Sample **weight** of the landing, the weight of the landing needs to be measured and has to be recorded for each species or species group separately;
2. **Effort** or the number of gear units used for the catch;
3. **Price** per kilo, or the total **value** of the catch, on a species level, this will normally not change much on a day to day basis. It is enough to get a general idea of the prices so the price and value can be recorded once a month and used for all the catches during that month; and
4. **Number** of fish, or average size of the fish, on a species basis, can give very useful additional information. In practice it will not be possible to count all the fish, but by taking a sub sample and counting the number of fish the average weight of a species in a landing can be calculated.

It is *essential* that the species composition of the catch be assessed as accurately as possible. It is important that all the data collectors are familiar with the species that can be encountered know how to recognize the species. Taxonomy forms the basis of all statistics and without proper species identification, reliable data cannot be collected. If the landing is big, time constraints will make it almost impossible to identify all the fish, at the landing site. By weighing the total weight of the landing and looking at the species detail in part of the catch, the species composition can be estimated. It is likely that certain species (groups) will already be pre-sorted and this will facilitate the collection of data.

In general in the sample based approach only some landings are sampled for some pre-selected landing sites during some randomly chosen days in the month. Obviously, when the fishing for some boat/gear types is concentrated in 2 weeks during the month only, all sampling for these boat/gear types should be concentrated during this period too.

As a rule of thumb, it is necessary to sample at least 30 landings for each boat/gear type spread over 5 or 6 days every month. This minimum means that the sample can be regarded as sufficiently large to be able to replace the number of degrees of freedom with n-1 and the population variance with that of the sample. This increases the reliability of the estimates for mean and variance considerable.

The reliability of the estimate should be the basis for the sample size. In general there is no need to collect data for the same boat/gear type from different sites within a minor stratum, if there is a big difference in species composition and catch amount further stratification of the area under study is needed. It is not necessary to collect data for all sites and boat-gear types on the same 6 days, as long as there is data for all the boat/gear types for 6 days. If there is a problem in covering all the boat/gear types at a certain landing site on one day, it is alright to sample landings from some boat/gear types on one day, and the remaining boat gear types on another day, as long as all the gears are sampled for the same number of days.

Some fishermen may have used two gear types for the landing. It is recommended that only those landings originating from the use of single gear types are recorded.

7.1.5.3 Sample survey for effort

Effort needs to be recorded at two levels, the number of boats which went out with a certain gear and the number of gears that was used. It is better to use the number of gear units that was used, since the size of gears can differ: basically a census of all the boats and gears going out from a given village, for some days and some villages. An example of the form which can be used in the collection of effort data is included as Annex III.

Before effort can be recorded it must be clear what the gear unit and the effort unit will be. In general the gear unit will be a length of net, not the surface area, since the depth of nets is mostly standard and for a gear where that is not the case the depth is mostly proportional to the length. Where the depth is not standard, with gears which are made by fishermen themselves like the ‘tiger mouth’, the surface of the opening can also be used as gear unit, as well as the length.

Internationally agreed standards for gear and effort units should be adopted, when and where ever possible. For example for drift nets the length of nets is normally expressed in 100-meter units. The effort then is the total number of sets multiplied by the number units of 100 meter length. This is equal to the accumulated total length in meters of nets used in a given time period divided by 100. It must be clear which gear units and effort units are used to be able to compare with data from other countries. Unfortunately most available international definitions as compiled by FAO are for industrial fisheries and for many of the gears used in inland and coastal fisheries there are no standardized definitions.

If there is a strong relationship between the size of the gear or the time out fishing and the catch, it is necessary to collect the catch and effort with as much detail as possible. More

detail means more work and possibly more mistakes. Statistics must be cost-efficient; the extra detail should be worth effort.

The effort survey is almost independent on the time of landings, a count of the boats not out fishing on a certain day gives, on a boat/gear basis, the number of boats out fishing. Depending on the amount of gear detail necessary it is sensible to collect the effort information on a name (boat owner) basis so that back in the office the amount of gear owned by a fishermen out fishing can be established. It can be assumed that fishermen will take all the available gear they own of a particular type with them on every trip during the season for that gear. There may be some fishermen, who own more than one gear type which can be used during the season, but this will be rare and any occurrence may be noticed during the collection of the catch and associated effort in the sample survey for the catches.

7.1.5.4 Survey for active fishing days

This survey is not really a survey, but can be derived from empirical knowledge from the data collectors. Active fishing days are the days on which there is fishing. In general this will be all days on which there is fishing. This can be different for different gear types and therefore this information needs to be collected for each boat/gear type separately. As indicated under the sampling survey for catch (and associated effort), this information is vital for the estimation of the total catch.

7.1.5.5 Bias

When using the sampling approach, care has to be taken to avoid bias in the sampling. The resulting estimates should describe the actual situation as closely as possible. There are a number of fluctuations that are apparent in most fishery situations:

Timing of landings, landings are not spread out over the day; instead they are sharply punctuated in time, with peaks at different times during the day. It is normal to have an early morning peak, since many fishers catch fish at night or in the early morning. Similarly different gears may target different fish species and fishing grounds and may be landing their catch at different time depending on the distance to the fishing grounds. There may also be an qualitative assessment possible. Near shore fishing grounds are easily accessible and therefore may be less productive. Fisheries may have to spend more effort to get the same catch or may catch smaller sized specimens. Fishers going to near shore fishing grounds may return back to the landing site before fishers that fish on more remote fishing grounds. This means that there is an important bias in the estimate if all samples would be taken from the first wave of fishers arriving back.
Landing sites, landings at different landing sites will not be the same, bias can occur if one of the landing sites is near a market or fish processing plant, or has better land access than other landing sites. If the fishing grounds are not homogenously distributed over an area or when different habitats are concentrated near some landing site, the landed catch can have a biased species composition or the production from certain areas may provide for better fishing grounds and hence influence the CpUE. Any sampling design should cover the whole area and during the design phase any bias should be taken into account in the sampling design.
Fishers Age, age does matter; older fishers often have more experience and in general are better in catching fish. Younger fishers are more open to new techniques, this emphasises the need for inclusion of both young and old fishers.

Another source of bias falls outside the realm of fisheries and is with the data collectors themselves. One example is that people tend to favour large fish over small fish. Any attempt at random sampling will be sabotaged by the unconscious selection of above average individuals. Similarly, enumerators may select fishers to sample based on age or ethnicity, selecting those fishers with whom they can relate.

All sources of bias should be taken into account to be able to tackle enumerator bias, it is necessary to leave as little as possible to the enumerator, but provide strict rules for sampling and selecting.

7.1.5.6 Application

This type of methodology can be very effective in coastal fisheries, and in lakes and reservoirs. Similarly large commercial operations in rivers can also be covered by this method.

The requirements, in terms of staff, training and supervision are relatively high and unless there is a clear economic incentive, or strong demand for information on the fisheries, it may be difficult to justify this type of survey. Still the results can be very reliable (provided the sampling design is done properly) and this sampling approach is very cost-effective compared to census based approaches.

7.1.6 Length Frequency Survey

Length frequency data is an important set of data that can be used for stock assessment. In particular it is used to see what size and age classes are present in the catches.

As a first step the number of species for which this data will be collected should be established. This survey can be rather labour intensive if too many species are included, so it is best to select a few indicator species, with special interest for the fishery, or those that are believed to be under threat.

It is not required to sample all the landings at a certain landing site, as long as the total number of landings are known, or can be estimated with reasonable reliability. It is sufficient to measure only a sample of the total catch for a boat gear type. The results will later be extrapolated for the whole catch and later on for all the landings for a particular fishery.

A selected landing should first be sorted by species. To be able to raise the results for the sample to the whole catch it is necessary to weigh the whole landing for one boat-gear type. A sample should be selected for all species of interest; the sample should be weighed before all the fish in the sample are measured.

In the case the catch comes pre-sorted, things are complicated somewhat if different sized individuals are grouped into different categories. Fish are often sorted according to trade categories and these are often based on size of the fish. If fish are sorted this way it will be necessary to assess the length frequency for each species in all the categories to get an unbiased sample for each species.

If a catch is not sorted into species, or part of the catch consists of unsorted fish then a sample can be taken that will be sorted into different species, weighed and measured.

Length measurements are normally done using the total length (TL).

In order to estimate the length frequency for the whole population for anyone species, a number of samples should be taken from different landings during any given period. If all the landings originate from the same stock then calculations are relatively straight forward.

$$N_{sp} = N_{sa} * W_{sp} / W_{sa}$$

W_{sp} = weight species catch in landing
W_{sa} = weight for species in sample
N_{sp} = number of individuals for species in landing
N_{sa} = number of individuals for species in sample

This formula is valid both for the total number of individuals as well as for the number of individuals for each length range. The same formula is used for different parts of the catch with the difference that if an unsorted catch is sampled the sample has to be sorted and weighed to obtain the proportion of each species of interest.

The raised frequencies for each length range can be simply summed to obtain the total number of individuals in each length range for an individual landing.

The frequencies for different landings can be summed, but only when they are comparable, both in terms of effort and in terms of gear use. In the case that they are fairly uniform (either by design, sampling each boat gear category separately) or when the vessels used are uniform), raising the frequency distribution is again simply a case of establishing the raising factor. Multiplying this with the (summated) frequency for each length range gives the total frequency for the landing site. If more than one landing site is sampled than these raised frequencies can simply be summed.

$$F_{ld} = \sum F_{\ln} * \frac{Tp}{Ts}$$

F_{ld} = Frequency for the landing site
F_{ln} = frequency of each length range
T_p = total number of trips
T_s = the number of trips sampled

To establish the total frequency for all landing sites (sampled and non-sampled a raising factor has to be calculated, based on the effort (i.e. fishing days) for each of the landing sites:

$$\frac{\text{Total effort for all landing sites}}{\text{Effort of sampled landing sites}}$$

Multiplying this with the summated frequency will give the total frequency for all landing sites.

The length frequency survey has to be done on a regular basis. It is quite normal to conduct this survey at least every 3 months. Longer periods should be avoided as this may make it impossible to distinguish age cohorts accurately.

Another important issue is that of discards. The length frequency survey can only measure the fish that are landed. In many cases the fish that are too small to be marketed are discarded, and normally do not survive. These fish were caught and taken from the population, but are not measured. This can be very serious for the length frequency data. In some fisheries, especially shrimp fisheries, the percentage discards may be extremely high, since the fishers are only interested in the valuable shrimp, even marketable finfish may be discarded.

It would make sense to try to sample the discards and treat them as another sample in the length frequency survey. Unfortunately sampling discards is expensive, as it normally involves placing an enumerator on board a fishing vessel. However if reliable length frequency data are required and the amount of discards is high then getting it right is important enough to warrant the extra cost of obtaining this data.

When selecting sub samples from unsorted landings care has to be taken. People have a preference for larger individuals; this means that when baskets or crates are filled with fish the first ones will have a larger proportion of large fish than the last batch of containers. Any sub sampling should therefore be at random when 3 sub samples are taken then structural sampling should be implemented so as not to unconsciously pick baskets with more big fish.

7.1.7 Catch Composition Survey

There where the catches are not recorded separately by species, it may be useful to conduct a separate species composition survey. This needs to be done for each boat-gear type separately on a monthly basis as species composition for different gears differ and some species only occur in the catch on a seasonal basis.

The approach is very similar to the length frequency data. If the fish comes sorted the weight for each species should be recorded and calculated as a fraction of the total landing. If the fish comes unsorted or sorted according to economic categories (length or quality) then sub sampling is required. In case of sub samples the total weight for the sub sample is recorded and after sorting the sample the weight for each species in the sample is recorded. The weight of species is:

$$Wsp = Wt * \frac{Wss}{Wts}$$

W_{sp} = weight for a species
W_t = total weight of the catch
W_{ss} = weight of the species in the sub sample
W_{ts} = / total weight of the sub sample
In case of large landings more than one (sub) sample should be taken to avoid bias when fish is landed in smaller units, like baskets or crates. The average weight for each species in different samples should be combined using the method to calculate the weighted mean for the whole landing.

$$\bar{x} = \frac{\sum w_s * x_s}{\sum x_l}$$

w_s = weight for the sub sample
x_l = mean weight for species in landing
x_s = mean weight for species in sub sample

7.2 Using Logbooks for Catch Assessment

7.2.1 Introduction

Instead of sending enumerators to weigh and measure catches and landings, and record effort, it is an option to let fishers do the work and hand out catch logbooks to them. In effect this can result in the same information as would be obtained through sampling, however instead of sampling some fishers on some days, a fixed group of fishers is asked to record information for all fishing and non-fishing days.

7.2.2 Stratification and sampling

Logbook surveys are often setup for a relative small area and the results subsequently extrapolated. The catch and effort are estimated at the level of an individual fisher, household or village.

To extrapolate the results to a higher level unit of measurement some additional information on the number of fishers per village or average number of fishers per household should be established. This is normally done either with assistance a village head or by means of a household survey.

It makes sense to try to stratify the fisheries into either the main boat-gear types or according to the average catch/effort (i.e. fishing days per month). Commercial gillnet fishers have a different catch pattern than fishers who use traps or household members that use hook and line or small lift nets. Remember that the reason for stratifying is to reduce variation and to reduce the number of samples required to obtain reliable estimates. Spatial stratification can be used to cover the major habitats: river, lake and reservoirs (i.e. areas in close proximity to permanent water bodies), flood plain areas and upland areas.

Before being able to initiate a logbook survey it is essential to have good knowledge on the fishery or fisheries. This base-line information is needed to assess the number of different strata that should be distinguished and should give estimates for the number of fishers, gear use, average catch and locations (habitats) fished during different parts of the year. The best approach for this information is to conduct a household fishery survey, which can be repeated on a regular basis.

As well as producing the inputs for the planning face, the same survey can also be used to verify the results of the logbook survey, by asking about gear use patterns (effort) and catches.

As in most cases little or no information will be available at all for the small-scale fisheries, the stratification initially may need to be quite coarse. This can be refined at a later stage once better information and more experience with the methodology has been obtained.

Because a fixed group of fishers is asked to participate, care has to be taken in selection of the participating fishers. In practice random selection is impossible, since it is not possible to force fishers into keeping accurate logbooks. Even if there can be some sort of legal requirement for filling out of logbooks, experience has learned that reporting is never overly accurate. For the few examples that have been documented, this is either because the catch data is used for taxing purposes or the estimated (reported) catch influences the license fee to be paid.

Instead of working with a fixed group of fishers, it is also possible to rotate the fishers that participate on a monthly basis. As long as fishers stay committed, there is no good reason to do this, since it will be easier to work with a fixed group of fishers.

The number of participating fishers that is required can be calculated based on the variation of catches and the required reliability of the resulting estimates (see section 4.3).

7.2.3 Design of logbooks

To minimise the work for filling out the daily log sheets for catch and effort, they have to be designed carefully and customised for each participating fisher separately. For example details for each fisher (name, gears and village) should be pre-printed. A monthly logbook should be prepared that has the data pre-printed for each day; this will ensure that fishers record non-fishing days as well as days without catch.

Normally a one page log sheet with information on effort (hours fishing), gears and species caught is sufficient. A list of species (in local riparian names) is normally included with tick boxes to indicate if a species is caught. Details on the weight and number of individuals (fish) should also be asked for. The species list is obtained by interviews with participating fishers and may contain species groups or even economic classifications or species grades with which the fishers are familiar.

The ease of use is very important and irrelevant questions should not be included. Although details on weather conditions or time of catching may seem 'nice-to-have' if they will not be used, then leave it out. Many small-scale fishers use several gears in different habitats, and may use a combination of gears during one fishing trip. If the unit of effort is simply fishing days, and participating fishers have been selected based on their main gear, it is not even necessary to record the gears and gear sizes used. The more questions to more likely errors will be made.

For most purposes the catch in weight and number of individuals by species and the duration of fishing is sufficient for the data to make the data suitable for catch assessment.

An example of a log sheet that was used for a survey in the mainstream Mekong River targeting small-scale commercial fishers is included as Annex IV, while a more general form (annex V) was used in a logbook survey for catch assessment of family fishing in a floodplain area in Cambodia.

7.2.4 Practical experience

Selection of commercial (small-scale) fishers is often done with the assistance of local fishery officers and village headmen who will identify people that are expert fishers, based on the time they have been fishing or because they are full-time fishers. These fishers are approached to come to a village meeting where the survey is explained. Further one-on-one interviews will reveal if the fishers are suitable participants based on experience, gear use and habitats fished. Suitable candidates are added to a list from which a number of fishers are selected based on catch/activity patterns (both full-time and part-time fishers are selected) and gear use and asked to participate.

In the case family fishing is the subject of the survey, households will be selected at random and one household member is asked to keep a logbook for the whole household. In some cases school children can be mobilised to record household catches as a school project. Catch assessment for family fishing using logbooks will be covered in section 7.3.5.

Fishers are always suspicious of government officials asking questions about catches. In most circumstances direct contact between fishers and fishery officials is limited and fears of taxation or catch restrictions may limit the amount of cooperation. Cooperation to a logbook survey should not be forced, as this may negatively impact on the quality of the data, and therefore fishers have to volunteer. This requires building of trust between officials and fishers, an essential but often slow process.

Logbook surveys require regular contacts between participating fishers and local fishery officials, who are responsible for explaining the survey, handing out logbooks, providing assistance and feedback and collecting the filled in log sheet books. Therefore they play a crucial role as they are often the only contact persons on issues regarding the survey. Therefore the fisheries officers should be thoroughly briefed and trained.

Even if the initial cooperation is high, there will be a definite decline in enthusiasm as the data collection continuous month after month. This can only be countered by having regular meetings with participating fishers and communities or by giving some bonus for those who stick with the survey. The best incentive for participating in logbook surveys (besides offering a small incentive) is to link it to participatory management initiatives.

A major problem often is that fishing trips/days during which nothing is caught are not recorded. These cases should be identified as soon as possible and clearly explained (again) to the fishers.

7.2.5 Estimation

The logbook survey will result in large amounts of data. The need for speed in producing estimates is particularly urgent to be able to give feedback to the participating fishers and to ‘supervisors’, the local fishery officers. Estimates for catch and effort need to be made every month. This is a relatively simple process.

For each fisher (logbook) the total monthly catch and effort is calculated, resulting in an individual CpUE for each fisher. The monthly results have to be handed back to the participating fishers in the form of a one page summary report for each month. The contents should be explained and discussed with the fisher. Any problems need to be discussed with the fishers as soon as possible. The average monthly catch and effort per fisher in the sampled villages can be calculated easily. If the total number of fishers in the village is known, this average can be simply raised to a village catch and effort. The average catch and effort per village can be average over all sampled villages and then raised for the whole area of interest, taking into account the spatial stratification, estimates should be made for each stratum separately and extrapolated for the whole survey area.

If on the other hand the selected unit is the fisher then the average for all participating fishers in each stratum is calculated and then raised to the total number of fishers in each stratum. Another approach is to calculate the production per habitat area. Catches in inland waters are normally associated with certain more or less distinct fish habitats. Each habitat has their own

fish assemblage and some habitats are only aquatic for a part of the year. Unfortunately this is more complicated than it would seem. Even if fishers can indicate where fish were caught, this does not mean that the fish were produced locally. In fact many floodplain catches constitutes of fish that only come to the floodplain for feeding or breeding. While on the floodplain they migrate in and out of different adjoining areas. Only when a relatively closed system can be found, is it possible to derive an estimate for the fish production per unit of area. This can then be extrapolated for similar areas elsewhere using GIS tools. In general this is not the task for a routine collection, more of scientific research.

7.3 Catch Assessment by means of Interviews

7.3.1 Introduction

Another approach to assess the catch is to have regular interviews with either fishers or key informants on the fishing activities. This can be used to obtain monthly catch and effort estimates.

Using the interview method for fishers is very similar to sampling for catch and effort using direct measurement. Interviewing middle persons or traders is a higher level approach that tries to estimate the fisheries production based on partial information from trade information. The latter approach is less reliable and often has less (species/effort) detail, but requires considerably less sampling effort.

Key targets for this method can be fishers, middlepersons, traders, import/export firms.

Although interviews may seem too unreliable for assessing catches, in many cases it may be the only feasible way, in the absence of easily accessible landing sites or in case there are no central or fixed landing sites. In addition, key informants like middle persons or traders often may have written records that can be used for catch assessment purposes. Interviewing fishers at the point of landing, where they sell their catch, and thus know the weight, the method could be as reliable as direct measurement of the catch by enumerators.

7.3.2 Stratification and Sampling

Fisher interviews

In an interview approach for sample catch, effort and prices, the enumerators work according to a schedule of landing site visits to record data. Enumerators can be mobile (that is sites are visited on a rotational basis) or resident at a specific sampling site. Their job is to sample vessels, obtaining data on landings, effort and prices from all boat/gear types that are expected to operate during the sampling day. The sample should be as representative as possible of fleet activities. Some additional data related to fishing operations may be required for certain types of fishing units, such as beach seines or boats making multiple fishing trips in one day. For these, the interview may cover planned activities as well as activities already completed.

In an interview approach for boat/gear activities, their job is to determine the total number of fishing units (and if feasible, fishing gears) for all boat/gear types based at a homeport and the number of those that have been fishing during the sampling day.

There are several ways of recording boat/gear activities. In many cases, they combine the interview method with direct observations. Direct observations can be used to identify inactive fishing units by observing those that are moored or beached, and the total number of vessels based at the homeport is already known, perhaps from a frame survey or register.

Often enumerators will still have to verify that vessels are fishing as opposed to other activities by using interviews during the visit.

The pure interview approach can be used in those cases where a pre-determined sub-set of the fishing units has been selected. The enumerator's job is to trace all fishers on the list and, by means of interviewing, find out those that had been active during the sampling day. For sites involving a workable number of fishing units (e.g. not larger than 20), the interview may involve all fishing units.

The stratification approach is exactly the same as for sampling surveys for catch and effort using direct measurement. Survey forms used for direct measurements can also be used for the interview method.

The advantage of this method is that it takes less time to obtain the information. In addition local residents can be recruited as data collectors. If fishers are interviewed at home it could reveal more information, also for fishers that do not land their catch, but instead market it directly at a local (fish) market, or who use (part of) the catch for fish processing.

The interview method (for effort) can cover a larger time period than the current catch, although it may not be possible to go back much further than a few days without jeopardising the reliability of the information. This additional information does increase the sample and thereby the reliability of the resulting estimates for the fishing effort. Most of the variability in boat/gear activity is in time rather than space, so by increasing the sample size without much additional cost, the reliability is increased.

Trader interviews

There are some examples of systems that rely on interviews of key informants. The viability of this approach depends on the existence of a marketing/trade structure that records transactions and is willing to share this data for fish production estimates. The coverage of the trade network is also important, i.e. if most or all of the landings are traded this method is convenient and reliable. Otherwise it may only be possible to obtain an indicator for the fluctuations in the total production. Trade data also provides information on trade networks and flows and for this reason alone is very valuable (see section 8.3).

Traders or middle persons may be resident, located and operating from a single or at a limited number of fixed landing sites or they can be wandering, depending on the supply of certain species or sizes of fish, over a number of landing sites. In most cases traders operate at a limited number of landing sites. The wandering traders often specialise in certain high value products, like shrimps or high value fish species.

Before information from traders can be used for catch assessment a complete picture of the trade structure, number of traders and area of operation needs to be established. This can be done by the marketing surveys described in section 8.3. This is similar to a frame survey

(census). If the middle persons are stratified according to their yearly overturn, then a random sample will enable to estimate the total fish production that is traded through this channel.

This method is very similar to sampling landings, with the difference that at landing sites only a few middle persons are operating. Instead of sampling from the pool with all landings, only the landings that are traded through the middle persons are included and several other disposal pathways are not considered (direct sale, marketing by fishers or family, consumption and processing).

Interviews with traders and fishers will indicate what proportion of the catch is normally traded through the traders. This probably depends on the supply, which in turn depends on the season. This proportion should be assessed every month to enable estimation of the total trade volume regularly.

In most cases it may not be possible to get species detail with this method, besides economic classes or grades of fish, or at best at an aggregated level. However this can be addressed with separate catch composition surveys for the appropriate gears or fisheries sub sectors.

7.3.3 Survey Forms

Since the approach is very similar to direct measurement of catch and effort, the same forms can be used to record the data obtained.

For trader interviews slightly different forms need to be used. This depends on the amount of detail available, but this will be very much a census approach for all trading activities within a given period. Therefore the form needs to have columns for economic grades or species, the weight and the location or source. If prices can be obtained, these can also be recorded.

The survey form that can be used (Annex VIIc) is very similar to the form that can be used to establish the trade volume at markets described in section 8.3, but can be adjusted to conform with local trader records.

7.3.4 Estimation

Since the interview method results in the same data types as with direct measurement the same estimation procedure can be used.

Estimation for the trade volume in a given area based on information obtained from traders is relatively straight forward. If information for a whole month can be obtained, based on trade records or on the results of a logbook kept by a trader, then the mean volume per economic or species group per trader can be calculated. The coverage of the trader should be carefully analysed, if the trade from a limited area (village, district, lake, reservoir etc.) needs to be calculated the location/origin information is essential.

Problems with coverage may arise, where traders are active outside the boundaries set for the survey or show overlap. This can normally be solved by aggregating the trade data to the next highest level. The trade volume from a certain area can be calculated using the mean trade volume multiplied by the number of traders for each stratum.

The estimate for the proportion of the catch that is disposed through the traders can be used to raise the traded volume to estimate the total catch for a given area.

The reliability of this method depends on the co-operation and honesty of the respondents. In order to establish the general reliability, both the interview method and the direct measurement method can be implemented concurrently for the same area or can be scheduled as regular verification surveys.

7.3.5 Catch Assessment by interview or logbook for households

7.3.5.1 Introduction

Similar to the method of interviewing fishers for their catch and associated effort it is also feasible to assess the catches (and effort) by means of interviewing households, on fishing activity levels, catches and effort. This is often done in fishery economic surveys where the catch for the past month or in some cases for the whole preceding year is based on recall interviews for average catches and effort.

Relying on the memory of people for something as variable as fishing can at first seem to be just asking for trouble. However provided certain guidelines are followed some surprising good results can be obtained.

The period over which information on fishing can be obtained with a reasonable reliability is depending on the frequency of fishing activities. If catching fish is an almost daily activity, the memory of one day will easily blend into another and essentially the only accurate information may be on the last fishing trip, and definitely not longer back than a week. If fishing is quite rare, then a fishing trip that happened a few months ago may still be fresh in memory. There are basically two options:

1. Interview individuals on individual or household catch and effort variables on a regular basis; or
2. Use logbooks to record catches and effort on a more permanent basis.

Interviewing households for catch and effort patterns is quite labour intensive and may not be worth the effort of implementing on it’s own except when trying to validate estimates obtained with another method. Often these catch assessments are part of a larger household survey for fisheries information that also looks at economic activities, landowner ship, household composition, consumption patterns, post harvest activities, etc.

Logbooks surveys for catch assessment for households are almost the same as those discussed for the small-scale fisheries sector in section 7.3. The difference is that the unit of measurement are not individual fishers, but instead all fishing activities of all family members are taken into consideration. This will include collecting fish by children, subsistence fishing as well as commercial fishing activities. The scope of the survey is similar and even similar log sheets can be used.

7.3.5.2 Stratification and sampling

Establishing the sample size (number of households to cover) and required calculations are very similar to those used for interviewing commercial fishers. However it is important to sample different household members, or interview all household members as a group. Just

talking to the household head, most often male, will give incomplete information, fishing activities by other household members will likely be under reported or excluded altogether. The same issue is important for logbook surveys. These should ideally be filled out by individuals covering their own fishing activities. Coverage for interviews and logbooks should be gender and age based. Both women and men and both boys and girls should be sampled separately, as each group will have separate fishing opportunities, which should be recorded and counted.

7.3.5.3 Survey forms

Since the interview and the logbook method are basically the same as discussed in section 7.2 and 7.3 the same log sheets and survey forms can be used (Annex IV and V).

7.3.5.4 Estimation

If household members are visited repeatedly over each period of one month, (or keep a daily log for all fishing activities) the series of observations for each household member should be considered separately. The average for each complete series of interviews should be calculated by fishing method and if collected by species and multiplied by the number of active fishing days. For family fishing this is often estimated. For logbooks the monthly catch and effort can be very easily established, by summing the fishing days and the catch.

There are two ways to estimate, by individual (separate by gender and age group) or by family unit, the household, with all individual catches (and effort) combined. The survey setup may already have selected the household as the unit and collected the data accordingly. Using the household is slightly more convenient for extrapolation, and will ensure a more robust estimate.

The individual catches (and effort) need to be calculated from the activity levels for each household member (group) and the associated catches. The total extrapolated catches for each household member can be combined into a figure for the household.

There is a distinct difference of considering all discrete observations as independent values to grouping the observations per unit (household) over a given time frame. A household will likely fish in similar patterns over any given time frame, that may or may not be equal to that of other households. Although the catch on any day is independent from catches on other days, the catches for each unit (fisher or household) are related to skill, habitat fished and gear types used as these differ from one unit to another. If the basis of calculations will be the measurement unit (household) then it makes sense to estimate the catch for individual households first and then consider the (household) estimates for average catch and effort for discrete units (household and fishers) as independent variables.

The data obtained will produce a value for the mean catch and effort for the fishing unit. This estimate can be easily raised to obtain an estimate for the total production for each stratum.

Either way there should be a measurement for the amount of error so that the resulting data can be adjusted or evaluated in relation to the expected error. The real catch can be assessed only by direct measurement. Selected households are randomly visited for a number of days to measure the catch for a particular day; catches are grouped by fishing method.

The average measured catch is then compared with the average catch obtained through recall and the difference can be expressed as the average error of the interview method.

Although assessing the average error should be done for every fishing method separately and in different fishing seasons (most notably the wet/flood and the dry season, for inland fisheries), the estimates for the error can be used for a number of years, unless there is a major shift in fisheries, in terms of participation, gear use or habitat exploitation.

In comparison with the classical catch/effort surveys, where each survey was independent, and where exact counts are made of active boat/gears and total number of units, this approach may seem a bit coarse and unreliable. Estimation of household catches will come with a large variation and several assumptions on average activity levels, household size and access to resources need to be made to be able to allow estimation. For the small-scale family fisheries this is the only feasible way of estimating the fish production based on catch surveys. The other method uses fish consumption surveys that will be covered in detail in section 9.1. In most cases the amount of error can be kept within reasonable limits with a good survey design and well-trained data collectors and supervisors.

Recommended further reading

There is no shortage of texts dealing with collection of catch assessment, although only a few are general enough to be useful.

Reyntjes, D., 1997. Handbook for Fisheries Officers. Lake Fisheries Development Project Phase II, working paper No. 24, 92 pp.++

Stamatopoulos, C., 2002. Sample-Based Fishery Surveys - A Technical Handbook. FAO Fisheries Technical Paper: No.425, FAO Rome, 76 pp.

There are a number of publications available that list and describe fishing gears (and gear categories). Below some examples are give. In late 2003 the MRC will publish a gear catalogue for Cambodia.

Claridge, G.F., Thanongsi Sorangkhoun and lan G. Baird (1997). Community Fisheries in Lao PDR. A Survey of Techniques and Issues. IUCN – The World Conservation Union, Vientiane, Lao PDR.

FAO, 1987. Catalogue of small-scale fishing gear. Second edition, revised and enlarged by J. Prado. Farnham, Surrey, U.K., Fishing News Books Ltd. 223p.

Nédélec, C. and J. Prado, 1990. Definition and Classification fishing gear categorizes. FAO Fisheries Technical Papers - T222Rev. FAO Rome 92 pp.

Species information and pictures are available from the FAO Species Identification sheets, the MRC Mekong Fish Database 2003 for inland species (that can be ordered at *www.mrcmekong.org*) and ICLARM's FishBase, that is available on-line at *www.fishbase.org*.

8. Economic Surveys

Data on economic variables is useful to be able to measure the (economic) performance of the fisheries. In section 2.3.2 some variables and indicators were discussed. It does not make much sense for most of the inland and coastal fisheries to collect in depth economic data on a routine basis and often this is left to research studies. However some coastal fisheries are highly commercial, as are some of the larger scale inland fisheries and an economic analysis has been done for the Dai (or bag net) fisheries in Cambodia. However in most cases there is little management to appraise (the main objective for any economic analysis), and therefore the primary objective of economic data for most fisheries is to assess the importance of the fisheries in economical terms. These can be described by the net worth of the catch and the level of employment.

Information on trade is important to be able to assess the importance of specific fisheries for export or food supply to other parts of the country. Food security is also an economic issue, if not enough cheap fish protein can be produced then other protein sources have to be used, that are often more expensive, including cultured fish. Loss of fisheries production therefore has a certain cost, the replacement cost of fish protein.

8.1 Fish Price Surveys

Fish prices are essential for calculating the value of the fishery. Fish prices are available at several levels:

1. Price of first sale, when the fisher sells the catch at a landing site to a middle person or directly at the market;
2. Whole sale price, at large markets where the fish is sorted and marketed for transport to regional centres; and
3. Retail price, fish price at the market, in a shop or restaurant.

Fish prices should be recorded at different levels because it is important to know what the fisher receives for his effort, as well what the price is for the consumer. Since fish price differs for different species, the price should be collected by species and/or by quality of the fish. In a commercial fishery anything between 100-200 different fish species may be marketed on a regular basis, but in most cases a list of around 40 species can be compiled that are the most important species in terms of importance (volume or price) in the markets at all times. Fish that only rarely are marketed can be left out. If the fisheries department is unaware of which species may be important, the main information source for the occurrence and importance of fish species are people working in fish markets or the fishers themselves. Sometimes the size of the fish is also important. In all cases different fish products should also be included. All prices should be expressed by kg, even though the unit by which it is sold may be otherwise.

A special area is formed by the estuarine area where the inland riverine zone and coastal zones meet and estuarine species abound. Separate lists should be available for inland and coastal species. In those areas where both marine and freshwater species are marketed both lists should be covered. In some countries where the same species is available from culture and the wild, the prices for each can be separately monitored.

It does not make sense to perform random sampling of traders or fishers for prices. In general prices used for price indexes are based on "purposive" or judgment samples, where the sample is selected on the basis of the knowledge and judgment of staff compiling the index.

- Factors other than sales volume are important when selecting species and/or fish products and respondents. These include availability of prices on an ongoing basis, degree of price dispersion and the pricing behaviour of respondents.
- Judgement sampling is more practical in the day-to-day operations of price collection, where items and respondents regularly need to be replaced.

This means that a number of key informants should be identified that are regularly revisited. If the right respondents are involved the prices that are collected will be correct and reflect the market prices at each level. Note that it is necessary to obtain an estimate for the average price to be able to monitor price fluctuations and to be able to calculate margins (profits).

Some knowledge on the marketing process, trade flows and important products is required to be able to select respondents and items to be monitored.

The fish price should be collected on a regular basis, at least every month, but better every week, on randomly selected days, as not to collect prices during the same days every time. During some periods and for some species a daily price survey may be appropriate since during peak catches, the price for some species may fluctuate wildly in response to supply and demand. If possible prices should be collected by questionnaire; still some samples have to be taken to check the returned data on a regular basis.

The price for fish should be collected at landing sites, whole sale fish markets, city retail markets and in shops and restaurants. It is recommended to cover both urban and rural markets as the prices will differ from place to place.

If other departments already collect price index information, then this information can also be used, or some fish products may be added to the price index. Note that for fishery purposes a price index is not required, as this normally focuses on inflation calculations for a standard package of goods.

In many cases it is found that fish prices form clusters with certain species almost always sold for similar prices. In those cases it is possible to reduce frequency or the number of categories (species/quality grades) for which prices are recorded.

8.2 Employment

Employment opportunities in a sector indicate that the profit margin is high enough to allow wage labour and still make a profit.

Information on employment in fisheries can be obtained from official labour statistics, but often only for larger commercial fisheries, that pay taxes, this means that in order to get the whole picture surveys need to be done, depending on the state of the existing statistics.

There are two possible approaches:

1. questionnaire for commercial fisheries and fisheries related companies (trade and processing)
2. sample survey interview survey

If the sector is highly commercial then the questionnaire approach is feasible as most companies will be registered in some way, if only in tax records. In case of self employed fishers the situation is slightly more complicated, although this can be addressed through 'official' statistics on primary occupation. These are available in many countries. Unfortunately this will only include full-time fishers and not those that may be self employed in fish processing or marketing.

The interview method is very labour intensive, and is not really an option unless the amount of commercial operations (including single fisher operations) is very limited.

Because of the relative low effort involved questionnaires are normally used as a census instrument. This means that all fisheries and fisheries related companies should receive a questionnaire with a few simple questions on workforce, full-time and part-time employees. Unless the year the business started is not included in the registry, it is not necessary to ask for this.

If there is no registry available the information on fisheries and fisheries related companies needs to be obtained from key informants, trade federations, cooperatives, fisheries officers and village or community leaders. In fact conducting a village fisheries census by means of questionnaires may be one way to obtain a lot of valuable background information on involvement and activities.

Most fishing companies or trade or processing companies will probably not have much experience with receiving and filling out questionnaires, therefore it is necessary to keep as simple as possible and provide ample explanations. It is not possible to visit all companies in person to explain the questionnaire and the objective of the survey, so this should be explained on the questionnaire. An example of an employment questionnaire is included in Annex VI.

Besides wage labour employment, which will be rare except for middle scale commercial fisheries, involvement or self employment may be of interest and this will be covered under livelihood statistics in the next section.

8.3 Trade patterns

Trade patterns refers to trade of fish and fish products in terms of export and information on this is often available from tax departments and trade departments, although the amount of detail is often insufficient to allow detailed analysis assessing export earnings, cost of importing for example fishmeal for use in aquaculture or fish products for human consumption. Species detail will not be available at this scale. The FAO produces regular food balance sheets that are an important instrument in analysing food security issues.

To fully understand the importance of fisheries for rural and national economies a certain understanding of the flows of fish and the amount of inputs of capture fisheries outputs into other industries, including aquaculture are essential.

Currently there is virtually no info available on movements of fish (quantity and direction of flows).In most countries there is a good deal of information on the basic nodes of the marketing structure, i.e. the spatial distribution of markets, both whole sale and retail is fairly well

documented. In contrast information on traders (middle persons, companies) and transporters is at best very dispersed and therefore only limited information is available on domestic marketing volumes. What is available is mostly based on anecdotal information and is not well quantified.

To be able to obtain meaningful information on marketing objectives for three different levels of information need to be considered:

1. Identification of the main components of the spatial structure of the fish trade network;
2. Quantify market flows that can be represented in GIS terms; and
3. Identification of significance of the main components of the social structure of the fish trade network.

A number of marketing related survey formats, or questionnaires have been included in Annex VIIa thru VIIc.

8.3.1 Marketing Structure

If the information on markets is not available at a central level and cannot be obtained from existing sources than a survey to establish the location, size and type of markets and other trade nodes is needed. This is rather straight forward and can be done using questionnaires or interviews that target key informants at provincial or district level.

The survey should focus on location and size of

- Landing sites/ Ports
- Markets small and large
- Processing Companies
- Collection points
- Transport Companies

Size should be expressed in terms of numbers of employees/traders and volume/value traded per time unit. The survey should also try to establish the type of nodes and establish what percentage of the business is fish related. Some transport companies will specialise in fish only part of the year as fish supply is extremely seasonal, especially for inland areas and is closely related to the flood season. The main objective is to provide information, a frame of all marketing nodes, to enable the planning of more detailed studies into the actual marketing volumes.

It may be required to repeat this frame survey during different seasons, depending of the seasonality of fish supply it is likely that the importance of trade nodes and indeed the location of trade nodes themselves may change between times of large supply (flood season) and the period of low supply of wild capture fish (dry season). In addition aquaculture is in many cases a major actor in the trade network as it is an input oriented production system, in which inputs from the wild capture fisheries both in terms of fingerlings or food fish can be quite important. It is calculated that in some seasons as much as 70% of the fish feed is fresh fish from capture fisheries operations and this is an important factor to take into account.

Therefore a few more nodes may have to be added depending on the importance of the aquaculture sector:

- Fish Feed Companies
- Private Hatcheries
- Government Hatcheries

8.3.2 Marketing volume

After the spatial structure of the marketing system is established the next step is to quantify volumes of fish and fish products, their origin and destination. As a first step a few key markets should be selected. The objective is not to be able to estimate the marketing volume for all markets of all sizes, but simply the main flows and in this way identify key fish transport routes that are essential for the local economy.

The best approach for this purpose is to issue logbooks to selected traders at markets and ask them to record transactions (by weight), origin (location and sector: marine/freshwater, capture/culture) and where possible destination.

This methodology will not work unless the respondents have trust that the information they provide is only used for the quantification of marketing volumes and not for taxing or licensing considerations. Therefore the logbooks need to be anonymous, with only the market location indicated. An example of a marketing log sheet is included in annex VIIc.

In order to be able to quantify the importance of markets quantification of trade between markets or the price differential between the various markets and traders is required that can then be represented in a GIS there are several options available:

1. Assign a relative position to markets (local, district or provincial market) mainly based on differences in prices between markets and other more qualitative information, such as type of market (fresh good market or mixed good markets) and connections with other markets (direction of trade flows);
2. Flow of goods in the form of lines relating to the quantity of trade going between the various markets; and
3. Number of traders that are trading to different markets, again in the form of value specific lines between markets.

For the last two methods it is necessary to have a census of the numbers of traders from all of the markets to give a complete picture of the flow of trade for the province. Alternatively, major markets in the province can be identified and the targeted by the survey, after they are identified in the frame survey for existing markets.

Many traders develop strong relationships with suppliers, either fishers or lower level traders due to provision of credit either in money or in goods and services. Although many traders do work on a full-time basis it must be emphasized that there where the fish supply is highly seasonal many opportunistic traders will occur. These are difficult to identify, but may be of major importance for the efficient distribution of such perishable commodities as fish and fish products. Therefore it may well be a better approach for questions on marketing to be included in socio-economic household surveys.

Local people generally know where the fish traders are, and there is no problem in finding them. Local level small traders specialise, bigger traders are less specialised i.e. they will sell/buy everything.

Economic classifications may change by season or year, by trader (level of trade) and species (quality classes) and so species detail may or may not be available at all, or at best only part of the year.

Establishing the importance of marketing nodes and identifying the main routes is essential for selection of the nodes that should be monitored more closely by logbook surveys to enable quantification of the trade flows. Unless those participating in the logbook system are sampled at random or are assumed to be representative for the market they work in the resulting data cannot be used to estimate the total volumes with great accuracy. Therefore the participants in the logbook survey have to be selected carefully and a raising factor established to estimate the overall trade volume.

It must be emphasised that methodologies for market surveys are not standardised and the actual design needs to be adjusted to the level of detail that is required. There are two additional approaches for obtaining more detailed information that are beyond the scope of this handbook

1. fisher survey
2. market manager survey

Although trade companies can be very good sources of information, often they specialise in the top end of the market and may focus mainly on export markets and their information may be limited on trade with other companies.

Finally a few suggestions of some importance:

- it is better to concentrate on a few traders at key locations that have contacts with middle persons
- use of combinations of logbook + questionnaire (for obtaining details on background of trader) to get spatial information on trade flows:
  - ownership/value of assets
  - distinction between local marketing (trade) vs. 'export' oriented trade
  - use of credit for time/resources/goods (bartering)
  - pricing of fish and fish products, and how they are determined
  - actual categories traded

9. Livelihood Data

Livelihood data or socio-cultural data are very important to be able to understand the importance of fisheries in the daily lives of people. Two main categories of information are required:

1. Distribution of fish consumption; and
2. Involvement in fishing activities.

In general these surveys are not performed on an annual basis; instead they are performed every 3-5 years (or sometimes on an even longer time scale). The reason is that information stays current for longer periods than the highly variable catch and effort, besides the cost and effort that is involved in obtaining this information is quite high, so most departments will not be able to afford these studies on a regular basis.

9.1 Fish Consumption surveys

Fish consumption data is important for a variety of reasons:

1. Consumption is a large part of the total catch or yield (especially in inland areas), and so is a good indicator of the value of the fishery. If the value is higher then the fishery is more important and thus it should have more weight in policy and planning in relation to water resources;
2. In terms of food security, the total amount of fish and other aquatic organisms in relation to other protein sources indicates the reliance on fisheries in different areas and the nutritional impact that changes to these areas would have; and
3. Fish is also highly nutritious, with amino acids in the optimal proportions for absorption and use by our bodies. Fish also provide a large degree of calcium.

There are three main methods of collecting information to measure household food consumption:

- Intake surveys
- Direct measurement
- Expenditure

These methods area usually carried out at great cost and require highly motivated enumerators, all the more reason to do it properly and accurately. Consumption studies are very specialized surveys. It is possible to get very accurate results, although this is not as straight forward as getting catch and effort data. Conducting the survey properly requires a lot of training and skill.

Intake surveys are the most common method applied and is better known as recall surveys. They are often done at different times of the year, like wet and dry season for inland areas. Recall surveys ask for estimates for different food items. This not the best approach, even if a relatively short period is considered, like the consumption in one week. This form of questioning does not take into consideration variation within the wet and dry season, intra-household variation, cultural or social variation, and geographic distribution. As such this method may produce highly inaccurate estimates. Other methods are the use of logbooks or direct measurement of consumption.

There are basically two practical methods to obtain consumption data, using interviews based on recall, or using logbook systems where a family member has to write down what quantity was caught, bought and consumed in what form (processed or unprocessed). Often these studies are either done over an extended period, often 12 months either continuously or in blocked visits. Overall these are considered to be far more accurate. These studies are however intensive both in terms of time and effort. Direct measurement is in many ways the most reliable method, but very labour intensive and therefore expensive.

The interview method can be conducted on different time scales, from a once a year estimate down to daily estimates. It is important to return frequently enough to be able to cover different seasons. It is not necessary to return on a weekly basis, as long as the differences between the main fishing seasons are well defined. The minimum period to obtain meaningful statistics is determined by the required reliability. A daily interview will obviously be more reliable than weekly or monthly recall survey, i.e. an interview covering the previous day, week or month. The consumption should be sampled at random moments during each period

of interest (fishing seasons), to estimate the mean consumption for that period instead of trying to do a census.

The best approach is to have regular visits in different parts of the year where households/individuals are interviewed on meals in the last 24 hours, as well as asked for an estimate for a standard period in wet and dry seasons. By at the same time actually measuring the meals, the recall estimates can be compared.

There are a number of ways to calibrate the results, these include comparison with:

- Fishing activity and catches;
- Other yield estimation methods;
- World figures for consumption; and
- Consumption by expatriates (in another country) from the area under consideration.

Since the fishery sector for which the consumption method is applied often is not covered by other catch assessment approaches there has been very limited cross-checking. Besides since catch assessment is so difficult for family fisheries, the estimates that are obtained may have a large error margin and thus are not always reliable.

For monitoring, interviews alone are not enough unless the accuracy of the method is known first. Being able to put a definite value on the error will increase the credibility of the final estimate for the consumption and fish production based on the interview or logbook method. So far nobody has been calibrating interviews against measurement, although this is currently attempted by the MRC Fisheries Programme.

Important considerations for consumption studies are conversion factors of processed fish products to fresh fish weight and protein content calculations.

Consumption studies need to look at different sources of animal protein, not just from fish, but also from beef, pork, chicken, eggs, insects etc. In addition different processed fish should be included, such as fish paste, dried fish, fish sauce etc. For these different types of fish products, conversion factors should be used to calculate the weight as fresh fish weight. It is not sufficient to list the amount of different types of processed fish in fresh fish weight; there should also be an estimate for the amount of protein and the quality and type of protein.

These conversion factors need to be established in experiments, or should be taken from standard tables. Unfortunately in many cases the conversion factors for different types processed fish will also differ by species and the exact type of processing. Although certain countries have produced comprehensive tables with conversion factors these often do not include special types of fish processing as they are found in South-East Asia. This means that countries need to establish the conversion factors themselves for products like fish paste, prahoc, etc.

The use of the proper conversion factors is essential. There may be different types of fillet or fish paste and each should have their own unique conversion factor. Different species, sizes, and even fish caught in different seasons have different fat/protein content and this can influence the calculations.

Expenditure surveys take a more economical approach and assess the amount of money that is spent on different food items and other household expenditure. Many countries perform

expenditure surveys and these can, if they contain fish and fish products as food items often be used to assist in fish yield estimates.

There is not much information available on methods for fish consumption surveys for inland areas and for coastal and marine fisheries the situation is even worse. In the following pages some further details are discussed in relation to appropriate methodologies.

9.1.1 Production/Yield Estimates using Consumption Surveys

Estimating total fish yield (per year) is based on multiplying per capita consumption by the population for each province or district, a method that is gaining greater acceptance in largely artisanal fisheries (Bayley and Petrere 1989; Crispoldi 2000).

This method is especially appropriate for small-scale and family fishing operations, in particular in inland fisheries where it is often the only method available that can provide a reliable estimate for the fisheries production for family fisheries where most of the catch is consumed in the household

Estimating production from per capita consumption is considered one of the more accurate methodologies within inland fisheries (Bayley and Petrere 1989; Crispoldi 2000). This method depends on accurate population data and a relative high level of subsistence fishing. Although a useful method its main shortfalls are derived from the complexity of inland fisheries, the lack of knowledge that exists regarding imports and exports of fish and other aquatic organisms (Bush, 2000; Bush 2002) and the inaccuracies and errors involved in consumption data collection.

The general methodology for logbook surveys is covered in section 6.2.4.1. The logbook method used for catch assessment using fish consumption is similar to the one that can be used for fish consumption (section 9.1). As with other logbook surveys, this can be very reliable if some basic guidelines are followed.

In general some comments on using consumption for yield estimates and for surveys of small-scale and family fisheries in general can be given (Hortle and Bush, 2003):

1. It is important that the methodology is standardised and, as with all surveys done, a Quality Assurance Plan (QAP) is required to ensure comparability of the survey results and high quality data that is acceptable to fisheries scientists and fishery economists too;
2. Focus on the information available in the fisheries. Fewer data of good quality are preferable. Catches usually are dominated by five species at any location (50-80%) of total weights), so records of their catches and weights suffice;
3. Simple questions, which have categorical answers, are less prone to error than questions that require estimation. In the case of assessing involvement it is easier to assess the type of involvement than the level (in hours/days or percentage of available time);
4. Categories of catches or foods should be standardized as far as possible with particular attention to Other Aquatic Animals (OAA), that are very important for consumption in small-scale and family fishing. OAAs can be best categorised taxonomically (separated into vertebrates/invertebrates and then classes) and by habitat: aquatic, amphibious and terrestrial;
5. Visual aids should be used in any interviews. Particular, a comprehensive set of photos is needed for OAAs where there is much confusion over terminology and definition;

6. Quantitative annual data including consumption and catches may be obtained by interviews, but their accuracy has never been validated. Intensive studies to compare actual catches and c against recall would be invaluable for calibrating results. Accuracy can be improved by using portion size estimation aids PSEAs. See e.g. Mitchell et al. 1996; Sechena et al. 1999; Shimìzu et al. 1999; and Swindale and Ohri-Vachaspati, 1999);
7. Consumption on certain days may be high for cultural reasons. Consumption may also be clumped seasonally and over short time periods because high fish or OAA catches are obtained under particular environmental conditions (e.g. 'elating to flows or lunar phase). Any longitudinal time blocks of 2 weeks. Ideally some studies would track families daily for a year so that the results could be used to examine variance and define the optimal sampling frequency and duration; and
8. Any survey performed should be well documented and properly published, as to make it available to a wider community.

9.1.1.1 Stratification and Sampling

Consumption studies are normally conducted in small areas with limited coverage, but it can range from a few villages to an area covering one or several provinces. The results of a small area can be extrapolated over a larger area provided the characteristics of the fisheries (and consumption patterns) do not differ significantly. Alternatively a larger group of people can be interviewed sampling a larger area, whereby stratified sampling is appropriate.

Representativeness has been addressed to some extent in most studies done so far, by applying stratification, but bias, completeness and comparability, which should all form part of the sampling plan are rarely (if ever) mentioned in reports for consumption studies. There is little point in accurately stratifying if your method of measurement has unknown precision and bias, or if you get very incomplete data, or if your results cannot be compared with those from other studies or countries. Therefore consumption methods should be standardized for a country or group of countries, and the bias of the sample as well as the error of the estimate should be calculated.

For logbook surveys the person who prepares the meals will have to keep the logbook and weigh or estimate the weight of each protein source. For the interview method the best way to go about this is to use standardised meal sizes. This involves the use of pictures with standard dishes and portions of different sizes and to assess the consumption in an interactive way.

Consumption varies considerably and the variance can be quite high unless some rigorous stratification is applied (both in space and time). For inland areas, a convenient stratification is between urban and rural areas, that often have different consumption patterns, as well as between different 'habitats'. Villages within close proximity to a fishing ground will have more fishing activities and higher fish consumption than a similar village further away from water resources that can be fished. For floodplain systems, the stratification could also follow the edge of the average flooded area, or this could be distinguished as a separate strata. Stratification between fishing vs. non-fishing rural areas may be difficult, as this assumes some information is already available. Even if it is, these areas may be difficult to separate with sufficient certainty. This can also be done retrospectively if any significant differences in consumption patterns are found between areas or based on the replies on fishing frequency.

Household wealth is an important factor in consumption of animal protein. In general rich households will eat less fish and more protein from other sources. Big households, i.e. with

many children, may have a low per caput consumption, but with a fishery resource nearby more people are available to catch and collect fish and other aquatic organisms. If sampling is truly random, than this will already be covered and should not give a bias in the estimation or problems with extrapolating.

The amount of fish consumed will depend heavily on the availability of fish. This means that the consumption of fish will be higher in periods with a large supply of fish or other aquatic organisms. If the consumption is used for catch assessment then it is necessary to run the survey for a whole year to identify seasonal differences in protein intake. This will greatly enhance the reliability of the estimates. Running the survey for only a month carries the danger that this period is not representative for the whole year. That is the reason why in many cases, logbooks are preferred over interviews. With logbooks it is possible to get a census of the fish consumption over a longer period, from one month to a complete year. Keep in mind that logbooks are far cheaper than deploying enumerators. However, if the main fishing seasons are known then it is also possible to take a few random samples from each season and thus reduce the required sampling.

The sample size can be established based on the size of the total population and the variation in the mean consumption of fish. This can be established by means of a household survey or taken from previous studies in similar areas. Including species detail is possible but this will increase the sample size considerably. This can be minimised by formulating wide species groups for which the consumption is estimated. Logbooks are more suitable for assessing species detail, alternatively separate surveys could be done to establish the main species consumed in different areas and seasons.

9.1.1.2 Survey forms

Consumption surveys generally cover both fish protein sources and other animal protein sources. To establish the yield based on fish consumption other protein sources can be disregarded, which simplifies the survey form considerably, however adding these does not add too much to the workload and may be useful for other sectors.

In general the species consumed will be known for fresh, smoked or dried fish. Using the interview method, it is unlikely that precise quantities per species can be obtained. This is best reserved for the logbook approach or even a limited scope direct measurement survey. Especially where the fish is bought, and where it is cultured by the household the species detail is relatively easy to obtain. However in the case processed fish is being consumed, the species composition may be obscured, especially for fish paste or fish sauce.

An example of a catch assessment interview format for consumption is given in Annex VIII.

9.1.1.3 Estimation

The total yield can be estimated as:

$$Yield = Consumption - Imports + Exports + Animal\ Feeds + Waste + Aquaculture\ Feed - autotrophic\ component\ of\ aquaculture\ fish\ consumed$$

The values for the terms in this equation cannot be entered with certainty, but for inland fisheries the following points are worth noting (Hortle and Bush, 2003):

- Imports of marine products are excluded from the consumption studies, and imports from adjacent basins would be very minor, so there is no necessity to subtract imports from the figures.
- Exports from river basins, especially those that are still relatively healthy can be significant. For the Mekong huge amounts of *Pangasius* catfish from the delta are 'exported' to other parts of Viet Nam and to other countries, and fresh and processed fish from the Great Lake in Cambodia to Thailand and other countries. It is likely that exports exceed imports.
- Animal feed (i.e. fish used as feed for livestock) and waste are unknown, but are certainly at least an additional 10% per year.
- Fish feed to aquaculture is generally for snakehead and catfish cage culture. For snakehead, the conversion factor of wild fish to aquaculture fish is approximately 4:1 (i.e. 4 kg of wild fish produces 1 kg of snakehead). For catfish the conversion factor is approximately 1, because the fish are fed about 50% rice bran, about 25% marine fish and 25% small freshwater fish. Some other fish used in aquaculture (carp and tilapia) provide autotrophic production, but are assumed to be minor.

Taking the above into consideration, the yield could be higher than just the consumption, depending on the area under consideration, perhaps by as much as 50%,

To be able to do make the above calculation, some additional information has to be available or collected simultaneously:

1. Some measure of the origin of the fish consumed is essential:
    a. At the very least it is essential to know whether the fish consumed is freshwater or marine. In many rural areas in South East Asia, people eat a lot of marine fish, especially the smoked Indo-Pacific mackerel (Pla Too in Thailand) is a favourite food fish due to its low cost;
    b. A distinction should be made between capture and cultured fish; and
    c. It may also useful to know if the fish was caught, bought or received as gift.
2. An estimate of the amount of 'import' and 'export' of fish and fish products from the survey area is useful to calculate the fish production sample, although not essential if information on the source (caught, bought, gift or cultured) is obtained;
3. The amount of fish used as inputs into aquaculture feed (and animal feed) and the local aquaculture production should be available from fisheries statistics; and
4. Total number of households or number of household members in the survey area should be available from population census results.

Provided the sample is representative for the whole area covered by the survey, above will be sufficient to be able to calculate the production balance in which the production from aquaculture facilities should be subtracted from the estimated production based on consumption patterns, to get a pure estimate for the capture fisheries production.

In case existing data is used to estimate the yield for an area, it may be necessary to fill up missing provinces/districts with existing data for neighbouring areas. Bush and Hortle (2003) give some general guidelines on this:

- Extrapolate common figures across upland provinces and lowland provinces;
- In case similar figures in surrounding provinces are encountered, averages of those provinces were can be taken; and

- If no link of pattern is apparent (based on population or geographic features) the lowest figure for the whole area or country can be taken to stay on the safe side.

9.1.2 Fish Consumption Distribution Surveys for Food Security

In contrary to the previous section, the main objective in a socio-cultural sense is to assess the relative fish consumption, relative to other animal protein sources, and to rate the importance and to assess the preferences and distribution of fish over different social, age and gender groups.

The methods used (interview or log book) are the same as mentioned for the yield estimate survey, but since the objective of the survey is slightly different, a different emphasis should be put on the sampling. In addition, it may be required to target individuals, if indeed the distribution of fish for individuals will be assessed.

Fish consumption surveys for distribution of consumption would perhaps be conducted every 5-10 years. Often these surveys are imbedded into socio-cultural household surveys and these normally will ask for consumption patterns over a long period, sometimes a whole year, other times for seasonal consumption patterns. This approach is criticised as even though quantification may not be the main objective, depending on recall for periods of longer than a few days will simply result in guestimates even for relative consumption. In some cases households are revisited regularly to obtain information on a few randomly selected intervals, over different seasons.

The same considerations as for yield estimate surveys apply; there is no substitute for a long term study with regular revisits or a long term logbook approach. In interviews, some people will be able to estimate the amount consumed better than others, but will on average under estimate the consumption, or be influenced by the last meals. These may or may not be typical for the average consumption.

Consumption studies are often considered to be outside the expertise, or jurisdiction of fisheries departments. However unless general consumption studies can be found that contain sufficient detail on fish consumption, there is no other choice but to perform a dedicated fish consumption survey, with general coverage of other protein sources.

9.1.2.1 Stratification and sampling

The stratification is the similar as for the consumption survey for obtaining yield estimates, and will not be repeated here. The sampling approach however may be different; this depends on the exact objectives of the study. If the consumption patterns for individuals need to be assessed, then although the household can form the basis of the survey, the consumption of different household members has to be separated. This means that more samples will be required to counter the increased variability of individual consumption as compared with that of a household.

9.1.2.2 Survey forms

The emphasis in consumption studies is on establishing the amount of fish consumed in relation to other protein sources. This means that instead of focussing solely on fish and fish products, other categories have to be included as well.

The logbooks and survey forms should have a list of different protein sources included, the list included should cover all possible categories of fresh and processed fish. The amount of writing should be reduced to the minimum, categories could include:

- Fresh fish
- Fish paste
- Fermented fish
- Fish sauce
- Smoked fish
- Dried fish (incl. salted)

It is important to get an impression of the origin of the fish, especially:

- freshwater or marine fish
- bought, caught, or received as gift
- wild capture or culture fish

The other protein sources can be lumped a bit further:

- Beef
- Pork
- Goat/sheep
- Poultry
- Hen Eggs
- Wildlife (not aquatic)
- Insects (not aquatic)

Again the categories should be adjusted to include only the categories that are expected to be consumed in the survey area. The units used should be logical for the type of protein source, i.e. litres for fish sauce, number for eggs and weight for most other categories.

Although the species consumed are not important for comparison of relative protein consumption, this may be important for catch assessment. If the same survey will be used for both consumption and catch assessment it does make sense using the same general survey approach, or even try to combine reaching both goals with one survey.

9.1.2.3 Estimation

The estimation of fish consumption by different social, gender and age groups is much less complicated than the estimation of yield. Basically the average consumption for each group that is recognised in the survey should be raised to the total number of members of each group in the survey area. This number is available from census data, or can be estimated from household survey information.

The same considerations apply with regards to conversion factors as mentioned in section 9.1.

9.2 Involvement in Fishery Activities

The distribution of the workload of fishing and fishing related activities is an important part of the socio-cultural puzzle. Different social, gender and age groups are influenced differently by policies or management, and the potential impact should ideally be evaluated before implementing policies. If detailed information on livelihood strategies is available, then this

can be used to assess the likely impact of policies and management measures on different socio-cultural groups.

The reason for collecting this information is:

1. establish the importance of fisheries and related activities in the daily lives of people
2. establish the importance of fisheries in relation to other activities
3. establish the livelihood options socio, gender and age groups have
4. provide the basis for predicting the behaviour of different socio, gender and age groups

Involvement in fishery and related activities is normally assessed in household surveys in individual interviews, but there is not really one right approach to assess this:

1. rank activities according to the amount of time spent
2. rank activities according to income generated
3. rank activities for food supply

Although in theory it is also possible to use logbooks to get this information, it is seldom done this way. Recording the importance or involvement in activities is quite complex and can be best done using an interactive process using interviewers.

Many activities may be seasonal and hence the temporal variation may be included either in a one-off approach or by repeating the survey in different seasons. For inland fisheries the main two seasons are the dry season and the wet season, but for rice culture based communities there may be more 'seasons' depending on the intensity of rice culture (irrigated vs. rain-fed rice culture). Especially the planting and harvest periods are highly specific.

Ranking can be done using a qualitative scale, like high importance, medium importance or low importance if the main objective is to gauge the variation of involvement between different periods over the year. Alternatively the amount of days a certain activity is undertaken per month or the percentage time spent can be used if the involvement between activities need to be compared. In any case this has to be standardised for all surveys, so they can be compared properly.

Every person should be asked if they are involved with each activity. Do not assume that a person does not do a certain activity (except for "student", "child at school" categories for older persons that will no longer be attending schools). It also should not be assumed that children do not do a certain activity. For example, even very young children can be involved in professional fishing (for example by helping their father).

It is important to understand the distinction between 'activities' and 'profession', especially when talking about fishing. Gathering aquatic animals is usually not considered a fishing profession by people interviewed. Note: in most languages there are very different terms for fishing as a profession and to fish – with very different connotations. Incorrect translation would undermine the whole survey process:

- "Professional fishing" means fishing commercially as a major activity (at any time of the year), that is - going out and catching fish for profit or income; and
- "Other fishing and collecting aquatic animals" means all other fish (etc.) catching and gathering activities. Note: this includes the setting of "passive" gears such as traps which still operate as gears even if not attended to by the person at the time.

There may be other more specialist activities that can be added, in relation to trade and marketing, and the general categories covering these may be split up in their composite activities if required.

9.2.1 Stratification and sampling

Activity patterns will differ significantly between urban and rural areas. While many people in cities will have be involved in wage labour, most people in rural areas won't, although there are a few exceptions when processing or manufacturing plants are located in rural areas. For fishing and related activities, the availability of fishing grounds is essential. However even if water resources are plentiful, the level of fishing may be low, either because other economic activities are more rewarding or because the fishery resources have been degraded due to intensive agriculture and use of pesticides etc.

The stratification between urban and rural areas has to be implemented as a bare minimum and this should be relatively easy to do, based on population census data and spatial population distribution patterns.

The more socio-cultural classes (age, gender) that need to be distinguished the more samples are required. There is the usual trade-off between increasing the number of strata to reduce the variation within each strata and subsequent reduction in the number of samples that needs to be taken. The sample size basically depends on the variability between members of the same group and the formula for the sample size can give a general idea for the actual sample size required for different values of the variability.

9.2.2 Survey forms

There are different formats that can be used to collect the information, from a simple interview to allowing respondents to distribute a fixed number of tokens (that can be equivalent to 15-30 minute periods of time) over a number of activities. The survey form is just used as a data entry format and thus does not normally reflect the complexity of the actual method used. In many cases it will look as a simple list of activities with a box to indicate the rank and/or the amount of time spent (Annex IX).

The primary objective of the survey is to assess the (amount of) involvement of individuals in different economic activities and if possible differentiate between different seasons. For most purposes a list with a mix of fisheries and non-fisheries activities can be used:

- Fish commercially/professionally
- Fish otherwise or collect aquatic animals
- Culture aquatic organisms
- Processing aquatic animals
- Sell aquatic animals
- Making, selling or repairing fishing gear
- Rice planting, transplanting, harvesting or looking after
- Looking after vegetables or orchard inc. planting and harvesting
- Looking after livestock
- Handicrafts (making)
- Trading (not fish related inc. handicrafts)
- Money lending

- Perform wage labour : employment in fishing or fish processing, marketing, gear making or transport
- Perform wage labour (not fish related)
- Government service
- Transport service (land or water)
- Student (resident outside village)
- Child at school in village or near village

A list of activity categories should be on a laminated sheet, along with other list of categories used in this questionnaire, and carried separately. This can be used as and aid to describe the information requested to the individuals interviewed. It will also help them provide an answer. It may help if tokens are distributed that the respondents can use to assign to activities as to assess the relative importance.

9.2.3 Estimation

The estimation process is rather straight forward. For each individual a measurement for the involvement of the activity will be obtained. The **mean involvement**, be it in time (days or hours) or relative ranking should be calculated for each group and for all activities. These mean involvement levels can be used as they are to indicate the different involvement levels between activities within each group. The variation that can be calculated for the sample is assumed to be representative for the variation of the whole population (i.e. the socio-cultural group). To compare involvement levels for the same activity between groups the mean involvement levels can also be used.

Provided the involvement is given in hours, days or percentages of an average working day, it is also possible to calculate the cumulative involvement, the number of hours, days or man months a certain activity is done by each of the different groups. For this the mean involvement (per individual member of a group) needs to be raised for the whole population. Using a simple multiplication of the mean involvement and the total number of individuals in each socio-cultural group, this gives the **total involvement** for each activity by group.

Alternatively the involvement can be ‘normalised’ by calculating the percentual contribution of the mean involvement for each group and plotting this in an area diagram to show what groups are more depending on what activities. This can also be done for the total involvement, but the result should be the same.

Recommended Further Reading

There are relatively few references that cover methodological aspects of consumption studies, although there are many surveys done in the region. Three important references have been mentioned in the text, Bayley and Petrere 1989; Crispoldi 2000 and Bush and Hortle, 2003. All references mentioned in this section can be found back in the reference list at the end of this document, some additional references:

Acker, F., 2000. Cambodia. Fìsh consumption at household level survey. (Manual). Unpublìshed report. Cambodian Capture Fisheries Project, Mekong River Commission Secretariat, Phnom Penh.

Dubeau, P., Y. Dara, C. Piseth, P. C. Thyda, L. Saroeun and P. Degen (2002). Fishing and Livelihood Strategies in Phlong Village Analysis of Long-term Study of Economic and Social Activities (Dec. 1999 - Jan. 2001) Khampong Chhnang Province, Cambodia. Project for Management of the Freshwater Capture Fisheries of Cambodia, Mekong River Commission, Phnom Penh. 72

Hortle, K. G. and S. R. Bush (2003). Consumption in the Lower Mekong Basin as a Measure of Fish Yield. New Approaches for the Improvement of Inland Capture Fishery Statistics in the Mekong Basin. T. Clayton. Ad Hoc expert consultation Udon Thani, Thailand 2 to 5 September 2002, Food and Agriculture Organisation of the United Nations RAP Publication 2003/01: 76-82.

Prapertchob, P., P. Kachamart, W. Pakuthai, J. Viratchakul, A. Hornak, P. Thiranggoon and P. Kamsrakaeo (1989). Summary Report on Analysis of Freshwater Fish Consumption and Marine Product Marketing in Northeast Thailand. Department of Fisheries, Ministry of Agriculture and Cooperatives, Khon Kaen University and Environcon International Ltd.: 35

An useful publication for conversion factors for processed fish is:

Phitakpol, B., W. Varanyanond, S. Reungmaneepaitoon and H. Wood (1995). *The traditional fermented foods of Thailand*. Institute of Food Research and Product Development, Kasetsart University, Bangkok

10. Non-Routine data collection

Most of the fishery statistics should be collected on a routine basis. This means that the statistics are collected with regular intervals with estimates prepared on a monthly or annual basis. There are cases where data collection can be described as non-routine and where collection on a *less-than-annual* basis can be appropriate.

There are basically two different cases that can be described as non-routine:

1. This is the case when information requests come up that cannot be answered by the available data; this is often referred to as ad-hoc surveys; and
2. It can also refer to fishery statistics that are collected on a longer time frame, this means that instead of collecting it every month or year a survey is conducted every 5 or 10 years.

The term non-routine is most often used to describe the second approach, while the ad-hoc surveys often equal scientific research that are designed to answer specific policy questions.

10.1 Ad-hoc surveys

Ad-hoc surveys are often performed to provide information on emerging problems related to policy issues. Fisheries management is seldom based on scientific considerations, i.e. on fishery statistics. Instead it is policy and political issues that often dictate management interventions. Therefore it is not strange that in many cases the existing fishery statistics do not provide enough detail for assessing the impact of any policy decisions or management. Most statistical systems would not be able to quantify the impacts of a fishing ban for large-

scale fishing within 12 mile zone on near-shore fishing operations. Instead a separate survey, often commissioned to an external institute is done. This is often expensive and although in some cases it may lead eventually to incorporating elements of the ad-hoc surveys in the routine collection, this is not normally the case.

The existence of ad-hoc surveys does not indicate any failure of the regular statistical system; instead the ad-hoc surveys are part of it, to allow flexible approaches into an otherwise rather static system.

10.2 Non-routine surveys

There may be two reasons for less than annual data collection:

1. The variables only change very slowly, this is the case for demographic data, data on consumption patterns or habitat degradation. Also frame surveys that form the basis of the catch and effort sampling survey are often done every 2-5 years or sometimes even less frequent; and
2. Operational constraints may make it difficult to collect data on a routine basis. This is often the case for small-scale (family) fisheries in inland and remote marine areas (like South Pacific or large archipelagos like the Philippines). Here fishing is often scattered in space and time and may be only a part-time activity. In many countries the lack of sufficient budget means that in most cases the economically most important sectors are covered relatively well while other sectors, like small-scale and family fisheries are at best covered on a non-routine basis.

Despite the constraints for routine collection of data on the small-scale and family fisheries sector, these are very important sectors in terms of involvement, production and food security. If they cannot be covered in a routine way, then at least they should be covered by some other surveys, instead of relying completely on guestimates for this sector. In the previous sections the methodology for the collection of a number of variables was discussed. Not all countries will have the budget or the requirements to collect all the variables that have been discussed for all fishery sectors. Even then it may be possible to perform some of the surveys on a less than annual basis.

Non-routine approaches are very similar to those used in routine collection of data, although the frequency and the scope are often different. For example instead of trying to establish the consumption or involvement patterns for an area or fishery in a routine way less frequent targeted surveys make more sense to provide key information on catches, effort, consumption and importance of fisheries in the daily lives of rural populations. These can be, but are not limited to:

- *Limited scope census or sample-based pilot surveys;*

These are valuable to assess the fisheries at a local level or can be implemented for seasonal fisheries, for example for migrating fish at a particular spot for 2-3 months. Specific targeted sample surveys can be implemented with limited spatial and temporal focus. In addition pilot studies may show the local importance of fishing activities that do not have a national coverage. These surveys can also be used to obtain estimates for catch composition or length frequencies for certain fisheries that are often not monitored on a regular basis.

- *household surveys or surveys for fish consumption;*

These are useful tools to cover large areas with relative small sampling effort to obtain a full picture of socio-cultural variables. Especially the use of consumption studies has large potential for catch assessment purposes when a large area with a large range of fishing activities needs to be covered. These surveys are often done in inland areas and are particularly well suited to cover part-time fishing operations that are spread out over large areas. Although the resulting data does normally not contain species based (catch) data, the estimates for total production for broad categories can be fairly accurate and give a good picture of the overall importance of fishing.

- *trade patterns;*

Trade patterns, or more specifically market flows at a local and national level is a high level approach to fish supply (production) and demand (consumption) and can be a powerful tool to analyse marketing patterns as well as provide an approach for catch assessment.

- *logbook systems.*

Logbook systems are particularly well suited for small-scale fisheries where production estimates for fisheries or habitats need to be made. More details can be found in section 6.2.4, 7.2 and 7.3.5.

All of these methods can also be used for cross-checking landings data as well as providing production and socio-cultural information. These methods have been discussed in some detail in section 6 and 7 and will not be repeated here.

As the small-scale fisheries in inland areas is largely unmanaged, data collection does not have the same focus as managed fisheries, i.e. provide measurements for the effectiveness for policy and management. Instead the main objective of statistics on this sector is to provide a measure of the importance of the small-scale fisheries sector.

The main issue with non-routine data collection is that if the results are to be compatible and comparable with other fishery statistics, then the same standards and approaches should be used. Even though these surveys are not performed on a routine basis, they should still form part of the regular fishery statistical programme. They should be planned for and be performed on a regular basis, even if this means performing the surveys only every 5-10 years.

10.3 Structural Fisheries Data

An important non-routine survey is the frame survey for structural fisheries data. Structural data describes the units that make up the fisheries, from gears, boats to landing sites, markets and locations for support industry. A complete census or count of the main fishery units is essential for the proper statistical collection of information on the primary fishery sector. This includes:

1. Existing ports and landing places and their pattern of distribution;
2. Number of fishing units and information on their components, such as fishermen, fishing boats, fishing gear, and the clustering pattern of the fishing units (wide-spread, or clustered into fishing ports and landing places);
3. Fishing and landing habits of the fishing units and the diurnal and seasonal pattern of activity in the fishery;
4. Supply centres for capital goods and essential materials (e.g., gasoline, netting, etc.); and
5. Fish distribution routes, processing and marketing habits and related costs, etc.

For the collection of the information required from the small to middle scale commercial fisheries, the best approach to Frame Surveys is by water or road, supplemented if possible by low-cost remote sensing techniques (Aerial Frame Surveys). For a complete inventory of information from larger scale fisheries, either the interview or the reporting approach can be used.

How often the surveys should be conducted, is a function of temporal changes in the size, distribution and operational aspects of the target fishing population. Although this would mean that it may be necessary to carry out a frame survey every one or two years, this is seldom practical, or affordable. This means that a period of 5-10 years is more appropriate.

Performing a frame survey or fisheries census is a big undertaking and often will mobilize part-time resources. For those sectors that rely on accurate frame survey data to estimate catch and effort (small-middle scale commercial fisheries) the frame survey can be updated using limited scope census approaches or by using information from key informants collected by fishery officers during routine data collection activities.

10.4 Data collection in a co-management setting

Information/data collection is an important management function, the responsibility for which should be shared in a co-management set-up. There are various possibilities, which range from having fishers collecting data for (government) scientists to having scientists collecting information and 'knowledge' from fishers. There is a considerable literature on both of this, but actual practical examples of how-to-do-it manuals are almost absent. Co-management is a process rather than a fixed number of steps and therefore one approach cannot fit all. The same goes for ways to collect statistical data by community members.

In fisheries it is increasingly realized that fishers have broad knowledge of the resource that is not being adequately harnessed. Fishers' insights are often described, even by fishers themselves as "anecdotal", if compared with systematic data gathered through statistically valid population sampling procedures. Fishers' insights, however, are the result of observations that they make within the context of long term experience with what is and is not an important indicator of the health of fish stocks.

Fisher's knowledge is called either Traditional Ecological Knowledge (TEK) or Local Ecological Knowledge (LEK). Several **local community and environmental efforts** are incorporating TEK into their efforts to achieve management and sustainable development goals. Fishers are argued to emphasize the importance of habitat considerations, while managers emphasize population dynamics. Fishers are said to view the resource in smaller temporal and spatial scales than do the managers. These insights are helpful for understanding that the knowledge cultures of fishers and scientists can be quite different, but they should not be overdrawn. People's capacities should not be equated with the models they use. Fishers are perfectly capable of understanding how a population model can be a useful tool, and fisheries scientists appreciate the complexity of small-scale differences in ocean habitat.

In those cases where co-management is implemented, it is not necessary to collect statistics on catch and effort for management purposes. In most cases co-management is implemented in a data-less, but not information-less environment. There will not be detailed catch and effort statistics in the classical sense, but as a group the fishers will be able to provide information

on occurrence of fish during different times of the year, important habitats for different life stages and timing of migration and spawning, all based on experience.

Although information on ecological issues can be obtained quite easily, the nature of statistics is such that only frequent measurement may be able to obtain information in sufficient detail that this might be used for conventional analysis.

Community science, as it is often called, is beginning to emerge through efforts at fisheries co-management. For this it is important to realize that good quality information and data cannot be obtained without involvement of (fishery) scientists, who can lay the framework for what should be collected. At the same time recognition of communities to collect statistical data means a realization of the importance of fisher's knowledge, and the inherently political nature of management-related fisheries science. Collection and analysis of data by local communities will create a larger understanding and acceptance of required management interventions.

It is possible to integrate certain reporting duties into the co-management setup in close consultation with participating fishers; statistics can be obtained on a variety of subjects. For practical purposes, counts of fishers, activity patterns and gears will be available at some level of detail. If required catch data, can be obtained using logbooks. With proper guidance, even the estimation of catches and effort can be decentralised, where the community collates and analyses data and prepares estimates.

Although there is a clear scope to combine co-management with data collection, methodologies and appropriate approaches are nor readily available. Several initiatives do look at this aspect (CHARM project in Thailand that is looking at coastal resources management and Data collection and sharing mechanisms for co-management in the Mekong basin a DFID funded project), so it is expected that more information will be available in the not too distant future.

Data generation is not the primary function of co-management arrangements, and reliable production estimates can better be obtained using either consumption studies or limited scope sample surveys for catches (and effort) or marketing surveys. The costs that are associated with using co-management for data collection are relatively high and may not be cheaper than the combined budget for law enforcement, policing and conventional data collection.

Suggested Further Reading

Reference is made to the vast library of references on TEK/LEK and co-management. In South-East Asia the Mekong River Commission's Fisheries Programme has been particular active collecting fishers knowledge and this has been described in a number of publications (some available from the MRC web-site for free), these contain several related references for further reading:

Bao,T.Q., K.Bouakhamvongsa, S.Chan, K.C.Chhuon, T.Phommavong, A.F.Poulsen, P.Rukawoma, U.Suntornratana, D.V.Tien, TT.Tuan, N.T.Tung, J.Valbo-Jorgensen, S.Viravong, and N.Yoorong (2001). Local Knowledge in the Study of River Fish Biology: Experiences from the Mekong. Mekong Development Series No. 1, 220 pp, Phnom Penh, July 2001

MRC, 2003. Fish Migrations in the Mekong River Basin. Interactive CD-ROM.

Poulsen, A., Ouch Poeu, S. Viravong U. Suntornratana and Nguyen Thanh Tung, 2002. Deep Pools as Dry Season Habitat in the Mekong River Basin. MRC Technical Paper No. 4, Mekong River Commission, Phnom Penh, Cambodia, 24 pp.

Poulsen, A.F., O. Poeu, S. Viravong, U. Suntornratana and N.T. Tung, 2002. Fish migrations of the lower mekong river basin - implications for development planning and environmental management. MRC Technical Paper No 8. Mekong River Commission, Phnom Penh. 62 pp. ISSN: 1683-1489

Valbo-Jørgensen, J. and A.F.Poulsen, 2000. Using local knowledge as a research tool in the study of river fish biology: Experiences from the Mekong. Environment, Development and Sustainability 2 (3-4), 253-276.

Literature on co-management has been booming over the past few years, but as the field is highly dynamic it is difficult to list the most appropriate references.

Hardison, P. 1997. Suggested Readings on the Role of Conservation Biology in Community-Based Conservation. Department of Psychology NI-25, University of Washington. Seattle, WA.

Baird, I.G. 1999. The Co-Management of Mekong River Inland Aquatic Resources in Southern Lao PDR. Paper presented at the International Workshop on Fisheries Co-Management, 23-28 August 1999, ICLARM, Penang, Malaysis, 43 pp.

Nickerson, D.J. (ed.). 1998. Community-based Fisheries Management in Phang-nga Bay, Thailand. Proceedings of the National Workshop on Community-based Fisheries Management organized by the Department of Fisheries of Thailand, FAO and the Bay of Bengal Programme, Phuket, Thailand, 14-16 February 1996. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, RAP Publication 1198/3 (BOBP Report 1 No. 78), 227p.

CHAPTER IV
DATA PROCESSING AND ANALYSIS

11. Approaches for Processing and Analysis

11.1 Data Validation and Verification

It is important to invest sufficient effort in assuring the quality of the data. In any data collection system there will be problems with data. In some cases the data may be completely made up, in others missing data is interpolated from real data. Fake data is difficult to recognise, unless it is completely nonsense and does not fit in the expected pattern. Some software tools can be used to analyse time series to look for recurrent patterns, or dominance of odd number or prime number based data. In most cases cheating will be done intelligently, i.e. the fake data will be in line with previous real data or tries to follow an expected pattern like emulating a catch peak a few days before full moon or a growing trend for aquaculture output and a decreasing trend in capture fisheries production. In some cases, where the respondent has good general knowledge of the fishery, the fake data may give a better description of the fisheries than real data would be able to do.

The main objective of data verification is to get rid of any fake data or to correct problems caused by it. There are a few measures that can be taken to accomplish this:

1. strict planning of survey activities

Enumerators should know where to go to and when following a fixed schedule that can be checked by supervisors.

2. getting it right from the start

Data should be checked in the field shortly after collecting it while there is still a chance to correct missing data or obtain clarifications.

3. working in teams

It often is a good approach to work in teams of two enumerators. Especially in those cases where interviews are held the interviewer can concentrate on performing the interview and keeping the discussion going while the second person can note down the information on the survey form. This will also ensure a quality check during the interview when the interviewer forgets to ask clarification, or when the information given is insufficient.

4. strict supervision with regular activity reports

Supervisors should know where different teams of enumerators are on each given day and time and should conduct some surprise visits to landing sites or villages that should be covered and check if the visits where done on the days specified. Monthly activity reports should be prepared for enumerators and supervisors.

5. checking of data with separate verification surveys

Where possible (for example for frame survey data or household data) a sample survey should be conducted to redo part of the survey to verify the results of the original survey. In case of catch assessment it may be possible to use the length frequency data together with length weight data to estimate the catch separately, this then may be used to verify the catch obtained through sample surveys of catch and effort. If this method is used to check on the reliability of the catch assessment, then two different teams should be involved, one doing the regular catch assessment, the other independently implementing the length frequency survey.

Supervision and verification is an on-going process and may require as much effort as the actual data collection. Unless it is done properly it is not worth doing at all.

An important component of the data verification is obtaining feedback from enumerators and fishers on the information provided. This is only possible if the data is checked soon after being collected. Data processing should be fast and timely to be able to generate the required reporting and analysis for feedback and verification.

It is no good to have data entered only after 3 or more months after it was collected, data entry, reporting and analysis should be an integral part of the statistical system.

11.2 Data processing

Data processing is the process of transferring data collected in the field to a digital format. This has to be done with the least possible delay and without any data entry errors. It is essential that data that is collected is available for analysis and estimations as soon as possible. If monthly estimates are required then these should be available soon after the end of the monthly cycle.

In most cases data will be written down on survey forms. Digitising data can be done in two ways, depending on the way data is written down:

1. Optical character recognition (OCR) can be used where extensive use of tick boxes and numbers is used. Current software can distinguish numerals with great accuracy, and tick boxes are normally very easy to digitise using digital templates that indicate where the information is located; and
2. ‘Manual’ data entry. When a lot of text is entered on the paper survey forms, this has to be entered manually. Recognising hand written letters for English is often difficult enough, getting software to recognise non-Latin scripts is probably too much for most software packages.

It is important that all survey forms and sheets are:

1. *Checked* for missing data directly after the interview
2. *Coded* for gears, habitats, other categories used and species mentioned
3. *Translated* for those few text entries that are entered in riparian language (names and remarks)
4. *Entered*

After data entry the data in the database should be:

5. *Re-checked* to see if all data was entered correctly
6. *Cleaned* to take out ‘empty’ or unnecessary records

It is strongly advised that members of the survey team do the first four steps, if that is not practical at least try to involve people that collect data in the first three steps. Data entry should preferably be done in the field (or at the field station) as soon as possible after the data was collected.

The checking of the data entry can be done by double-punching or taking random samples of survey forms, log sheets or questionnaires that are checked completely.

All paper survey forms should be clearly coded for the location, enumerator, date and time and properly stored. Each completed data processing step should be indicated on the forms, so that the processing status of each individual data form can be checked.

There is another possibility that is making inroads in several countries, data entry in palmtop or tablet computers. Instead of working with paper forms, an electronic copy of the survey form is filled out during the survey. This removes a large source of error from the data processing, and although not complicated, will in most cases be regarded too expensive and not practical, given the lack of funds.

Data should be stored in a database. Word processors and spreadsheets are no databases and should not be used for data storage. Basically the data is not secure and can be too easily changed.

Data entry should use a secure platform that facilitates fast data entry with the least possible mistakes. Custom data entry formats need to be developed for each survey. The survey should be designed with data entry kept in mind and data should be organised in a database with the future data use (analysis) in mind.

For most purposes a custom database will need to be developed. To minimise data entry mistakes, the computer data entry screens need to look like the paper survey forms, questionnaires and log sheets. Developing a database from scratch is not required many database management systems exist that facilitate the design and use of custom systems without heavy investment in development (time and manpower). These database platforms allow for simpler procedures to be used and are much easier to adapt when that is required than custom systems developed on (outdated) UNIX systems.

The database should not just be a depository of data, it should also be capable of producing much of the standard outputs, monthly reports on enumerator activities, estimates of catch and effort, frame data, estimates by species, strata, province and country, etc. A link with GIS, indeed an integrated system that incorporates GIS would be convenient. In addition web access for data exchange and data entry, would also form an excellent showcase, provided that data ownership and data exchange would be arranged beforehand. It would be worth the investment to create a standardised database system that would incorporate all required functionality that could be used in all participating countries. This would reduce the required investment in time and money considerably and facilitate maintenance and exchange of data.

In general there are a number of points that have to be taken into consideration when designing a database Whether or not all of these points are taken into consideration depends on the size and importance of the database and how much time can be devoted to the development of any particular database. The following summarises the normal practice when managing a database, to govern the way data is entered, processed and 'validated':

1. All data should be stored with the largest possible detail, meaning raw data on non-magnetic media with safe back-ups

This should been implemented by keeping copies of the main database in different locations on CD-ROM's. The master copy of the main database is kept in a database centre. It then needs to be backed-up every week on CD (not on rewriteable CD's); a copy should be made that is kept at a separate place. In addition all data in the final database (after all the data is entered and screened) should be backed-up as platform independent data as comma separated values or text, this way the data may still be used in 10-20 years time when the particular data format used is probably long gone.

Whole volumes have been written on data security, but it simply comes down to taking all sensible precautions:

1) use computers with high quality components
2) use a stable operating system
3) only allow legal software to be installed
4) implement rigorous backing up and keep backup copies at multiple locations
5) install (and use!) anti-virus software and update definitions regularly
6) perform regular computer maintenance, especially defragmenting the hard drives and surface scanning of the hard drives.

This is of direct concern to the managers. Collecting huge amounts of data and then losing it all, due to faulty hardware, sloppy back-up procedures or a natural or unnatural disaster is not necessary.

2. Data collectors should process their own data

This should been implemented to the extent possible. Unfortunately this will not always be possible especially with surveys involving many data collectors. Often the supervisors will process the data (or at least supervise it), alternatively people involved in data analysis may be used to also enter the data, or professional data typists may have to be hired.

Spreading out the task of data entry, decentralise data punching has the added advantage that there will be less work for the central office, who then can concentrate on checking for errors, data cleaning and analysis.

Timely data entry will ensure timely estimates. In many cases data processing is a bottle neck, especially in those cases where data is sent to a central point for processing. There decentralisation of data entry can be the solution. However in many cases the main bottle neck is with obtaining the data. Especially when logbooks, questionnaires and reporting are employed or where other departments are in charge of data collection, the delay between collection and obtaining a clean data set can be quite long.

In these cases a detailed assessment should be made to identify the different steps and investigate where the delay is most severe. In case of decentralisation it is clear that there should be sufficient staff and resources available to support this, together with proper briefing of supervisors and support staff. In general staffing is barely sufficient at the central level,

therefore decentralisation will only add to an already stretched system. Unless proper resources can be allocated, decentralisation will not work.

3. Data preferably should be kept in several states (raw, filtered, audited and final).

The data recorded in the field and the data in the database may not be the same, but both data sets need to be kept. Even when what was collected in the field is clearly wrong; it needs to be possible to back track from the 'improved' data to the original inputs. Also filtered-out data, where we may decide to disregard certain records in the final database should still be retrievable. To this end at least three data sets are required:

1. Original non-edited field data straight from the forms;
2. Intermediate edited and screened data;
3. Final database with data as used in the final analysis.

This means that inputting should be strictly separated from analysis and editing data. The main purpose for a database is to act as a repository of survey data.

4. Any auditing should leave trails in the data and therefore the all auditing should be documented and be traceable

5. Software should provide assistance doing this (providing filters for realistic values and alarms for violations of validation rules) and provide fool proof ways of data security (only certain data can be accessed and changed, raw data never should be edited)

There are two levels of possible data validation:

1. There is double punching of data (each record is added to the database twice), to ensure that there are no mistakes in keying in data from paper to the computer;
2. In addition there is validation based on each field entry which is assessed based on validation rules (ages should be less than 100, integer fields cannot get a text input etc.).

Most database packages do not have built in provisions for double punching (and comparing the results), nor built in tools for auditing. Auditing basically means that any changes to the data are recorded and the change could be undone (data sets for raw primary data, improved data and a final set used for analysis, are kept separately). This can be integrated into the database through programming, or by making incremental back-up copies of the data and keep these in a safe place on safe media (CD-ROM).

The back-ups should not overwrite existing back-ups but they should make a complete copy of the database. Back-ups are essential during data entry. After data entry is completed and the data is screened and verified, most back-ups can be deleted. It then is important that the original data set is available in a separate copy of the database. When subsequent 'improvements' to the data are made it should always be possible to restore the original value from a back-up copy. Not only will back-ups allow to restore work when a hard disk crashes or when a fire wipes out the entire office it is also important for restoring data when somebody makes unwanted changes to the data.

6. Any software needs to be fully documented and with extensive tutorial and description of the data contained therein

It is absolutely essential that the database is fully documented. This will facilitate the usefulness of it, i.e. allow others not involved in the survey to understand the database, use the data and allow them to make changes.

7. Feed-back in local languages should be considered

Each survey should result in short reports alternatively monthly summaries should be produced. This should be done both in the national (local) language as in English.

8. Multi-language support for in and/or output by the system should be considered

Since the survey forms, log sheets and questionnaires will be in the national (local) languages, it is worth considering multiple language user interface, or even data. Especially when foreign specialists are involved, or when the data collection is a multi-national undertaking (for river basins or under the umbrella of international organisations). A simple way to implement this is to translate separate set of the data entry interface forms. More elegant solutions are available by using programming code to switch between different languages using one set of forms.

9. Pay attention to securing the data and the database

In general it is a good precaution to restrict access to a database, especially during data entry, put passwords on the computer, individual databases or on different levels of access. This will ensure that only people allowed to work on a database will be able to make changes, add data or edit data. With User level access you can specify what a user can do in a database, from only reading the data to changing the design of a database.

Designing and implementing a proper database is a very slow process. It is fairly easy to create a database within a (few) day(s) with for example MS Access. It may even serve it's purpose, but making the database safe and making it useful often require a lot of additional work.

No matter how much time and work has been invested in designing a fool proof data entry interface, data typist are sure to find novel ways to enter data. As with surveys themselves, databases need to be tested for inconsistencies and programming mistakes. The more complex the programming the more mistakes, or 'bugs' will be present.

10. Data Cleaning

Even well designed data entry forms may lead to faulty data in tables. A good design for a database may prevent adding certain types of erroneous records or data, but a computer based database will probably never be 100% foolproof. Many are the ways in which data can be entered and therefore many are the ways in which mistakes can be introduced to a database. Often this is not simply a consequence of the design of the data entry screens, but more often a combination of factors. This includes the unpredictable nature of data typists and a range of hard and software related glitches. This may lead to the following range of data mistakes:

- records with missing primary or foreign keys
- records that are not linked to other tables (orphan records)
- duplicated records
- 'empty' records
- records with missing data, or broken records

The objective of the 'cleaning' process is to obtain a database in which all the tables are linked together without obsolete data: a technically 'clean' database. Cleaning intends only to look at records or data that have been added to the database by mistake.

11. Interfacing the data

A modern fishery statistical system cannot exist without computer hardware and software. In many cases the data processing and storage software (the database) is custom built and may be running on anything from personal computers to a central server. With the advent of the Internet it has become very easy to implement remote data entry and editing using restricted access web-based data entry tools. This facilitates data entry, data management and system upgrades as well as data sharing.

There are many software solutions available that provide easy to use development tools. It is not within the scope of this handbook to favour one package over another, but for national data systems, professional solutions like SQL, Oracle are to be preferred over desktop solutions like Paradox, Access or Filemaker. In general sense the database should integrate data entry and editing tools, together with database management and also reporting tools. This will facilitate the estimation of certain indicators and the production of data reports. There are many packages that provide the tools to combine all basic requirements for an information system and some are capable to incorporate mapping tools too.

Analysis should be done with specialised software, but many of the indicators and estimates are normally fairly standard and it is good if these can be routinely generated from the database using a standard report. In addition remote access to the data should enable production of standardised reports with data summaries and appropriate estimates for different sectors and areas.

The development of an information system is a specialist job and can best be done by an external company or specialised government service. This will ensure that the system will be serviceable in future and compatible with other government systems. It is important to use tools that are generally understood by more than just the local programmer, this will ensure that the system can be expanded and adapted by anyone familiar with the system and the standard development tools.

There are numerous highly specialised manuals and books on programming tools and general approaches. Since developing a system is a specialist job, it is not necessary to list general database books as they are without exception very technical and detailed.

11.3 GIS as a tool for Stratification and Analysis

GIS is an abbreviation for Geographic Information System. Whole libraries have been written on GIS and what it can be used for. Therefore this section will only be a very brief introduction. There are some excellent manuals available, some of which will be mentioned at the end of this section.

Figure 6. GIS layer for Tra Vinh Province in the Southern Delta Region in Viet Nam with land use classification

In essence GIS is an information system that contains maps with different features, like roads, water ways, administrative boundaries, cities and villages, lakes, rivers, swamps, reservoirs etc. This is equivalent to having a digital map in the computer but one where the user decides what is displayed and that can be magnified to the required level. In addition the base maps with geographic features can be combined with spatial information, information for a particular location (a village or city or larger areas). For example it would be possible to combine data on the number of fishers by district with a map of all the districts in a country and show this as shades of red, or display rainfall patterns, or flooding information, population density, etc.

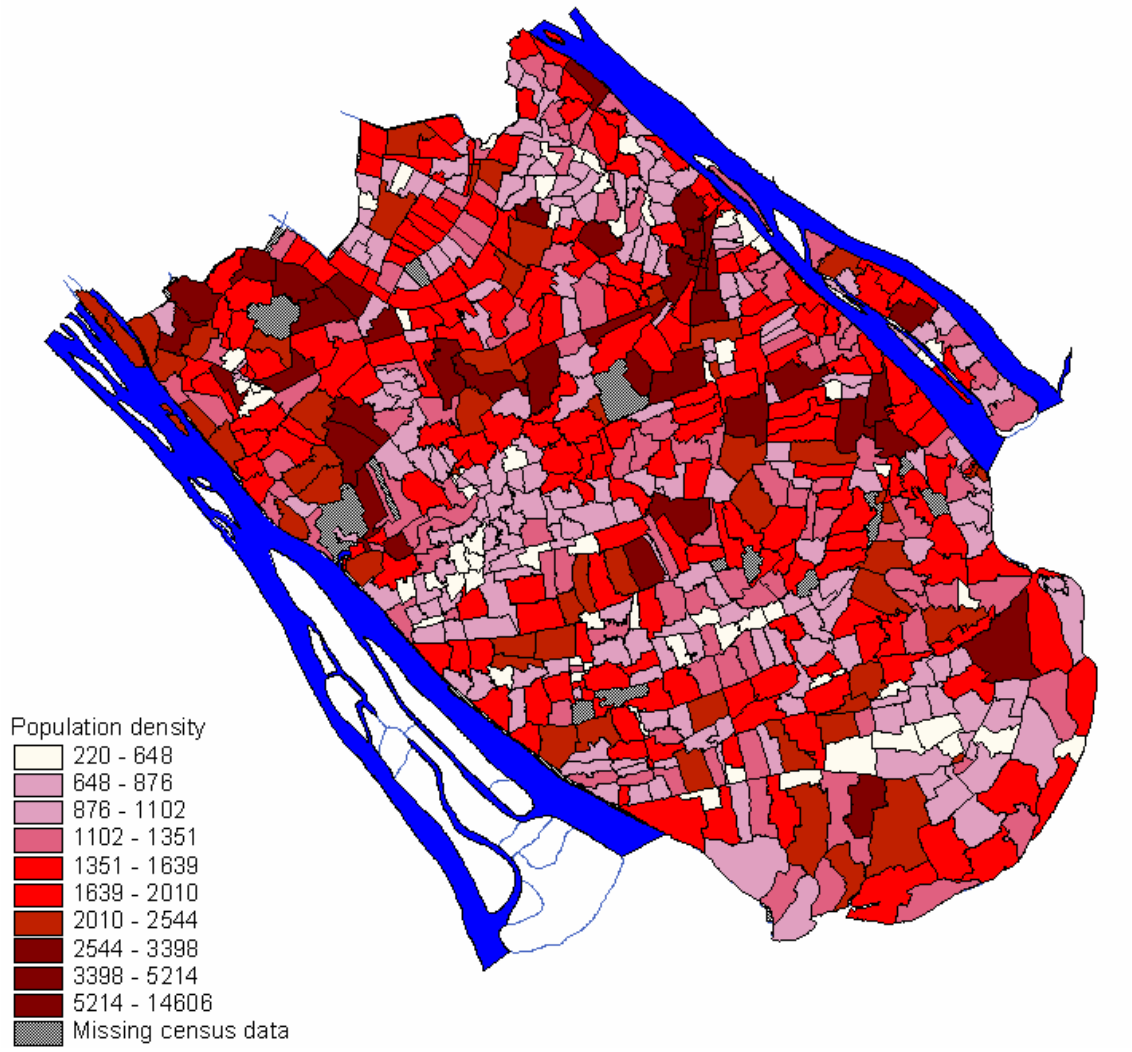

Figure 7. Population density for Tra Vinh Province, based on 2000 population census, numbers indicate number of individuals per sub-commune.

Maps and information that can be related to maps are the basis for any GIS. A good GIS will also contain a user interface to interact with the maps and display any information or combination of information layers by selecting categories from drop down menus, allowing queries of data etc.

In most countries considerable information is available on demographics, i.e. population census statistics. This data can be crucial in preparing the survey and sampling design for fishery surveys. However population statistics by themselves do not reveal much information. Unless the spatial distribution of people is known the population statistics can only be used for the coarsest of analysis and stratification.

Combining spatial information (GIS) with the population census data to arrive at the spatial distribution of the population is in itself relatively simple. Unfortunately, for many countries the geographic information is difficult to obtain. It is seldom available from one single source, can be stored in conflicting formats and sometimes is considered sensitive information, that isn't even freely available for government departments. In some cases (Viet Nam) the information may only be available at the local level at sufficient enough detail.

If the information has not been collated at a central location, this means that there needs to be a careful (and often lengthy) process of checking the information and linking the census information with the location information. It is often found that locations mentioned in the census information cannot be found as an existing location on maps or in GIS layers, or vice versa.

As soon as the population data is available as a GIS layer, this opens good opportunities for overlaying other information, like road network, waterways, water resources, land use, flooding information that can be of assistance of understanding the physical environment and indicate logical stratification areas. Several advanced tools are available hat can assist in analysing GIS data; a good example is the spatial analyst module of ESRI. Besides, being able to show the stratification on the map, with the location of landing sites, fishing grounds, markets and other fisheries related features, or make adjustments to the boundaries of each stratum can be very useful. It may help to understand the relationships between different fisheries and assist in displaying the results of the surveys.

GIS is a very useful tool not just to assist in stratification of the elements in a fishery, but also to display data in an easy to understand format. Most people can very easily relate to maps and results displayed on a map with other information can reveal relationships between fisheries and environmental parameters much easier than using plain tables to report the results.

GIS development is often centralised, at least for government agencies, which does not mean that similar data is not being compiled by different agencies. However there is often a structure available that standardises the data formats used and catalogues the available data sets.

GIS is not difficult to use. Although building a GIS is work for specialists, almost anybody can learn how to make maps and represent data in a GIS fairly quickly. Some basic training is required as for any new software package. The standard desktop software for GIS is Arc View. Several other packages for the desktop exist (like MapInfo or Manifold) but most people use Arc View or it’s server counterpart Arc Info. These programmes are fine for a general purpose GIS. Several excellent guidebooks are available that can teach the basics of these software packages and working with spatial data.

Figure 8. Monthly occurrence of large Pangasid fish in the Mekong river and the Songkhram basin in North-East Thailand.

A special application of GIS is in catch assessment. This approach uses separate estimates for per area production for different habitats as the basis for extrapolating fish production over a large area. This involves detailed catch assessment surveys over a number of years that estimate the fish catches for different fish habitats. These localised catch estimates in representative areas are then extrapolated using GIS. This involves quite complex analysis and ground truthing of remote sensing data, to establish the location and extent of each fish habitat, and also the temporal (seasonal) changes these habitats are experiencing.

These approaches have been applied in areas of Cambodia (by MRC) and in Bangladesh (see references below) and since this has been covered in considerable detail elsewhere, it is not necessary to cover it here.

Recommended further reading

Geographic Information Systems is a specialised field and there is a large library of books, manuals and reports available that can assist and often confuse. The following publications give a general introduction into general issues and some specific fisheries applications:

De Graaf, G.J., Born, B. Uddin, K.A. and Marttin, F. 2001. F1oods Fish & Fishermen. Eight years experience with floodplain fisheries, fish migration, fisheries modeling and fish biodiversity in the compartmentalization pilot project, Bangladesh. The University Press Lìmited, Dhaka, 108 pp.

De Graaf, G.J., F. Marttin and J. Aguilar-Manjarrez J. Jenness. 2003. Manual on the use of Geographic Informatìon Systems (GIS) in fisheries management and planning. FAO fisheries technical paper No. 449. Rome, FAO, xx pp.

Huxold, W.E. and A.G. Levinsohn, 1995. Managing Geographic Information System projects. Oxford University Press, 247 pp.

CHAPTER V
TRAINING

12. Training

Thorough training of staff is essential to be able to perform fishery statistical surveys with the largest possible efficiency and accuracy. Enumerators are often junior staff, and are expected to work independently in remote areas with limited or no supervision. Therefore they need good preparation.

Training is not a one-time effort. Since many junior staff will move on to other positions and even to other sectors (the dissipation of fisheries staff to other sectors is notorious), training is an on-going effort. It is necessary to train new staff or to upgrade the skills of existing staff to implement new methodologies.

There are several levels of training required to cater for the different positions:
Enumerators: staff involved in collecting data;
Researchers: staff who use (analyse) the data; and
Statisticians: staff designing the statistical system and analyse the data.

The training can be separated into several modules that should be targeted at specific groups of people:

Topics	enumerators	researchers	statisticians
Sampling and basic statistics	yes	yes	
Survey design		yes	yes
Data collection	yes		
Data processing	yes		yes
Data analysis		yes	yes
Reporting of Information		yes	yes

Additional general training may be required for computer software packages, like database software, database programming, statistical analysis software and GIS software. Each of these will have several levels to cater for different levels of experience. It is best if these training modules are customised. Commercial training in databases or specific software packages can be useful, but more advanced training in applying the packages to specific analysis or reporting needs is too specialised to be readily available.

Training in sampling techniques and survey design can be standardised, but should be conducted in collaboration with a fishery department of a university who may have more expertise in teaching and methodology than in-house experts. There are also some excellent on-line training opportunities available through several universities' statistical departments around the world.

In order to get most benefit from the training it has to be both practical and be conducted over a longer time frame. It is essential that staff is allowed to do the training during working hours. The benefit of short targeted training events often disappears shortly after the training has taken place, simply because the participants have not had the time to apply the knowledge in a field situation, or are not in a position to apply most of the newly gained knowledge in their normal job.

In most cases an extended training, with assignments and recurrent training sessions will provide the best assurance for lasting benefits.

Part of the basis for the fishery statistical training is provided by the current document with the addition of local examples and case-studies for each training venue. In addition it does not make sense for people to be trained in methods that are not going to be implemented. This means that the methods that will be used should already be known before the start of the training and this shows the way for the training, the complete sequence as outlined in section 5.2 should be followed:

1. An in depth desktop study is performed to assess the state of the fishery statistics in each participating country, this has to be done by a local expert who will be able to consult all relevant material, this report will advise what can be done to improve the situation;
2. A small group of researchers and statisticians should answer the *why*, *what* and *how* questions and come up with a plan for the collection of fishery statistics in a pilot area under the super vision of (regional) experts in collaboration with national experts from the statistics department and taking the report prepared under 1 into consideration;
3. The statistical system is designed as part of a training exercise;
4. Based on the selection of methodologies, survey forms and sample designs are formulated;

Note although the general methodology may be standard, some details for specific surveys may be different, depending on the local circumstances and statistical requirements for policy and planning of each particular fishery. The goal is to standardise the methodologies and approaches and to ensure that data is compatible and can be exchanged between sites and countries. Although it is possible that a minimum set of data may be collected at all sites, the data that is collected is decided by the specific requirements for each fishery.

5. Staff is trained in designing and programming databases, approaches and software used should be standard for all participating countries and be compatible;
6. Field staff is trained in executing the surveys on a routine basis and processing the data, including recognising fish and gears;
7. Staff is trained in analysing data with a standardised software package;
8. workshops are convened to discuss reporting formats and train participants in report writing targeted at different recipients;
9. the data is analysed using standard approaches and reporting under supervision of regional experts;
10. Monthly summary reports are produced targeted at policy makers and planners; and
11. The pilot project is evaluated in a national and international workshop after 1 year of implementation where the results of the data collection are exchanged between the participating countries.

Throughout the first half of this handbook, it has been emphasised that the main focus for any statistical system should be an in dept review of the objectives, data requirements and methodology. Every country and fishery is unique, and each country has their own approach to the methodologies that should be used. In many cases there is not a lack of understanding of how it should be done, rather an unsystematic approach of the whole statistical system.

This means that it is not by definition required to teach people how to conduct surveys. The capacity to do that is in many cases already present. What is often lacking is the ability to evaluate and assess, redesign, or adapt existing statistical systems or known methodologies to a particular fishery and in this respect it would make sense to follow a more holistic (and pragmatic) approach whereby indeed a pilot scheme is initiated that will do at a small-scale what is deemed necessary for the country as a whole.

This means that the current project for human development should have a follow-up phase or provide assistance for those countries who want to take the next step of redesigning their statistical system for the whole nation.

Several inputs are required for a thorough and successful training, but the exact content depends to a large extent on the statistical surveys that will be performed.

Two resources are especially useful: A gear catalogue and species lists with identification guide. Example of gear catalogues were given in section 7. A useful reference work for inland fisheries is currently prepared for Cambodia by MRC and this should be available some time this year. Species guides can be easily obtained from the MRC Mekong Fish Database 2003 that can prepare reports in several formats for over 900 species of freshwater fish. ICLARM's FishBase has a similar functionality.

CHAPTER VI
GLOSSARY

The terms and definitions in this glossary have been taken from a number of sources, ICLARM's Fishbase, MRC's Mekong Fish Database 2003 and various FAO sources, like the FAO Fisheries Atlas. Where necessary they have been adapted to fit the use and users of this handbook. Where SEAFDEC definitions are available these have been used in favour over other definitions.

Accuracy of estimates An indicator of the closeness of an estimated population parameter to the actual population value. Accuracy is generally not known unless crosschecking procedures are conducted from time to time using other survey approaches. It should not be confused with precision which measures the variability of the estimates and can always be computed from the samples.

Active fishing days Time extrapolating factor used in the estimation of total fishing effort. It is boat/gear specific and defined as the number of days in a reference period (e.g. a calendar month) during which fishing activities are "normal". Usually this variable is defined in reverse manner: by subtracting from the calendar days those days known for zero or negligible activity. Definition of active days is in itself a sample-based survey involving several sites and boat/gear types, but it is often specified at minor stratum level by means of empirical knowledge and/or information from the enumerators.

Artificial reefs Any man-made structure placed in the water body to provide shelter, habitat or breeding areas, which at the same time have an effect to exclude some fishing operation from the areas. (SEAFDEC)

Artisanal fisheries Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, definition varies between countries, e.g. from gleaning or a one-man canoe in poor developing countries, to more than 20, m trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. Sometimes referred to as small-scale fisheries. See: Subsistence fishery.

Base port The port from which fishing units operate, irrespective of where they are registered (homeport). The differentiation between base ports and homeports occurs when fishing units migrate from the locations indicated by the frame survey to other sites, usually on a seasonal basis.

Bias Bias is a term which refers to how far the average statistic lies from the parameter it is estimating, that is, the error which arises when estimating a quantity. Errors from chance will cancel each other out in the long run, those from bias will not.

Bias in estimates Estimated population parameters that are systematically smaller (negative bias) or higher (positive bias) than the actual population value. Biases are not traceable unless cross-checking parallel surveys are conducted from time to time. High precision is not an indication of unbiased estimates; in fact extremely high precision (= very low variability in the samples) may well be associated with positively biased samples.

Biodiversity The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Diversity indices are measures of richness (the number of species in a system; and to some extent, evenness (variances of species' local abundance). They are therefore indifferent to species substitutions which may, however, reflect ecosystem stresses (such as those due to high fishing intensity). (SEAFDEC)

Bio-economic model An analytical tool to facilitate management decisions. Bio-economic models establish functional relationships between specific characteristics of the natural resource base, (e.g. a fishery resource), and the activities of man to make use of such resource. The formalization of such relationships requires certain abstractions from reality, as well as assumptions about the biological processes and human behaviour. To the extent that these assumptions may be partially violated in a specific fishery under study, the results of models should be considered as theoretical and potentially biased. While the reliability of models increases with the validity of the assumptions, there are limits to formalizing and to interpreting the results of highly complex systems.

Biomass 1) The total weight of the living organisms concerned, whether in a system, a stock, or a fraction of a stock, e.g. plankton biomass in an area, biomass of spawners or of newly recruited fish.

2) Total weight of a resource, a stock, or a component of such stock. Examples: the biomass of all demersal fish on the Georges Bank; the biomass of the cod stock; the spawning biomass (i.e. the weight of mature females) (also standing stock).

Biometry The statistical study of biological data.

Boat Activity Coefficient (BAC) The proportion of fishing units that are expected to be fishing during any given day of the survey period. It is a sample effort parameter and usually expressed in percentage form.

Boat day A measure of fishing effort; e.g. 10 vessels in a fishery, each fishing for 50 days, would have expended 500 boat-days of effort.

Buy-back scheme Financial mechanism of a fisheries management scheme, usually supported and often subsidized by governments, in which governments or other relevant parties (e.g. fisher's association) buy vessels and fishing licenses from producer in order to reduce fishing effort and capacity. (SEAFDEC)

By-catch Part of a catch of a fishing unit taken incidentally in addition to the target species towards which fishing effort is directed. Some or all of it may be returned to the sea as discards. This is extremely rare in inland fisheries where all fish that is caught is generally used.

Catch 1) Any activity that results in killing any fish or bringing any live fish on board a vessel.

2) The component of fish encountering fishing gear which is retained by the gear.

Catch per unit effort (CpUE) The catch for a given amount of fishing effort measured in either number of fishing hours, number of fishers or number of boats. It is commonly used to measure the health of the fisheries stocks. However, it is of limited use in river fisheries where the natural variations in recruitment and mortality are much more significant than fishing mortality..CpUE can be used as a measure of the economic efficiency of a type of gear, but normally it is used as an index of abundance, i.e. a proportional change in CpUE is hoped to represent the same proportional change in abundance (of fish). Nominal CpUE is simply the measure of CpUE from the fishery. However, it is known that there are many factors (including economics, geographical distributions) which may affect CpUE but do not represent changes in abundance. Therefore, CpUEs are often "standardized" using a variety of statistical techniques to remove the effect of those factors which are known not to be related to abundance. Thus, using the standardized CpUE will be more appropriate for an index of abundance. Most assessment analyses (production models, virtual population analyses) use the index of abundance data to fit to calibrate (tune) the models.

catch statistics Data describing the results of catch assessments.

Catchment approach The analysis, protection, development, operation or maintenance of the land, vegetation and water resources of a drainage basin for the conservation of all its resources for the benefit of its residents.

Census A "complete enumeration" or count of certain variables for all members of a population. See fisheries census.

Closed area including marine parks, marine protected areas, etc.) Closure of an entire fishing ground for a particular fishing gear(s), or a part of it, for the protection of a section of population (e.g. spawners, juveniles), the whole population or several populations. The closure is usually seasonal but it could be permanent. (SEAFDEC)

Closed season Banning of fishing activity (in an area or of an entire fishery) for a certain period of time, usually to protect juveniles or spawners. (SEAFDEC)

Cluster sampling Cluster sampling is a sampling technique where the entire population is divided into groups, or clusters, and a random sample of these clusters are selected. All observations in the selected clusters are included in the sample.

Co-management (CM) The sharing of authority, responsibility, and benefits between government and local communities in the management of natural resources.

Coastal fisheries Fisheries by fishing ground or area. There are some States that set a wider fishing range like Indonesia (12nm), Malaysia (30nm), Philiipines (15km), and Thailand (12nm) or using different definitions like water depth (Cambodia; 20m). (SEAFDEC)

coefficient of variation A statistical term describing the percentage variation in a population.

correlation coefficient A statistical expression that varies between 1 and +1 depending upon how close the variables measured in a population are related, perfect correlation, r = 1.

Critical habitats A habitat that is essential to maintaining the integrity of an ecosystem, species or assemblages of species. (SEAFDEC)

Culture-based fisheries Capture or harvest of aquatic organisms grown in open waters from artificially-stocked seeds produced from hatchery or collected from the wild.

DANIDA Danish Development Aid Organisation

Data Facts that result from measurements or observations. (SEAFDEC)

Data flow A representational tool that shows how information moves in an organization or process. Special symbols represent different types of data flow.

Data set A collection of data and accompanying documentation which relate to a specific theme (usually consisting of one or more computer readable files on the same system).

Data validation Confirmation of the reliability of data through a checking process, usually involving information from an alternative source.

Database Any file containing data or information, often found in combination with data retrieval and management procedures.

Database Management System (DBMS) Application software that stores, maintains, locates and retrieves data for a database.

Demography The study of characteristics of human populations, especially size, density, growth, distribution, migration and vital statistics and the effect of these on social and economic conditions.

Destructive fishing gear and practices Fishing gear (including its accessories) and practices that have a destructive impact on the ecosystem, including fragile habitat, immature and juvenile species of commercial importance, unwanted fish and other animals. (SEAFDEC)

Discards/waste That portion of catch returned to the sea (or otherwise thrown away) because of economic considerations - deemed to have or even negative value to the catcher. (SEAFDEC) Discards are rare in inland fisheries.

Empirical Used in relation to statistics: based on experience or observations, as opposed to theory or conjecture.

Enumerator person who collects data, i.e. data collector.

Estimate a value that is obtained from a statistical sample which is assigned to a population parameter

Exclusive Economic Zone (EEZ) 1) A zone under national jurisdiction (up to 200-nautical miles wide) declared in line with the provisions of 1982 United Nations Convention of the Law of the Sea, within which the coastal State has the right to explore and exploit, and the responsibility to conserve and manage, the living and non-living resources. 2) The area adjacent to a coastal state which encompasses all waters between (a) the seaward boundary of that state, (b) a line on which each point is 200 nautical miles (370.40 km) from the baseline from which the territorial sea of the coastal state is measured (except when other international boundaries need to be accommodated), and (c) the maritime boundaries agreed between that state and the neighbouring states.

FAO Food and Agriculture Organisation of the United Nations

FAO area One of a set of large areas defined by FAO to record fisheries catches, as published in the FAO yearbook, fishery statistics, catches and landings.

Fillet In fish, a slice of meat without bones, cut out for human consumption.

Fish stock Group of individuals of a species which can be regarded as an entity for management or assessment purposes; a separate breeding population of a species; term used to identify a management unit of fishery species. See: Fishery resource.

Fisher A person (male or female) participating in a fishery (in preference to the previously used term 'fisherman'). An individual who takes part in fishing conducted from a fishing vessel, platform (whether fixed or floating) or from the shore. Often the term fisher folk is preferred.

Fisheries census Collection of structural fisheries information using a census approach. In practice this is often done by approaching key informants (like village representatives). The primary objective of fisheries censuses is to provide a detailed classification of the fisheries structure of the country. It provides estimates for each household, and therefore, aggregate data for the smallest administrative, political or statistical subdivisions of the country and for classifications of households by size or other subgroups of interest.

Fisheries management The integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives. (SEAFDEC)

Fishery The sum (or range) of all fishing activities on a given resource, i.e. the collective enterprise of taking fish, usually used in conjunction with reference to the species, gear or area involved. The term is often widened to include aquatic animals other than fish and is often defined to be targetting one or more stocks of fish, that can be treated as a unit for purposes of conservation and management and that is identified on the basis of geographic, scientific, technical, recreational, social or economic characteristics, and/or method of catch. See: Fishing.

Fishery management The integrated process of information gathering, analysis, planning, decision-making, allocation of resources and formulation and enforcement of fishery regulations by which the fishery management authority controls the present and future behaviour of interested parties in the fisheries; in order to ensure the continued productivity of the living resources.

Fishery resource Any stock of aquatic living animals which can be caught by fishing (except those specifically prohibited by law), and their habitat.

Fishery-independent Characteristic of information (e.g. stock abundance index) or an activity (e.g. research vessels survey) obtained or undertaken independently of the activity of the fishing sector. Intended to avoid the biases inherent to fishery-related data.

Fishing Any activity, other than scientific research conducted by a scientific research vessel, that involves the catching, taking, or harvesting of fish; or any attempt to do so; or any activity that can reasonably be expected to result in the catching, taking, or harvesting of fish and any operations at sea in support of it (Modified from US Department of Commerce, 1996).

Fishing capacity Total number of fishing vessels used in the particular areas or particular fisheries. (SEAFDEC)

Fishing effort 1) Amount of fishing vessels and gears of a specific type (or numbers of fishing unit or total engine capacity of fishing unit) used in the fishing ground over a given unit of time. (SEAFDEC)

2) The overall amount of fishing (usually per unit of time) expressed in units such as boat days on the fishing ground, number of traps, or trawl hauls, or (gillnet length x soaking time), etc. The effort may be nominal, reflecting the simple total of effort units exerted on a stock in a given time period). It may also be standard or effective when corrected to take account of differences in fishing power and efficiency and ensure direct proportionality with fishing mortality). If more than one gear is considered, standardization in relation to one of them is necessary. For biologists, a good measure of fishing effort should be proportional to fishing mortality. For economists it should be proportional to the cost of fishing.

Fishing gear selectivity A property of the fishing gear that reduces or eliminates the capture of unwanted sizes or species of fish and the incidental catch. (SEAFDEC)

Fishing industry Includes both recreational, subsistence and commercial fishing, and the harvesting, processing, and marketing sectors.

Fishing intensity Effective fishing effort per unit area. It is proportional to fishing mortality

Fishing license It is an authorization given to individuals or companies to enable them to do fishing. (SEAFDEC)

Fishing mortality A mathematical expression of the rate of deaths in a fish stock caused by fishing. See: Natural mortality, Total mortality rate.

Fishing right A kind of right, by which fishers may have exclusive use for a designated area and resources. It is an authorization given to fishing communities to enable them to do fishing. (SEAFDEC)

Food security Situation where adequate supply of appropriate foods at affordable prices are ensured. (SEAFDEC)

Fishing vessel Any vessel, boat, ship, or other craft that is used for, equipped to be used for, or of a type that is normally used for the exploitation of living aquatic resources or in support of such activity. This definition may include any vessel aiding or assisting one or more vessels at sea in the performance of any activity relating to fishing, including, but not limited to, preparation, supply, storage, refrigeration, transportation, or processing (e.g. mother ships).

Flag State State having registered a vessel under the national flag.

Fleet The aggregation of units of any discrete type of fishing activity utilising a specific resource. Hence, for example, a fleet may be all the purse seine vessels in a specific sardine fishery, or all the fishers setting nets from the shore in a tropical multispecies fishery.

Frame survey A complete description of the structure of the primary fishery sector including an inventory of ports, landing places, number and type of fishing units (boats and gears), and a description of fishing and landing activity patterns, fish distribution routes, processing and marketing patterns, supply centres for goods and services, etc.

Gear In fisheries: equipment used in fishing operations for catching fish, such as hook and line, trawls, gill nets, traps, spear etc.

Geographic Information System (GIS) An information system that stores and manipulates data which is referenced to locations on the earth's surface, such as digital maps and sample locations.

Geo-referenced data Data which is connected to a specific location on the earth's surface.

grade 1 fish The best quality of fish in the grading system used in Cambodian official fisheries statistics; first grade fish is supplied fresh to consumers; the grading is based on species, size and freshness. Other grades are grade 2, middle quality that is provided fresh to consumers, and grade 3 that is poorest quality mainly used for processing into fish paste.

High Seas Fishing Fishing in the open part of the sea or ocean, the sea or ocean lying outside the territorial waters or maritime belts of a country.

Home port Refer to base port described above. Boat and gear activities are sampled from homeports or base ports, in contrast to catches and species composition, prices, etc. that are sampled at landing sites.

Household A basic unit for socio-cultural and economic analysis. It includes all persons, kin and non-kin, who live in the same dwelling and share income, expenses and daily subsistence tasks.

Illegal fishing gear and practices Fishing gear (including its accessories) and practices that are prohibited by laws, rules and regulations. (SEAFDEC)

Index of abundance A relative measure of the abundance of a stock; e.g. a time series of catch per unit of effort data.

I**ndicator** A performance-based variable, measure or index that provides information on the condition and status of fisheries and fisheries resources. (SEAFDEC)

Information system A structured set of processes, people and equipment for converting data into information.

inland fishery Freshwater fishery; of extraordinary importance in the Mekong Basin both in terms of food security and in tonnage, however often severely underestimated due to unreliable statistics; especially important in Cambodia and Lao PDR where the contribution by marine fish is insignificant.

Innovative Fisheries Management Decentralization of selected fisheries management functions to the local level and progressive introduction of rights-based fisheries management through licensing and community fishing rights, the improvement of vessel registration systems and the development of supporting legal and institutional frameworks. (SEAFDEC)

Input control system (effort control) Control of amount of effort and capacity which can be put into a fishery. (SEAFDEC)

International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) Code system used in the FAO Year Books and in FAO Aquaculture Production Statistics.

Landing price Price for a product at the landing point, not taking account of any transportation or handling costs. Equivalent to the "farm gate" price for aquaculture.

Landing site Location at which boats land their catch. A landing site may be the same as the homeport or base port but it can also be different. Boat and gear activities are sampled from homeports or base ports, in contrast to catches and species composition, prices, etc. that are sampled at landing sites.

Landings Weight of the catch landed at a wharf or beach.

Life table A table summarizing statistics of a population, such as survival and reproduction, all broken down according to age classes.

Limit Reference Point (LRP) Indicates the limit beyond which the state of a fishery and/or a resource is not considered desirable. Fishery development should be stopped before reaching it. If an LRP is inadvertently reached, management action should severely curtail or stop fishery development, as appropriate, and corrective action should be taken. Stock rehabilitation programmes should consider an LRP as a very minimum rebuilding target to be reached before the rebuilding measures are relaxed or the fishery is re-opened. See: Reference point, Target Reference Point.

Logbook A record of the fishing activity registered sistematically by the fisher, including catch and its species composition, the corresponding effort, and location. In many fisheries completion of logbooks is a compulsory requirement of a fishing licence.

Local Ecological Knowledge (LEK) Area specific ecological knowledge. Fishers for example have a very detailed knowledge about the biology of the fish occurring in the area where they are normally fishing. This knowledge can be extremely useful for biologists because it has been gathered over many decades, sometimes even over several generations, and it is often surprisingly detailed. LEK has significantly improved our knowledge of fish migrations, spawning and other aspects of fish biology in the Mekong Basin; similar to traditional ecological knowledge (TEK).

Major stratum Conventional name describing various types of population groupings that are already in place and imposed on a data collection programme. They constitute standard aggregating levels of derived estimates for reporting purposes. Estimates are always produced at minor stratum and not at major stratum level.

Management authority The legal entity which has been assigned by a State or States with a mandate to perform certain specified management functions in relation to a fishery, or an area (e.g. a coastal zone). Generally used to refer to a state authority, the term may also refer to an international management organisation.

Management objective A formally established, more or less quantitative target that is actively sought and provides a direction for management action. For example, achieving a 40% reduction in fleet capacity, or ensuring a competitive income for individual fishers.

Marine parks A marine reserve, that allows multiple uses through zoning where conservation-oriented recreation, education and research are emphasized. (SEAFDEC)

Marine protected areas A marine area (including offshore and coastal habitats) set aside by law or any other effective means to conserve and protect part or the entire enclosed environment and where management guidelines are established. (SEAFDEC)

Maximum sustainable yield (MSY) Highest yield of fish that can be harvested on a sustainable basis from a fish stock by a given number of fishing efforts within a period of time under existing environmental conditions. (SEAFDEC)

Median the middle number (for an odd number of values) or the arithmetic mean of the two middle values (for an even number of values) for a set of numbers arranged (sorted by size)

Minor stratum Conventional name describing various types of logical population partitioning into homogeneous population sub-sets defined by the survey planner with the purpose of increasing the precision of estimated population parameters. Estimates are always produced at minor stratum level.

Modal Relating to the statistical mode, which is the value that occurs most frequently in a series of numbers; e.g., if, in a species of fish, two individuals have 14 pectoral-fin rays, seven have 15 rays, and four have 16 rays, 15 is the modal count.

Monitoring The collection of information for the purpose of assessment of the progress and success of a land use (or fishery management) plan. Monitoring is used for the purpose of enforcement and of revising the original plan, or to gather information for future plans.

Monitoring, Control and Surveillance (MCS) System A system that ensure the monitoring, control and surveillance of fishing activities. Monitoring involves the requirement of continuously observing, collecting, measuring and analyzing data and information on fishing activities. Control refers to specifying the regulatory conditions (legal framework) under which the exploitation, utilization and disposition of the resources may be conducted. Surveillance involves the degree and types of observations required to maintain compliance with regulations. (SEAFDEC)

MT Metric Tons, a unit of mass and weight equal to 1000 kilograms.

Nationality of catch The flag of the vessel performing the essential part of the operation catching the fish, should be considered the paramount indication of the nationality assigned to the catch data and this indication overridden only when one of the following arrangements between a foreign flag vessel and the host country exists (a) the vessel is chartered by the host country to augment its fishing fleet; or (b) the vessel fishes for the country by joint venture contract or similar agreements (as opposed to the ad hoc practice of a vessel selling catches to a foreign vessel or landing catches at a foreign port) and the operation of such vessel is an integral part of the economy of the host country. When governments negotiate joint ventures or other contracts in which vessels of one country land their catches at ports of another country or unload their catches to vessels of another country and the one of the above-mentioned criteria is applicable, the assignment of nationality to such catches and landings data should be specified in the agreement.

Natural mortality That component of total mortality not caused by fishing, but by natural causes such as predation and diseases. Usually expressed as annual mortality rate M, i.e., the fish dying during the year expressed as fraction of the fish alive at the beginning of the year. For example, M 0.5 means that half of the fish alive at the beginning of the year will die during that year. See: Fishing mortality, Total mortality rate.

New Fisheries Fisheries of under-utilized or not yet exploited resources. (SEAFDEC)

Nominal catch The sum of the catches that are landed (expressed as live weight equivalent). Nominal catches do not include unreported discards and may differ considerably from the actual catch.

Observer Any certified person serving in the capacity of an observer employed by the Management Authority, either directly or under contract. Usually embarked on large fishing vessels (principally but not exclusively foreign vessels), observers are responsible for monitoring fishing operations (e.g. areas fished, fishing effort deployed, gear characteristics, catches and species caught, discards, etc.). They may or may not be part of the enforcement system.

Observer data Fisheries information collected on-board fishing vessels by independent observers.

Open-access regime A condition of a fishery in which anyone who wishes to fish may do so. (SEAFDEC)

Outlier An outlier is an observation in a data set which is far removed in value from the others in the data set. It is an unusually large or an unusually small value compared to the others. An outlier might be the result of an error in measurement, in which case it will distort the interpretation of the data, having undue influence on many summary statistics, for example, the *mean*. If an outlier is a genuine result, it is important because it might indicate an extreme characteristic of the process under study. For this reason, all outliers must be examined carefully before embarking on any formal analysis. Outliers should not routinely be removed without further justification.

Output control system (catch control) Control of catch which can be taken from a fishery. (SEAFDEC)

Parameter A constant or numerical description of some property of a population (which may be real or imaginary), used mainly in statistics and computer science.

Performance Accomplishment; fulfilment; functioning, usually with regard to effectiveness. Indicators of performance will be interpreted in relation to reference points and objectives.

Phenogram A graphical means of depicting genetic relationships among populations in the form of a branching tree (also often referred to as a dendrogram). The phenogram is generated from summary statistics, such as genetic distances or similarities, and shows the results of clustering these populations based on these statistics. A clustering algorithm commonly used to generate phenograms from genetic distances or similarities is the unweighted pair group method with averages (UPGMA).

Policy A specific decision or set of decisions with related actions.

Population A population is any entire collection of people, animals, plants or things from which we may collect data. It is the entire group we are interested in, which we wish to describe or draw conclusions about.

Precautionary approach According to the Rio Declaration on Environment and Development, signed in 1992, where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. 1) Set of measures taken to implement the precautionary principle. 2) A set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent- foresight, reduces or avoids risk to the resource, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the potential consequences of being wrong.

Quota Amount of catch allocated; could refer to a fishery as a whole; or to that amount allocated to an individual or company of the total allowable catch from a stock. Quotas may or may not be transferable, inheritable, and tradable. While generally used to allocate total allowable catch, quotas could be used also to allocate fishing effort or biomass.

Recreational fishing Any fishing for which the primary motive is leisure rather than profit, the provision of food or the conduct of scientific research. and which may not involve the sale, barter, or trade of part or all of the catch.

Reference point 1) An estimated value derived from an agreed scientific procedure and/or model, which corresponds to a specific state of the -resource and of the fishery, and that can be used as a guide for fisheries management. Reference points may be general (applicable to many stocks) or stock-specific. 2) A reference point indicates a particular state of a fishery indicator corresponding to a situation considered as desirable (Target Reference Point) or undesirable and requiring immediate action (Limit Reference Point).

Resources Biological resources include genetic resources, organisms or parts thereof, populations or any other biotic component of ecosystems with actual or potential use of value for humanity. Fishery resources are those resources of value to fisheries.

Resource enhancement Intervention aimed at supplementing, augmenting or adding to the present population of fish by re-stocking or installation of structures such as artificial reefs and closed areas. (SEAFDEC)

Responsible fisheries A concept encompasses the sustainable utilization of fisheries resources in harmony with the environment; the use of capture and aquaculture practices that are not harmful to ecosystems, resources and their quality; the incorporation of added value to such products through transformation process meeting the required sanitary standards; the conduct of commercial practices so as to provide consumers access to good quality products. (SEAFDEC)

Responsible fishing technology Techniques or methods of fishing that are not detrimental to or do not impair the sustainability of fish stocks and their habitats and ecosystems. (SEAFDEC)

Right-based fisheries Fisheries where the right to fish or use the fisheries resources is licensed or permitted by the competent government authority, giving the licensed fishers access and use rights to the fishing ground. Such rights are accompanied by obligations to comply with the rules and regulations of the right-based regime. (SEAFDEC)

Round weight The weight of the whole fish before processing or removal of any part.

Sample A subset of a population; a value or number of values that constitute a subset of a population; it is used to describe attributes of the population through a number of indicators, like the mean and the variance

Sample design The sample design of a sample survey refers to the techniques for selecting a probability sample and the methods to obtain estimates of the survey variables from the selected sample.

SEAFDEC South East Asian Fisheries Development Center, an autonomous intergovernmental body established as a regional organization in 1967 to promote fisheries development in Southeast Asia.

Shared stock Fish species that migrate within an EEZ but extend their migration to other nation's EEZs. (SEAFDEC)

Skewness Skewness is defined as asymmetry in the distribution of the sample data values. Values on one side of the distribution tend to be further from the 'middle' than values on the other side. If there is evidence of skewness in the data, we can apply transformations, for example, taking logarithms of positive skew data.

Spawning stock The part of a stock which is mature and breeding.

Spawning Stock Biomass (SSB) The total weight of all sexually mature fish in the population (both males and females). This quantity depends on the abundance of year classes, the exploitation pattern, the rate of growth, both fishing and natural mortality rates, the onset of sexual maturity, and environmental conditions.

Species group Group of species considered together, often because they are difficult to differentiate without detailed examination (very similar species) or because data for the separate species are not available (e.g. in fishery statistics or commercial categories).

Stakeholders Individuals or groups of individual who are involved in utilization of fishery resources and have interests in the fisheries. (SEAFDEC) More general it includes a large group of individuals and groups of individuals (including governmental and non-governmental institutions, traditional communities, universities, research institutions, development agencies and banks, donors, etc.) with an interest or claim (whether stated or implied) which has the potential of being impacted by or having an impact on a given project and its objectives. Stakeholder groups that have a direct or indirect stake can be at the household, community, local, regional, national, or international levels.

Standard Error Standard error is the standard deviation of the values of a given function of the data (parameter), over all possible samples of the same size.

State of the stock An appreciation of the situation of a stock, usually expressed as protected, under-exploited, intensively exploited, fully exploited, over- exploited, depleted, extinct or commercially extinct.

statistical analysis Process of applying statistical methods to obtain meaningful information from data collected. The analysis includes standard mathematical approaches that can be applied to data sets and leads to quantifiable estimates.

Straddling fish stock Fish species which are distributed or migrate within and beyond the EEZs during their life cycle. (SEAFDEC)

Stratified Sampling There may often be factors which divide up the population into sub-populations (groups / strata) and we may expect the measurement of interest to vary among the different sub-populations. This has to be accounted for when we select a sample from the population in order that we obtain a sample that is representative of the population. This is achieved by stratified sampling. A stratified sample is obtained by taking samples from each stratum or sub-group of a population.

Stock Group of individuals of a species which can be regarded as an entity for management or assessment purposes; a separate breeding population of a species; term used to identify a management unit of fishery species.

Stock assessment The process of collecting and analyzing biological and statistical information to determine the changes in the abundance of fishery stocks in response to fishing, and, to the extent possible, to predict future trends of stock abundance.Stock assessments are based on resource surveys; knowledge of the habitat requirements, life history, and behaviour of the species; the use of environmental' indices to determine impacts on stocks; and catch statistics. Stock assessments are used as a basis to assess and specify the present and probable future condition of a fishery. Applied widely but of limited use especially in river fisheries.

Subsistence fishery Fishery where the fish caught are consumed directly by the families of the fishers rather than being bought by middle-(wo)men and sold at the next larger market. [This constitutes the most significant part of most inland fisheries].

Survey design The overall survey design of a probability survey refers to the definitions and the established methods and procedures concerning all phases needed for conducting the survey the sample design, the selection and training of personnel, the logistics involved in the management of the field force and the distribution and receipt of survey questionnaires and forms, and the procedures for data collection, processing and analysis.

Sustainable development 1) The process of (economical) growth to become larger or more advanced which is maintained at a certain level, using means to avoid long-term collapse.
2) "Management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Such sustainable development conserves (land) water, plants and (animal) genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable" (FAO Council in 1991).

Sustainable use The exploitation of natural resources in a way and at a rate that does not lead to the long-term decline in biological diversity, and allows for the continued use by present and future generations.

Sustainable yield The number or weight of fish in a stock that can be taken by fishing while maintaining the stock's biomass at a steady level from- year to year, assuming that environmental conditions remain the same. Sustainable yields can take all sorts of values from very low in underexploited or overexploited fisheries to very high in properly exploited ones. Difficult to achieve in practice due to environmental fluctuations.

Target Reference Point (TRP) Corresponds to a state of a fishery and/or a resource which is considered desirable. Management action, whether during a fishery development or a, stock rebuilding process should aim at bringing and maintaining the fishery system at this level. In most cases a TRIP will be expressed in a desired level of output for the fishery (e.g. in terms of catch) or of fishing effort or capacity and will be reflected as an explicit management objective for the fishery. See: Limit Reference Point, Reference point.

Target species Species primarily sought or aimed at by the fishers. (SEAFDEC)

Total Allowable Catch (TAC) Total catch allowed to be taken from a resource in a specified period (usually a year), as defined in the management plan. The TAC may be allocated to the stakeholders in the form of quotas as specific quantities or proportions.

Total mortality rate (Z) The combined effect of all sources of mortality acting on a fish population. This is conveniently expressed in terms of instantaneous mortality rates because the total instantaneous mortality rate is simply the sum of the instantaneous fishing and natural mortality rates. For example, the total instantaneous mortality rate that is occurring when the instantaneous fishing. mortality rate is 0.3 and the instantaneous natural mortality rate is 0.2 would be 0.5. See: Fishing mortality, Natural mortality.

Traditional Ecological Knowledge (TEK) See local ecological knowledge.

Transboundary fish stock Fish species which migrate freely across the national boundaries in their life cycle. (SEAFDEC)

Transshipment Act of transferring the catch from one fishing vessel to either another fishing vessel or to a vessel used solely for the carriage of cargo.

Trash fish Fish with little or no commercial value and not sorted by species before landing. Usually part of the trawlers' by-catch. It can be used for aquaculture, fishmeal production and in many developing countries, for human consumption. As opposed to marine fisheries this is very rarely seen in freshwater fisheries where everything caught is being used.

trend (1) A statistical term referring to the direction or rate of increase or decrease in magnitude of the individual members of a time series of data when random fluctuations of individual members are disregarded.
(2) A unidirectional increasing or decreasing change in the average value of a variable.

Tropical Fisheries Fisheries that are multi-species and multi gear in nature. (SEAFDEC)

Under-utilized resources Resources that are not harvested to full potential due to limitations to stock access including inappropriate fishing gear and vessels, inadequately trained fishers, lack of markets or processing facilities and seasonal limitations. (SEAFDEC)

Variable Anything that can change, a quantity that varies.

Variance The (population) variance of a random variable is a non-negative number which gives an idea of how widely spread the values of the random variable are likely to be; the larger the variance, the more scattered the observations on average.

Vessel Monitoring System (VMS) VMS provides monitoring agencies with accurate locations of fishing vessels that are participating in the VMS. It tells the monitoring agency see new guidelines.

Yield The weight or number of fish removed by fishing during a defined time period. Catch and yield are often used interchangeably

CHAPTER VII
REFERENCES

This handbook have been prepared using a wide variety of sources that have not always been credited in the main text. This has been done mainly to improve the readability of the text. Below, all references that have been consulted for writing this document have been listed. In addition several references have been included in the Recommended Further Reading sections included in this document, they are not reproduced in below listing.

The FAO Guidelines for the routine collection of capture fisheries data has been used extensively to prepare the sections on variables and methods. Various material has contributed to the section on catch assessment, most notably material prepared by Dirk Reyntjes for two separate projects in Ethiopia and Bangladesh as well as material prepared by Constantine Stamatopoulos.

Since most fisheries scientists and fisheries statisticians are not familiar with marketing and consumption data below list contains some suggested reading to get acquainted and beyond. Unfortunately most of the marketing references are quite dated, both in content and age. The actual process of collecting information is best covered in Brummett (2000). The other papers (Murdoch various and Maxwell various) give a good background to important matters but are not practical based.

For consumption, Bayley 1989 and Hortle and Bush 2003 are some important references for *inland fisheries*. For marine fisheries there are only very few separate reports available.

Bayley, P. B. and M. Petrere, 1989. "Amazon Fisheries: Assessment Methods, Curent Status and Management Options." Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci.: 385-398.

Bouis, H. E., 1993. Food Consumption Surveys: How Random Are Measurement Errors. Data needs for food policy in development countries: new directions for houshold surveys. J. von Braun and D. Puetz. Washington, D.C., International Food Policy Research Institute: 219-231.

Brummett, R. E., 2000. "Factors influencing fish prices in Southern Malawi." Aquaculture 186: 243-251.

Bush, S. R., 2001. Review of Fish Marketing and Trade in Cambodia. Vientiane, Lao PDR, Assessment of Mekong Fisheries Component, Mekong River Commission: 17.

Bush, S., 2000. Social and Spatial Structure of the Aquatic Resources Market Networks of Travinh Province, Vietnam. Pilot study report. MRC AMF Component document. 15 pp.

Bush, S. R., 2002. Comparative advantage: changing market structures and food security in the Siphandone fishery, Lao PDR. International Symposium Sustaining Food Security and Managing Natural Resources in Southeast Asia - Challenges for the 21 st Century, Chiang Mai, Thailand.

Bush, S. R., 2002. Review of Fish Marketing in Lao PDR. Vientiane, Lao PDR, AMFC, Mekong River Commission: 49.

Bush, S. R. (In Press.). "Scales and Sales: changing fish marketing networks in the Siphandone fishery, Lao PDR." Journal of Tropical Geography Singapore.

Caddy, J. and Bazigos, G. (1985) Practical guidelines for statistical monitoring of fisheries in manpower limited situations. FAO Físh. Tech. Pap. No. 257. Rome FAO, 86p.

Chan, H. M., M. Trifonopoulos, A. Ing, O. Receveur and E. Johnson, 1999. "Consumption of Freshwater Fish in Kahnawake: Risks and Benefits." Environmental Research Section A 80: S213-S222.

Coates, D. and T.A.M. Visser, 2000. Guidelines for the Baseline Fisheries Survey. Songkhram river basin, Thailand. MRC AMF component document, 53 pp.

Coates, D., 2002. Inland capture fishery statistics of Souteast Asia: Current status and information needs. Asia-Pacific Fishery Commission, Bangkok, Thailand. RAP Publication No. 2002111~ 114 p.

Cowx, I.G., 2003. Improving Fisheries Catch Statistics in Lake Victoria. In: New Approaches for the Improvement of Inland Capture Fishery Statistics in the Mekong Basin. FAO RAP Publication 2003/01, 145 pp.

Crispoldi, A., 2000. Inland Fisheries and freshwater aquaculture productino statistics in Asia/Pacific - Some suggestinos for their improvement. APCAS (Asia Pacific Commission on Agriculture Statistics), 18th Session, Bali, 6-10 November 2000.

Dubeau, P., Y. Dara, C. Piseth, P. C. Thyda, L. Saroeun and P. Degen, 2002. Fishing and Livelihood Strategies in Phlong Village Analysis of Long-term Study of Economic and Social Activities (Dec. 1999 - Jan. 2001) Khampong Chhnang Province, Cambodia. Project for Management of the Freshwater Capture Fisheries of Cambodia, Mekong River Commission, Phnom Penh. 72

FAO, 1999. Guidelines for the routine collection of capture fisheries data. Prepared at the FAO/DANIDA Expert Consultation. Bangkok, Thailand 18-30 May 1998. FAO Fisheries Technical Paper: No. 382. Rome, FAO. 1999. 113 pp.

FAO, 2003. New approaches for collection of inland fishery statistics. Ad Hoc expert consultation, Udon Thani, Thailand 2 to 5 September 2002, Food and Agriculture Organisation of the United Nations RAP Publication 2003/01, 145 p.

Freund, J.E., and G.A. Simon, 1997. Modern Elementary Statistics. Ninth edition. Prentice-Hall International, Inc. New HJersey, USA, 612 pp++.

Gereffi, G. and M. Korzeniewicz (1994). Commodity Chains and Global Capitalism. Westport, CT, Praeger.

Gulland, J.A. 1966. Manual for sampling and statistical methods for Fisheries Biology. FAO Manuals in Fisheries Science No. 3. Food and Agriculture Organisation of the United Nations, Rome 1966, 87 pp.++

Hortle, K.G. and S.R. Bush, 2003. Consumption in the Lower Mekong Basin as a Measure of Fish Yield. In: New Approaches for the Improvement of Inland Capture Fishery Statistics in the Mekong Basin. FAO RAP Publication 2003/01, 145 pp.

Leslie, D. and S. Reimer, 1999. "Spatializing commodity chains." Progress in Human Geography 23(3): 401-420.

Librero, A.R., 1985. Marketing Systems for fish in the Philippines. Small Scale Fisheries in Asia: Socioeconomic Analysis and Policy. T. Panayotou. Ottawa, Canada, IDRC: 197-201.

Maxwell, S., 1996. "Food security: a post-modern perspective." Food Policy 21(2): 155-170.

Mitchell D.C., S.S. Jonnalagadda, H. Smiciklas-Wright, K.B. Meaker and P.M. Kris-Etherton, 1996. Accuracy of portion size estimation using the 2-dimensional food portion visual. FASEB Journal, 10(3), abstracted in www.ncc.umn.edu/abstract/abs138.htm.

MRC, 2003. Mekong Fish Database version 2003. CD-ROM, Mekong River Commission, Phnom Penh, Cambodia.

Murdoch, J., 1995. "Actor-networks and the evolution of economic forms: combining description and explination in the theories of regulation, flexible specialisation, and networks." Environment and Planning A 27: 731-757.

Murdoch, J., 1997. "Inhuman/nonhuman/human: actor-network theory and the prospects for a non-dualistic and symmetrical perspective on nature and society." Environment and Planning D: Society and Space 15: 731-756.

Murdoch, J., 1997. "Towards a geography of heterogeneous associations." Progress in Human Geography 21(3): 321-337.

Murdoch, J., 1998. "The Spaces of Actor-Network Theory." Geoforum 29(4): 357-374.

Reyntjes, D., 1997. Handbook for Fisheries Officers. Lake Fisheries Development Project Phase II, working paper No. 24, 92 pp.++

Sechena R., C. Nakano, S. Liao, N. Polissar, R. Lorenzana, S. Truong and R. Fenske, 1999. Asian and Pacific Islander Seafood Consumption Study in King County, WA. USEPA 910/R-99-003. 169 pp.

Shimizu H., H. Ohwaki, Y. Kurisu, N. Takatsuka, M. Ido, N. Lawakami, C. Nagata and S. Inaba, 1999. Validity and reproducibilìty of a quantitative food frequency questionnaire for a cohort study in Japan. Japanese Journal of Clinical Oncology 29(1): 38-44. Available on www.ncc.go.jp/en/jjco.

Stamatopoulos, C., 2002. Sample-Based Fishery Surveys - A Technical Handbook. FAO Fisheries Technical Paper: No.425, FAO Rome, 76 pp.

Sparre, P. and S.C. Venema, 1992. Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper: No. 306, Rev. 1. Rome FAO, 376 pp.

Swindale A. and P. Ohri-Vachaspati, 1999. Measuring Food Consumption: a Technical Guide. FANTA Project, Academy for Educational Development, Washington DC 14 pp. Available www.fantaproject.org.

Visser, T.A.M., 1997. The Collection Of Fishery Statistical Data. Paper prepared for TCP/MYA/4553, FAO RAP Bangkok, 21 pp.

Visser, T.A.M.,J.Valbo-Jørgensen and T. Ratanachookmanee, 2003. MFD 2003, Introduction and data sources. Mekong River Commission, Phnom Penh, Cambodia 63 pp.

Examples of Survey Formats

In the following pages a number of example survey forms are included that are either taken from a number of surveys that have been implemented in South East Asia, or have been adapted from a number of sources.

The survey form examples are not intended as examples to be followed with out adapting them to local situations or information requirements, but can act as a reference of what can be included in survey formats.

The survey formats have mainly been based on the work by the Mekong River Commission's Fishery Programme together with riparian line-agencies in the Mekong river basin.

generalised formats for catch assessment using sample surveys for catch and effort (including frame survey):
Annex 1 frame survey data
Annex 2 catches and landings
Annex 3 collection of effort data

Two logbook formats used for similar purposes (catch monitoring), but with different emphasis (species vs catch amount and post harvest):
Annex 4 log sheet migration monitoring
Annex 5 Catch assessment logbook sheet

Assorted economic and livelihood survey forms:
Annex 6 employment questionnaire (for wage labour with companies etc)
Annex 7 marketing log sheets (series of formats for marketing studies)
Annex 8 consumption form (household interview survey)
Annex 9 Fishery activities form (individual interview survey)

Annex I Frame survey form

Landing Site name:		**Date:**	
Name:		**Enumerator 1**	
Village:		**Enumerator 2**	
District:			
Province:		**GPS**	
	Boat/Gear category:	**# Boats:**	**# Gears:**

	Name # 1	...	...
	Name # 2	...	...
	Name # 3	...	...
	Name # 4	...	...
	etc.		

Landing Site name:		**Date:**	
Name:		**Enumerator 1**	
Village:		**Enumerator 2**	
District:			
Province:		**GPS**	
	Boat/Gear type:	**# Boats:**	**# Gears:**

	Name # 1	...	...
	Name # 2	...	...
	Name # 3	...	...
	Name # 4	...	...
	etc.		

Annex II Catches and landings

DATA COLLECTION FORM FOR LANDINGS

Site		**Boat/gear category**			
Date		**Time**			
# boats		**# gears**		**# days**	

Supplementary information

Extrapolated weight		**Enumerator**	
Boat name		**Registration #**	
Fishing ground			
Observations			

Species Name	**code**	**Weight**	**Price**	**Value**	**# of fish**
Species 1					
Species 2					
Species 3					
etc.					

Annex III Collection of effort

DATA COLLECTION FORM FOR BOAT/GEAR ACTIVITIES

Site		
Date		
Time		
Enumerator		

Boat/gear category		**Active boats**				**Active gears**		
motorized	**bottom gill net**		**of**				**of**	
unmotorized	**bottom gill net**		**of**				**of**	
motorized	**drift net**		**of**				**of**	
unmotorized	**drift net**		**of**				**of**	
motorized	**trammel gill net**		**of**				**of**	
unmotorized	**trammel gill net**		**of**				**of**	
motorized	**tiger mouth**		**of**				**of**	
unmotorized	**tiger mouth**		**of**				**of**	
etc.								

Annex IV Migration monitoring log sheet

MRC Assessment Fishing logbook		Date:	/ /			No fishing today ○	
Fisher	(pre-printed)	○	Gill nets	○	Gear 4	Hours Fishing	
Village	(pre-printed)	○	Gear 2	○	Gear 5		
District	(pre-printed)	○	Gear 3	○	Other:		
Province	(pre-printed)	time of day			weather		
Habitat	Mekong river	○	○	○	○	○	○ ○ ○
Other							

Species			Number of fish		weight			length	
Code	Local name		No	Unit	Min	Max	Total	Min	Max
	(pre-printed)	○							
		○							
		○							
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Annex V Daily Fish Catch Logbook4

VCFC[5]: …… **Date**[6]:……

1. Did you go fishing? **Yes** □ **No** □ (if **No** please go to 2.)
(including catching of other aquatic animals)

1.1. Where did you go to fish? What type of gear did you use? Which species did you catch?
(Please tick and fill in details)

Place of fishing:	**Gears used**	(fish) **species** (including other aquatic animals):
Pond □	……	
	……	
	……	
Canal□	……	
	……	
	……	
Stream	□ ……	……
	……	
	……	
Wet rice	□ ……	……
	……	
	……	
Dry rice	□ ……	
	……	
	……	
Reservoir	□ ……	
	……	
	……	
Other place	□ ……	……
	……	
	……	

1.2. When did you catch?	**Morning** □	**Afternoon** □	**Evening** □	**Night** □
1.3. Time spend on catch?	……	……	……	……
1.4. How much did you catch?				
* **fish**:	……kg	……kg	……kg	……kg
* **other aquatic animals**:	……kg	……kg	……kg	……kg

2. Did you spend any time on:
- Construction/mending/buying fishing gear? **Yes** □ **No** □
- Mending or buying boat for fishing? **Yes** □ **No** □ (if **yes**, please continue)

2.1. How much time did you spend on it? ……

3. What is the post-harvest use of the catch?
Eat……kg **Sell**……kg **Gift**……kg **Processing**……kg **Other**……kg

[4] Survey form as used in Khmer translation in 12 month Cambodian floodplain survey
[5] Village Code and Fisher Code, pre-printed for each participating fisher linked with general information on age and location
[6] pre-printed for each date during survey period

Annex VI Employment Questionnaire

1. Name of Company:……. CSC[7] ……...

2. Year of establishment ……

3. Indicate sector of operations:
Fishing □ processing □ marketing □ transport □ support industry □

4. Type of company:
Co-operative □ family business □ State owned company □ listed[8] □

5.1 Total number of employees (who are paid in cash or kind[9]): ……
Male: …… Female: ……

5.2 Indicate number of wage labourers:

Full-time ……	Male: ……	Female: ……
Part-time ……	Male: ……	Female: ……

5.3 Is employment seasonal? **Yes** □ **No** □

If yes, indicate period with largest number of seasonal employees: ……
Are the employees recruited locally: **Yes** □ **No** □

6. State name and position of person filling out this form:

Name: ……. Position: …….

[7] Pre-printed Company Survey Code
[8] Listed as public company with stocks issued
[9] or receiving a catch share

Annex VIIa Market Manager Interview Form

Date: / /

1. Location

Name of Market: …… Year established: …….
GPS location: …… Number of Managers:……
Village:…… Sub-District:……
District:…… Province: ……
Country: …… Market Code: …….

2. Description

How many traders are there in this market? ☐

How many fish traders are there in this market? **Registered** ☐
Non-Registered ☐

Where do the fish that are sold in this market come from?

☐

Do traders pay a fee to trade in this market? **YES** How Much: ☐ **NO**

Do traders always sit in the same position in market or do they move around from day to day?

Different Position ***Same Position***

Are the same traders here everyday? **YES** **NO**

Average trade per day (in value)? ☐

Do you keep records of prices or quantities? **YES** **NO**
If YES What records? ☐

What percentage of **traders** in this market are: **WOMEN** ☐ **MEN** ☐

What percentage of **fish traders** in this market are: **WOMEN** ☐ **MEN** ☐

What have been the changes in the way that fish are traded in the last 10 years?

☐

What is the **area** of the market? ☐

Annex VIIb Fish Trader Interview Form

Date / / Market Code:……

1. Flow of Trade

Where do you live?_____
Where does your family come from? _____
How long have you traded fish?_____ Age ____
What is your primary position in the fish trade? (Circle one)

Collector Broker Wholesaler Retailer

Are you: **Registered Non-Registered**

What other roles do you have in the fish trade? (Circle: can answer more than one)

Fisher/Farmer Collector Broker Wholesaler Retailer

Do you work: **Full-time Part-time**

How many people do you employ? **0-5 6-10 11-15 16-20 >20**

Does this change through the year? When?

How many are MALE: **0-5 6-10 11-15 16-20 >20**
How MANY are FEMALE: **0-5 6-10 11-15 16-20 >20**

Do you have a (business) partner **YES NO**

How many: **1 2 3 4 >4**

Do you sell your fish from: **Market Shop in market Shop outside market**

Does this ever change? When?

Which of the following do you own/rent in your business and how many of each:

	Own	Rent		Own	Rent
____Truck			**___ Boat < 50 hp**		
____Refrigerated truck			**___ Boat > 50 hp**		
____Motorbike			**___ Car**		

2. BUYING

A. Where do the people you buy fish from live? Town, District, Province

Town, District, Province	Product	Amount and Price/kg

B. If you buy your fish locally, which if the following do you buy fish from? Please Indicate how many of each

____FISHERS
____FARMERS
____COLLECTORS
____DISTRICT TRADERS
____PROVINCIAL TRADERS
____COMPANIES: name(s)_____

C. If you buy your fish from other areas, which if the following do you buy fish from? Please Indicate how many of each

____FISHERS
____FARMERS
____COLLECTORS
____DISTRICT TRADERS
____PROVINCIAL TRADERS
____COMPANIES: name(s)_____

D. Do you always buy from the same people? **YES** **NO**

Why Yes/No? If YES, for how long and **How** did you start?

Do you loan money to the people that you buy from? **YES** **NO**

If yes do you loan money in the following ways:

____ADVANCE ON GOODS
____LONG-TERM LOAN
____SHORT-TERM LOAN

Do the traders that you lend money to only sell to you? **YES** **NO**

3. SELLING

A. Where do you sell your fish? Town, District Province

Town, District, Province	**Product**	**Amount and Price/kg**

B. Which if the following do you sell fish to? Please Indicate how many of

Selling Locally:

___FISHERS
___FARMERS
___COLLECTORS
___DISTRICT TRADERS
___PROVINCIAL TRADERS
___COMPANIES:
name(s)_____

Selling Other Areas:

___FISHERS
___FARMERS
___COLLECTORS
___DISTRICT TRADERS
___PROVINCIAL TRADERS
___COMPANIES:
name(s)_____

C. Do you borrow money from the people that you sell to? **YES** **NO**
Do you borrow money in the following ways:

____ADVANCE ON GOODS
____LONG-TERM LOAN
____SHORT-TERM LOAN

D. Do you always sell to the same people? **YES** **NO**

Why Yes/No?

If YES, for how long and **How** did you start?

E. Who pays for the transport of the fish? **YOU** **THEM**

F. How much does it cost to send the fish?

4. PRICING OF FISH

What are the determinants of fish price?

BUYING	SELLING
____Market price of fish	____Market price of fish
____Cost of transport and storage	____Cost of transport and storage
____Number of middlemen to buy from	____Number of buyers
____Your relationship with the seller	____Your relationship with the buyer
____Species available	____Species available
____Volume of fish	____Volume of fish demanded
____Quality of fish: Freshness, colour meat	____Quantity or Scarcity of fish available
____Price dictated by people you buy from	____Price of fish dictated by customer
OTHER:_____	OTHER:_____

What are the ways of setting the price?

What fish are more expensive? AQUACULTURE FISH CAPTURE FISH
Why? _____Taste _____Colour _____Health
_____Other:_____

What classes of fish do you sell:

FIRST CLASS **SECOND CLASS** **THIRD CLASS**

5. COMPOSITION OF TRADE

What types of products do you trade? (Please Tick)

___FRESHWATER CULTURE FISH ___FRESHWATER CAPTURE FISH
___SALTWATER CAPTURE FISH ___FRESHWATER CAPTURE SHRIMP
___FRESHWATER CULTURE SHRIMP ___SALTWATER CULTURE SHRIMP
___SALTWATER CAPTURE SHRIMP ___OTHER:_____

Annex VIIc Marketing Log Sheet

Bought/Sold	Species/ Product	AC or WC	Amount	Price/kg	Sold to Bought From	Location

Annex VIII Consumption Interview Survey Form

Section 1. Quantification of protein consumed

1.	Quantity fresh fish and aquatic animals consumed by HH per week			Source[1] %			
				C	**AR**	**P**	**G**
	Wet season	kg					
	Dry season	kg					

2.	Indicate the percentage of each category of fish and aquatic animals consumed			
	Marine	**Inland**		
		Fish	Shrimps	Other aquatic organisms
Wet season				
Dry season				

Section 2. Quantification of processed fish consumed

Quantity processed fish and aquatic animals consumed by household per week											
			Source[1] %					Source[1] %			
	Type	Dry season	**C**	**AR**	**P**	**G**	Wet season	**C**	**AR**	**P**	**G**
i.	Fish paste	kg					kg				
ii.	Fermented fish	kg					kg				
iii.	Fish sauce	litre					litre				
iv.	Smoked fish	kg					kg				
v.	dried fish (incl. Salted)	kg					kg				
Other, please specify:											
vi.											
vii.											

Section 3. Quantification of animal protein consumed

Quantity animal protein consumed by household per week			
	Type	dry season	Wet season
i.	Beef	kg	kg
ii.	Pork	kg	kg
iii.	Goat/sheep	kg	kg
iv.	Poultry	kg	kg
v.	Hen Eggs	#	#
vi.	Wildlife (not aquatic)	kg	kg
vii.	Insects (not aquatic)	kg	kg
Other, please specify:			
viii.			

[1] Source, express as percentage coming from:

C	Capture and gathering (by HH-members)	**AR**	Aquaculture/Reared (for livestock) by HH-members
P	Purchased	**G**	Gift to household from elsewhere

Annex IX Fishery activities form

Activities	Yes	No		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Commercial fishing	☐	☐	Done during												
			Days[1]												
Other fishing activities or collecting aquatic animals	☐	☐	Done during												
			Days[1]												
Aquaculture	☐	☐	Done during												
			Days[1]												
Processing aquatic animals	☐	☐	Done during												
			Days[1]												
Sale of aquatic animals	☐	☐	Done during												
			Days[1]												
Making, selling or repairing fishing gear	☐	☐	Done during												
			Days[1]												
Employment in fishing or fish processing, marketing, gear making or transport	☐	☐	Done during												
			Days[1]												
Rice planting, transplanting, harvesting or looking after	☐	☐	Done during												
			Days[1]												
Looking after vegetables or orchard inc. planting and harvesting	☐	☐	Done during												
			Days[1]												
Looking after livestock	☐	☐	Done during												
			Days[1]												
Handicrafts (making)	☐	☐	Done during												
			Days[1]												
Trading (not fish related inc. handicrafts)	☐	☐	Done during												
			Days[1]												
Money lending	☐	☐	Done during												
			Days[1]												
Wage labour (not fish related)	☐	☐	Done during												
			Days[1]												
Government service	☐	☐	Done during												
			Days[1]												
Transport service (land or water)	☐	☐	Done during												
			Days[1]												
Student (resident outside village)	☐	☐	Done during												
			Days[1]												
Child at school in village or near village	☐	☐	Done during												
			Days[1]												
Other, describe			Done during												
			Days[1]												

[1]Indicate the number of days (per month) that this activity is undertaken, 30 is full-time