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MANUAL ON FISHERY STATISTICS

Government of India
Ministry of Statistics and Programme Implementation
Central Statistics Office
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PREFACE

One of the mandates of the Central Statistical Organisation [CSO] is laying down norms and standards and evolving concepts, definitions, methodology and classification in relation to statistics. Even though the CSO has been performing these mandates in many fields of statistics, the absence of proper documentation in this regard led to a decision to prepare statistical manuals in respect of 28 subjects detailing concepts, definitions, classification procedures, compilation of data, estimating procedures, dissemination and other relevant explanatory notes, including methodological framework in the statistical indicators/statistics to make the manual comprehensive reference books comparable to the manuals being proceeded by the UNSD from time to time.

This manual on Fishery Statistics is one of series of 28 manuals on statistical indicators proposed to be brought out by the CSO. The basic purpose of this manual, like those of all other in the series, is to provide the users of Fishery Statistics data with a ready-to-use reference guide on methodological aspects of data (metadata) on Fishery Statistics based on harmonised concepts and methodologies that facilitate international comparison and help in aggregation of statistics to derive meaningful conclusions. The other purpose of this manual is to provide the statistical offices both at the national and state levels with guidelines in the compilation of Fishery Statistics data.

The materials included in this manual are expected to bring in harmonization in concepts, definitions and methodology of compilation of Fishery Statistics data. The adoption of the methodology suggested in this manual will go a long way in facilitating data aggregation and data comparison both at intra-regional and inter-regional levels, including international levels.

This manual has been prepared by Indian Agricultural Statistics Research Institute (IASRI) under the guidance of Steering Committee for Preparation of Manuals on Statistical Indicators headed by me. I acknowledge the work done by the team of officers from IASRI and the expert Shri Madan Mohan, ADG, ICAR for reviewing the manual for its improvement. I also congratulate to the team of officers from the Social Statistics Division comprising Smt. S. Jeyalakshmi, Additional Director General, Shri Inderjeet Singh, Deputy Director General and Shri M.P. Diwakar, Assistant Director for their excellent work in bringing out this manual.

I hope that the manual will serve as a useful reference document on the subject. Any suggestion to further improve the contents of the manual is welcome.

SKDas

(S. K. Das)
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Introduction

0.1 Fish is an important source of protein and its harvest, handling, processing and distribution provide livelihood for millions of people as well as providing valuable foreign exchange earnings to the country. It is a highly perishable food, requires proper handling, processing and distribution, if it is to be utilized in a cost effective and efficient way. Today, fisheries are estimated to provide 16% of the world population's protein, and that figure is considerably elevated in some developing nations and in regions that depend heavily on the sea.

0.2 The world capture fisheries production in 2008 was about 90 million tonnes, with an estimated first-sale value of US$ 93.9 billion, of which about 80 million tones from marine waters and a record 10 million tonnes from inland waters . It has been relatively stable in the past decade , with the exception of marked fluctuations driven by catches of anchoveta – a species extremely susceptible to oceanographic conditions determined by the El Niño Southern Oscillation – in the Southeast Pacific. In 2008, China, Peru and Indonesia were the top capture fish producing countries. China remained by far the global leader with production of about 15 million tones (FAO-2010).

0.3 With its 8129 km long coastline, India has immense potential for developing and producing a variety of sea foods, highly sought after throughout the world, directly leading to a huge amount of export in this field. It forms more than 70% of sea food all over the world. This requirement has created a big fishing industry. The increased requirement of sea food all over the world and relatively easy breeding of certain varieties of fish, has led to creation of sea breeding farms in the shallow coastal areas of our country's eastern coast. Fish breeding is a new industry in our country.

0.4 Fisheries are next to agriculture in terms of providing employment and food supply. Fish is an important source of quality protein and cheaper in cost compared to other source of animal protein. About 35% of Indian population is fish eaters and the per capita consumption is 9.8 kg whereas the recommended intake is 13 kg. Fisheries provide employment and sustenance to sizeable sections of the society in Rural India, especially weaker sections.

0.5 Fisheries are a renewable natural resource, subject to its own dynamics, acted upon by various forces. Open access system of exploitation of the resources lead to overcapitalization, resulting in decrease in the yield rates and unprofitability of operations and threatening the food security as well. The concomitant uncertainties make it imperative that the resources have to be scientifically developed, monitored and managed.

0.6 Development of the resources should comprise measures to augment the abundance level of the resources, strategies to exploit them in such a manner that food security is ensured, the exploitation process being economically viable and the resources conserved at a steady state allowing maximum potential for exploitation. This calls for strategic planning on the basis of scientific assessment of various biological, social and economic indicators.

0.7 It is well known that a good statistical system is essential for decision making and forming viable public policies. The National Statistical Commission set up by the Government of India under the Chairmanship of Dr. C. Rangarajan made a critical examination of the statistical systems of various sectors in India and proposed many recommendations for revamping the existing system. The status of the statistical system in the fisheries sector has been reviewed and the commission suggested ways and means of improving the current system.

0.8 There are two important sectors in Fisheries namely, Marine Fishery and Inland Fishery. Both sectors play an important role in Indian economy. Marine fisheries is an important sector of the nation's economy supporting the livelihood of the millions of fisher-folk inhabiting the long coastline of India and those who are engaged in the related activities. The marine fisheries sector in India has witnessed a phenomenal growth during the last five decades both quantitatively and qualitatively. The subsistence fisheries during the early 50's produced about 0.5 million tonnes annually. The total potential yield of the marine fishery resources of the Indian EEZ is revalidated as 3.93 million tonnes. The marine fish production during 2009-10 was 3.07 million tones. The gross revenue from the catches at the point of first sales (landing centre) was estimated at Rs. 19,753 crores, and at the point of last sales (retail market), it was estimated as Rs. 28,511 crores (ICAR, 2011). Export of Marine Products during April - March 2010-11 have achieved the US$ 2.84 billion mark by registering a growth of 18.96 % in quantity, 27.64 % in rupee value and 33.17% in US$ realisation compared to the same period of last year according to the provisional export figures. This is the first time in the history of Marine Products Industry; these exports crossing the 2.8 billion mark (MPEDA, 2011).

0.9 The increase in marine fish production is the result of improvements in the harvesting methods, increase in the fishing effort and extension of fishing into relatively deeper regions. Fleet size and operations underwent quantitative and qualitative changes. Traditional boats are being increasingly motorized and the mechanized sector operating with trawlers and gillnetters are resorting to multi-day fishing and thus, contributing to increased fishing pressure. The increased effort over time and space, is the consequence of ever-increasing demand for marine food both from external and internal markets. This phenomenal growth also brought in its wake imbalances in the exploitation across the regions and among the resources.

0.10 Inland fisheries enjoys prime of place in Indian economy. It provides employment and livelihood for fishers who solely depend on it. In Inland fishery sector, the data collection on various important parameters such as the catch taken, size of fleet employed, present level of employment, per capita yield etc. is an enormous task often beset with hurdles owing to the sporadic spatial and temporal distribution of the resources. Since the independence, particularly with the start of the five year plans, Planning commission and R & D organizations were seized of the problems and made many attempts to schematize, scientifically, the collection of basic fishery data. Nevertheless, unlike marine sector, inland fisheries cannot claim a satisfactory status with regard to data collection.

0.11 The absence of basic data often set limitation to the planning process. India has vast potential inland resource with all India distribution. However, the data collected from these resources are sometimes neither comparable nor aggregated at national level as their concepts and definitions vary from region to region. Hence, there is a strong need for evolving a scientific methodology of data collection with uniform concepts and definitions.

Section-A

MARINE FISHERY

CHAPTER – I

INTRODUCTION

1.1 The National Statistical Commission set up by the Government of India under the Chairmanship of Dr. C. Rangarajan made a critical examination of the statistical systems of various sectors in India and proposed many recommendations for revamping the existing system. The status of the statistical system in the fisheries sector, particularly the marine fisheries, has been reviewed and the commission suggested ways and means of improving the current system. The Commission observed that: *As regards marine fisheries statistics, the sample methodology in use is considered to be satisfactory. There is, however, a need for periodic review of sample size, stratification and intensity of data collection in view of the changes in the pattern of fish landings*.

1.2 Marine fisheries is an important sector of the nation's economy supporting the livelihood of the millions of fisher-folk inhabiting the long coastline of India and those who are engaged in the related activities. The marine fisheries sector in India has witnessed a phenomenal growth during the last five decades both quantitatively and qualitatively. The subsistence fisheries during the early 50's produced about 0.5 million tonnes annually. The total potential yield of the marine fishery resources of the Indian EEZ is revalidated as 3.93 million tonnes. The marine fish production during 2009-10 was 3.07 million tones. The gross revenue from the catches at the point of first sales (landing centre) was estimated at Rs. 19,753 crores, and at the point of last sales (retail market), it was estimated as Rs. 28,511 crores (ICAR,2011). Export of Marine Products during April - March 2010-11 have achieved the US$ 2.84 billion mark by registering a growth of 18.96 % in quantity, 27.64 % in rupee value and 33.17% in US$ realisation compared to the same period of last year according to the provisional export figures. This is the first time in the history of Marine Products Industry; these exports crossing the 2.8 billion mark (MPEDA,2011).

1.3 The increase in marine fish production is the result of improvements in the harvesting methods, increase in the fishing effort and extension of fishing into relatively deeper regions. Fleet size and operations underwent quantitative and qualitative changes. Traditional boats are being increasingly motorized and the mechanized sector operating with trawlers and gill netters are resorting to multi-day fishing and thus, contributing to increased fishing pressure. The increased effort over time and space, is the consequence of ever-increasing demand for marine food both from external and internal markets. This phenomenal growth also brought in its wake imbalances in the exploitation across the regions and among the resources. Besides, with production levels for most of the commercially important resources showing signs of attaining saturation levels, inter-sector conflicts increased due to competition to exploit the common resource. It is also felt that intensive fishing by the mechanized sector and indiscriminate fishing of juveniles and spawners has attained serious proportions. This has led to promulgation of fishing regulatory measures by most of the maritime states through closure of fishing during certain seasons.

1.4 Monitoring and assessment of the exploited marine fishery resources of India is one of the major projects of the Central Marine Fisheries Research Institute (CMFRI), Kochi. With this in view, the CMFRI has developed a multistage stratified random sampling design to collect the required information to estimate the marine fish landings along with effort expended and other biological information. Recognizing the scientific validity of the sampling design, the FAO has recommended the same to all the developing countries for use in their fisheries statistical systems. The project provides resource-wise, region-wise and gear-wise estimates of landings of the exploited stocks from the coastal waters of the Indian EEZ. The data is now exclusively used in the various research projects of the Institute dealing with fish stock assessment and fisheries management. For proper formulation of the sampling design and updating the sampling frame the Institute has also conducted all India fishermen census and frame surveys in the years 1973, 1980 and 2005. The Marine Fisheries Census-2005, conducted by CMFRI during 2005 and funded by DAHD&F (MOA, Govt. of India), not only covered the details on the fish landing centers, craft and gear but also collected data on the marine fishermen population, their occupation, educational status, family status, number of craft and gear owned by the fisher-folk, craft and gear in the fishery and the fishery related infrastructure. The Institute has recently completed The Marine Fisheries Census-2010 and will be published soon. The Institute has a strong database on the exploited marine fishery resources of the country and the ARIS Cell of the Institute manages the repository of information.

Measurement needs of the sector

1.5 The exploited fish populations and the fishery dependent on them are highly dynamic that require regular monitoring and periodical stock assessment. The resource evaluation is essential for evolving appropriate management strategies for rational exploitation and long-term sustenance of the exploited stocks. The validity and efficiency of the management formulations depend on the quality of database of which information on the catch and fishing effort is an important component. Thus, the data on catch and the expended effort besides other fishery-related statistics (including socio-economic status, infrastructure etc.) are essential for effective management of the fisheries. The compilation of accurate, relevant and timely data in a standard form that makes it comparable, and the considered analysis of this data, is essential to underpin the development and utilization of the fisheries sector. As per the FAO Technical Guidelines for Responsible Fisheries, "States should ensure that timely, complete and reliable statistics on catch and fishing effort are collected and maintained in accordance with applicable international standards and practices and in sufficient detail to allow sound statistical analysis. Such data should be updated regularly and verified through an appropriate system" (CCRF 7.4.4).

Development of Statistical system of the sector

1.6 In India, the earliest reference to estimates of marine fish catch can be traced to the report of marketing of fish in Indian Union. Data were not collected by any scientifically planned surveys but only by trade enquiries and similar evidences. India is among the few nations which has adopted a sampling system based on the theory of sampling for collecting the fishery catch statistics (Banerji, 1971). For the first time in India, a pilot survey was initiated by the Indian Council of Agricultural Research (ICAR), along the Malabar coast during 1950-51 and the work was continued in the succeeding years on this coast and other important coastal regions of the country.

1.7 The first attempt to build up a planned survey for the estimation of fish catch on an all India basis was made after the establishment of the CMFRI in 1947. In the pilot survey conducted in 1948-49, village-wise data were colleted on the area exploited, the number of persons engaged in marine fishing, the number of various types of fishing boats and nets, fishing season, type of fish caught and the number of fish landing centers. This brought forth a complete picture of fishing activities and threw light on the potentialities of marine fishery.

1.8 On the basis of this survey, fisheries data were collected on regular basis from 1950 by dividing the entire coastline of India into twelve homogenous survey zones – each zone put under the charge of a well-trained field staff for the purpose of collection of all basic data. Fairly accurate estimates of marine fish production in India were arrived at from the estimates of each zone. With the availability of more funds and additional staff, the survey zones were further increased from twelve to twenty in 1957 covering more landing centers. Additional data on fishing effort were also collected from that year. Between 1950-51 and 1954-55 the ICAR also initiated a number of pilot surveys following various designs in different regions of the country with a view to evolve most suitable sampling design for the estimation of fish landings in the country. The pilot surveys and their results have influenced a great deal in modifying the currently designed sample surveys undertaken by the CMFRI. To bring out the nature of changing pattern of fishing industry and its consequent impact on fishermen and to develop the sampling design according to changing field conditions, census of fishing villages were repeated during 1957-58, 1961-62 and 1972-73. Since any betterment plan of fishing industry must also aim at betterment of the condition of fishermen engaged in fishing, socio-economic data with regard to them are also necessary. During the 1972-73 census, this information was also collected.

1.9 The present sampling design involving space-time stratification was first put into operation in the Kerala State in the middle of 1959 and was slowly extended to other states of the west coast of India. From 1961, the design was introduced in the east coast of India also. A number of geographically contiguous landing centers form the stratum in space. A ten-day period of a month is the time-stratum. The primary sampling unit is a centre-day or a centre-two days group. Sampling is also adopted over hours of the selected day and the enumeration units, which are landing boats and are selected in a systematic way. The night catches are obtained by enquiry from fishermen. On the basis of the estimates obtained for the primary sampling units, stratum estimates and their percentage error are arrived at. The period of estimation is a calendar month. Additional data on size composition of the catch of the most important fishes like oil sardine, mackerel and Bombay duck and also of penaeid prawns are collected for the study of stock assessment of these fisheries. This enables to get the abundance of size and age composition of the catch leading to estimation of mortality parameters.

1.10 In tune with the fast changing marine fisheries scenario, the scope, the structure and administration of the resource data collection is periodically modified. Also, the data collection system is reviewed annually in the Zonal Workshops held for the benefit of the field staff. The details of the methodology followed by CMFRI are given in Chapter III.

1.11 Fisheries is a State subject and the responsibility of monitoring and management of the coastal resources exploited in their territorial waters wrests with each State Government. In order to address the issues related to marine fisheries management, the State Governments recognized the importance of marine fishery statistics. Until the mid-eighties, the State Governments were obtaining the required statistics from the CMFRI. With the expertise gained over the years, the Institute conducted training programmes from time to time on sampling methodology, data collection and analysis for the benefit of the fisheries departments of the State Governments.

Scope and Purpose of the manual

1.12 The marine fisheries statistics not only includes estimates of catch (production) and the effort expended but also information on fleet size craft and types and number of gears used, fisher-folk population, active fishermen, number of people involved in fishery related activities, number of fishing villages, number of landing centres and other infrastructure facilities. In India, with a long coastline of 8129 km (including the Island territories), it is not possible to completely enumerate all the landing centres along the coastline owing to obvious limitations. The information on total marine fisher-folk, their occupational status and the total fleet size etc. are obtained periodically through a Nation wide Census (Complete Enumeration). The last such census was conducted by CMFRI in the year 2005 on the mainland by the FSI in the Island Territories. However, the information on production (catch or landings) and the associated fishing effort, that is required on a regular basis for fisheries management and fish stock assessment, is collected by sample surveys. Scope of this manual is restricted only to describe such sample surveys that are existent. The manual will serve as a ready reckoner for all the user organizations and help them in following uniform definitions, data collection procedures and methodology for the analysis of data. It is hoped that this manual will also be useful to administrators, planners and researchers for evolving new policies and developmental programs for the fisheries sector.

Contents and organization

1.13 The manual consists of four Chapters and Appendices. Chapter I highlights the significance of the sector, need for statistical standards and development of statistical system of the sector. Concepts and definitions are placed in Chapter II. Chapter III presents sources of data and details of methodology being adopted for generating these data. Chapter IV conveys the suggestion for ensuring quality standards. Lastly, appendices include estimation methods, forms and schedules and major resources available in the Indian seas.

CHAPTER - II

DEFINITIONS

2.0 The source of these definitions is the FAO Fisheries Technical Paper, No. 382: Guidelines for the routine collection of capture fishery data, 1999.

2.1 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. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. Sometimes referred to as small-scale fisheries.

2.2 Biomass: 1) The total weight of the living organisms concerned, whether in a system, a stock, or a fraction of a stock. 2) Total weight of a resource, a stock, or a component of such stock.

2.3 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.

2.4 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.

2.5 Catch per unit effort (CPUE): The amount of catch that is taken per unit of fishing gear. 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. 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.

2.6 Census: A fisheries census is a survey in which the value of each variable for the survey area is obtained from the values of the variable in all reporting units, that are usually fishing households. 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.

2.7 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.

2.8 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.

2.9 Fishery: 1) The sum (or range) of all fishing activities on a given resource (e.g. shrimp fishery). It may also refer to the activities of a single type or style of fishing (e.g. beach seine fishery or trawl fishery). The fishery can be artisanal, or/and industrial, commercial, subsistence, and recreational, and can be annual or seasonal. 2) Activity of catching fish, from 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.

2.10 Fish stock: The living resources in the community or population from which catches are taken in a fishery. Use of the term fish stock usually implies that the particular population is more or less isolated from other stocks of the same species and hence self-sustaining.

2.11 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.

2.12 Fishery resource: Any stock of aquatic living animals (except those specifically prohibited by law) which can be caught by fishing, and their habitat.

2.13 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.

2.14 Fishing effort: 1) The amount of fishing gear of a specific type used on the fishing grounds over a given unit of time e.g. hours trawled per day, number of hooks set per day or number of hauls of a beach seine per day. 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. Relates usually to a specific fishery and gear. 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.

2.15 Fishing industry: Includes both recreational, subsistence and commercial fishing and the harvesting, processing and marketing sectors.

2.16 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).

2.17 Fleet: The aggregation of units of any discrete type of fishing activity utilizing 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.

2.18 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.

2.19 Gear: Any tools used to catch fish, such as hook and line, trawls, gill nets, traps, spears, etc.

2.20 Landings: The weight of a product (fish) at the time of landing of the boat.

2.21 Landing centre: 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.

2.22 Responsible fisheries: The concept "encompasses the sustainable utilisation of fishery resources in harmony with the environment; the use of capture and aquaculture practices which are not harmful to ecosystems, resources and their quality; the incorporation of added value to such products through transformation processes meeting the required sanitary standards; the conduct of commercial practices so as to provide consumers access to good quality products" (International Conference on Responsible Fishing, Cancun, Mexico, 1992).

2.23 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.

2.24 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).

2.25 Stock: 1) In theory, a *unit stock* comprises all the individuals of fish in an area, which are part of the same reproductive process. It is self-contained, with no emigration or immigration of individuals from or to the stock. On practical grounds, however, a fraction of the *unit stock* is considered a "stock" for management purposes (or a *management unit*), as long as the results of the assessments and management remain close enough to what they would be on the *unit stock*. 2) A group of individuals in a species occupying a well defined spatial range independent of other stocks of the same species. Random dispersal and directed migrations due to seasonal or reproductive activity can occur. Such a group can be regarded as an entity for management or assessment purposes. The impact of fishing on a species cannot be determined without knowledge of this stock structure.

2.26 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.

2.27 **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.

2.28 **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.

2.29 **Yield:** Catch in weight. Catch and yield are often used interchangeably.

CHAPTER – III

SOURCES AND SYSTEMS

National Status

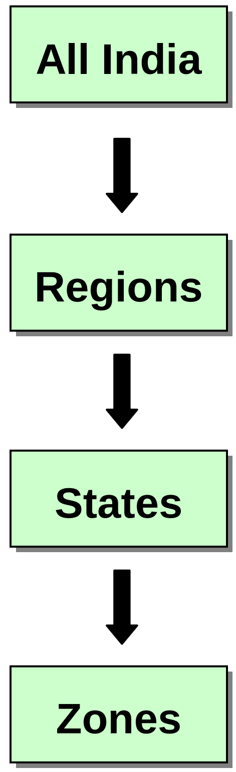
3.1 Fisheries management within territorial waters wrests solely with State Governments and thus any information on fish catch from those waters and landed within the state has to emanate from the State. Fisheries Departments in various maritime states have been collecting statistics on marine fish landings and other fishery related information. States such as, Maharashtra, Gujarat and Tamil Nadu are collecting catch statistics as per sampling designs either same or similar to that followed by Central Marine Fisheries Research Institute. In some maritime states catch statistics are collected through Departmental staff who visit fixed centres and collect the data through enumeration**.** National level marine fish production statistics are compiled and published by the DAHD&F, MOA, Govt. of India. The CMFRI has developed, standardized and implemented the Multistage Stratified Random Sampling Design to estimate the marine fish production in India on a continuous basis from 1947 onwards and built up time series data on season-wise, region-wise, gear-wise and species-wise marine fish production. The CMFRI is responsible for collection of biological data for conducting research and stock assessment.

3.2 The Central Sector Scheme on "Strengthening of Database and Information Networking for the Fisheries Sector" is in operation during the Tenth and Eleventh Plan. As per the Scheme, the respective State Governments collect the marine fish catch statistics and transmit the estimates to the Department of Animal Husbandry and Dairying (DAHD), Ministry of Agriculture, Government of India, through Fishery Survey of India, Mumbai that collates and prepares national level estimates of marine fish production. These estimates are then submitted before the Technical Monitoring Committee of the DAHD&F. The Director, IASRI, New Delhi is the Chairman of the Committee consisting of subject matter experts. The Committee reviews the estimates submitted by the various maritime states and approves the national level estimates of marine fish production, after incorporating necessary validations. The Committee also suggests, wherever necessary, methodological changes for estimation of marine fish production to improve the precision of the estimates. The DAHD&F then publishes the national marine fish production statistics. The methodological support is given by the CMFRI as when required.

Methodology for Estimation of Marine Fish Landings

3.3 India has a coastline of about 8129 km including Island territories. Landing of fish takes place at numerous locations all along the coastline during day and at times during night also. There are 3202 marine fishing villages and 1332 landing centres along the coastline of the mainland. The sampling design adopted by the CMFRI to estimate resource-wise/region-wise landings in the mainland is based on stratified multi-stage random sampling technique. In this, the stratification is over space and time. Over space, each maritime state is divided into suitable, non-overlapping zones on the basis of fishing intensity and geographical considerations (Fig. 1). The number of centers may vary from zone to zone. These zones have been further stratified into substrata, on the basis of intensity of fishing.

Fig. 1 Stratification over space



3.4 There are some major fisheries harbours/centers which are classified as single centre zones for which there is an exclusive and extensive coverage. The stratification over time is a calendar month. One zone and a calendar month is a space-time stratum and primary stage sampling units are landing centre days.

3.5 If in a zone, there are 20 landing centers, there will be 20 x 30 = 600 landing centre days in that zone for that month (of 30 days). For observation purpose, a month is divided into 3 groups, each of 10 days. From the first five days of a month, a day is selected at random, and the next 5 consecutive days are automatically selected. From this three clusters of two consecutive days are formed. For example, for a given zone, in a given month, from the five days if the date (day) selected at random is 4, then these clusters are formed, namely, (4, 5); (6, 7) and (8, 9) in the first ten day group. In the remaining ten day groups, the clusters are systematically selected with an interval of 10 days. For example, in the above case, the cluster of observation days in the remaining groups are (14, 15), (16, 17), (18, 19) (24, 25), (26, 27) and (28, 29). Normally, in a month there will be 9 clusters of two days each. From among the total number of landing centers in the given zone, 9 centers are selected with replacement and allotted to the 9 cluster days as described earlier. Thus in a month 9 landing centre days are observed. The observation is made from 12.00 hrs to 18.00 hrs on the first day and from 06.00 hrs to 12.00 hrs on the second day, in a centre. For the intervening period of these two days, the data are collected by enquiry from 18.00 hrs of the first day of observation to 06.00 hrs of the 2nd day of observation of a landing centre-day, which is termed as 'night landing '. The `night landing' obtained by enquiry on the second day covering the period of 18.00 hrs of the first day to 06.00 hrs of the next day are added to the day landings so as to arrive at the landings for one (landing centre day) day (24 hours).

Selection of units

3.6 It may not be practicable to record the catches of all boats landed during an observation period, if the number of boats/craft landings is large. A sampling of the boats/craft becomes essential. When the total number of boats landed is 15 or less, the landings from all the boats are enumerated for catch and other particulars. When the total number of boats exceeds 15, the following procedure is followed to sample the number of boats (Alagaraja, 1984):

Number of units landed	Fraction to be examined
Less than or equal to 15	100 %
Between 16 and 19	First 10 and the balance 50 %
Between 20 and 29	1 in 2
Between 30 and 39	1 in 3
Between 40 and 49	1 in 4
Between 50 and 59	1 in 5 etc.

3.7 From the boats, the catches are normally removed in baskets of standard volume. The weight of fish contained in these baskets being known, the weight of fish in each boat under observation is obtained.

Sampling scheme in a single centre zone

3.8 Normally, 16 to 18 days in a month are selected at random for observation. Depending on the type of landings, the observation is made on a cluster of 2 days or a single day itself. The sampling of units landed on a selected day is as described earlier.

Estimation of Marine Fish Landings and the Effort expended

3.9 The procedure adopted for estimating the marine fish landings of a zone (single center zone) is given in Appendix-A.

International Status

3.10 At the global level, FAO shoulders the responsibility of collecting and disseminating fisheries statistics. It does this by drawing on national level statistics contributed by individual countries. The compilation of accurate, relevant and timely data in a standard form that makes it comparable, and the considered analysis of this data, is essential to underpin the development and utilization of the world's fisheries and aquaculture sectors. This compilation is necessary to generate the data required to monitor the development of the sector and the state of its resources, as well as to recognize emerging and established trends. It requires intensive international collaboration and cooperation, an area in which FAO plays a central role.

3.11 The FAO Fisheries Department, which, since its inception, has built up its statistical database, is the only organization with a worldwide remit to engage in the systematic data collection and compilation on fisheries and aquaculture information. The data is provided by FAO member countries and is verified from other sources wherever possible. The reliability of the analysis based on the data, and the quality of the advice to which it gives rise, depends on the reliability and quality of the data itself. To this end, the FAO seeks to continue supporting and strengthening national capacity in the compilation, analysis and use of accurate, reliable and timely data. In this respect, the FAO has a unique role in supporting the management and development of the aquaculture and fishery sectors.

3.12 The FAO Fisheries Department recognizes the importance of internationally agreed methods and tools for data compilation. Thus, for the last five decades, it has cooperated in international efforts directed towards the development of standard concepts, definitions, classifications and methodologies for the collection and collation of fishery statistics, most notably through the Coordinating Working Party (CWP) on Fisheries Statistics.

3.13 The FAO uses the FISHSTAT reporting system to collate global statistics on catch and production from more than 220 countries and for over 1000 species of aquatic organisms considered to be of significant commercial importance. The FAO has developed an Internet-based Fisheries Global Information System (FIGIS), through which access to all FAO fishery statistics will become possible. Data is intended to provide management with a reliable basis for the interlinked management domains of policy, planning and implementation.

3.14 The FAO Fisheries Global Information System (FIGIS) aims at providing policy-makers with the timely, reliable strategic information on global fishery status and trends needed to make informed decisions about the key challenges of sustainable development. The information system is expected to integrate several technically specialized sub-systems, allowing the user to access information on biology, fishing technology, high seas vessels records, resources, fisheries management systems, aquaculture, products and markets.

Chapter - IV

ISSUES AND SUGGESTIONS

Issues and constraints of the existing marine fishery statistical system

4.1 Issues:

- Inconsistencies in national data sets as typified by the changes in the manner in which catches were categorized by species and by gear;
- Non-correction for nominal catch, non-calendar year reporting time frames and non-localization of catches and non-reporting;
- Need to review the classification of type of fishing gear and of species in view of the changes in the fishing methods or catch fish resources as previously designated;
- Issuing of daily, weekly and monthly (whichever possible) advisories to different stake holders engaged in marine fishery exploitation
- Preparation of policy papers and issuing guidelines based on latest information on zonal and regional basis
- Poor understanding of requirements of users;
- Lack of relevant and usable information;
- Insufficient channeling of data and information to target user groups;
- Identification of user needs and determination of minimum data requirements;
- Establishment and adoption of standardized or compatible data compilation methodologies and tools;
- strengthening of coordination and linkage mechanisms;
- Analysis of data and production of information packages for regional fishery management; and
- Skill development.

4.2 Constraints:

- Delays in compiling and submitting fishery statistics
- Incomplete and incorrect or unreliable data
- Incompatibility of data
- Poor accessibility
- Lack of skilled manpower
- Lack of commitment
- Lack of standardized/compatible data collection and compilation methodologies and tools.

Suggestions

4.3 Suggestions and recommendations made by various national and international bodies for improving and strengthening of marine fish statistical system are summarized below:

Institutional role

4.4 Recognizing the role of CMFRI as the nodal organization for collection, analysis and dissemination of data on marine fisheries of India, a policy decision was taken by the Planning Commission at its meeting on 9 December, 1981, recommending that the Institute should organize a National Workshop on Marine Fisheries Data Acquisition and Dissemination. Accordingly, the Institute organized a workshop on acquisition and dissemination of data on marine living resources of Indian seas during 21-23 October 1982. The workshop deliberated on various aspects of marine fishery statistics and related matters. Based on the discussions and requirements of the various end-users different proformae were developed for data collection and reporting. The workshop also made recommendations on issues concerning the policies, priorities, strengthening of data collection systems, institutional support and data dissemination. Although, some of them were implemented, majority of the recommendations still remains to be acted upon by the agencies concerned. The some of the salient points from the recommendations are:

- Strengthening and expansion of the Fishery Data Centre of CMFRI as a centralized National Marine Living Resources Data Centre (NMLRDC).
- Observing the deep involvement of States, Department of Agriculture of the Union Government, ICAR and other public and private organizations, it was recommended to form an Expert Committee to guide the modalities of functioning and to foster linkages and provide advice for an effective and functional system for resources data collection.
- Strengthening of State Departments that were collecting marine fishery statistics with adequate administrative, technical and financial support.
- The system of data collection based on tested statistical design developed by CMFRI be followed by all the States and the data are recorded and maintained in the accepted proformae developed by the workshop.
- Conduct of periodical training to the staff of the State Departments.
- Increase in the sampling coverage.
- Development of computerized information system by CMFRI.

Working Group for Revalidating the Potential of Fishery Resources in the Indian EEZ

4.5 The Working Group for Revalidating the Potential of Fishery Resources in the Indian EEZ constituted in the year 2000 by the Department of Animal Husbandry & Dairying, Ministry of Agriculture, Govt. of India has recommended that the present coverage of catch and effort statistics through the stratified multi-stage random sampling technique adopted by the CMFRI be strengthened to make it a 5% coverage and the States adopt the same methodology for a 5% coverage to ensure more precise resource assessment. CMFRI has carried out and published Marine Fisheries Census-2005 and again carried Marine Fisheries Census-2010 which is yet to be published.

4.6 The Working Group observed that the frame survey of the fishermen population, fishing crafts and gear, health, education and socio-economic status conducted over two decades ago by the CMFRI has not been updated. Such surveys enable formulating strategies for development. It is essential that the Central Government accords priority attention to this and provides necessary funding support to the CMFRI to immediately implement the same jointly with the maritime states. According to the National Marine Fisheries Census 2005, a total of 243, 939 fishing crafts were in operation in India, comprising of 59,743 mechanized vessels (about 29,000 of them were trawlers) and 76,372 motorized vessels and the remaining non-motorized vessels. The traditional crafts and motorized crafts were concentrated more in the east coast (73% and 60%) whereas the mechanized vessels were more along the west coast (64%). The post-tsunami flow of funds to support the coastal communities to recover from the loss of the calamity also helped to add more number of fishing units in the sector, especially the southern part of the Indian peninsula.

4.7 But according to the provisional figures provided by Department of Animal Husbandry, Dairying & Fisheries , Min. of Agriculture for National Marine Fisheries Census 2010, the number of fishing craft has come down to a total of 175,381 fishing crafts , comprising of 44,206 mechanized vessels and 82,642 motorized vessels and the remaining 48,533 non-motorized vessels. As was reported in 2005, in 2010 also traditional crafts and motorized crafts are concentrated more in the east coast (69% and 56%) whereas the mechanized vessels are more along the west coast (58%) . The total number of fishing craft also are more on the east coast of India (Table,1). According to this census, there are 3,975 fishing villages (maximum 840 in Odisha followed by West Bengal 833) with a total of 8,64,550 fishermen families (maximum in Tamilnadu 1,92,697 followed by Andhra Pradesh 1,63,427) with a total population of 3.99 million in which Tamilnadu accounts for 20% followed by Kerala, Andhra Pradesh and Odisha (Table 2).

National Statistical Commission

4.8 The National Statistical Commission has made the following observations and recommendations on the statistical system in marine fisheries:

4.9 A multistage sample survey is used to estimate the fish production from the marine sector. The survey design developed by the Indian Agricultural Statistics Research Institute (IASRI) and the Central Marine Fisheries Research Institute (CMFRI) consists of sampling of landing sites of the fishing craft as well as sampling over time of the landings.

4.10 As regards marine fisheries statistics, the sample methodology in use is considered to be satisfactory. There is, however, a need for periodic review of sample size, stratification and intensity of data collection in view of the changes in the pattern of fish landings. There are also problems in the flow of data from States and consequently much delay in the compilation of all-India statistics.

4.11 In the marine sector, there is a need to impart regular, training to field staff and impose adequate supervision to ensure quality of data. Use of modern tools of Information Technology for data communication and storage will improve the quality and timeliness of fisheries statistics.

Code of Conduct for Responsible Fisheries

4.12 The Code of Conduct for Responsible Fisheries was adopted on 31 October 1995 during the FAO Conference at its Twenty-eighth Session, which also reflected particularly these concerns. The Code stressed the essential need for reliable data as a basis for effective fishery management and policy making.

4.13 As part of its program of promoting implementation of the Code, FAO has proposed to potential donor countries an Inter-regional Programme of Assistance to Developing Countries. One such sub-program is concerned with Upgrading Capabilities for Reporting on Fishery Statistics and comprises three activities.

a) Design of a generic catch and effort data collection and reporting system for use by distance water fishing nations and coastal states fishing straddling fish stocks and highly migratory fish stocks;

b) Bringing existing statistical systems into conformity with the agreed system through a series of workshops conducted with or by regional fisheries bodies; and

c) Establish a reporting system that will allow rapid transfer of data between countries, regional fisheries bodies and FAO.

Kyoto Declaration

4.14 At the International Conference on the Sustainable Contribution of Fisheries to Food Security (December 4-9, 1995, Kyoto, Japan), 95 States adopted a Declaration and Plan of Action which were conveyed to the UN, FAO, UNCSD (UN Commission on Sustainable Development), the 1996 FAO World Summit, and other relevant international organizations for their consideration and endorsement.

4.15 The points in the Plan of Action relevant to marine fisheries statistical system are as follows:

1. To assess and monitor the present and future levels of global, regional and national production, supply and demand of fish and fishery products and their effects on food security, employment, consumption, income, trade and sustainability of production.
2. To identify and exchange information on potential mechanisms to reduce excess fishing capacity and implement action on programs to reduce excess capacity, where and when appropriate, as soon as possible.
3. To develop, promote and facilitate the exchange of information on the use of efficient and standardized methodologies for the study of social, cultural and economic characteristics of fishing and associated activities; and, in particular, attempt to develop methods designed to permit verifiable indicators of the importance of such characteristics and their interaction and compatibility with management objectives.
4. The timely collection, compilation and analysis of data are fundamental to the effective conservation and management of straddling fish stocks and highly migratory fish stocks. To this end, data from fisheries for these stocks on the high seas and those in areas under national jurisdictions are required, and should be collected and compiled in such a way as to enable statistically meaningful analysis for the purposes of fishery resource

conservation and management. These data include catch and fishing effort statistics and other fishery-related information, such as vessel-related and other data for standardizing fishing effort. Data collected should also include information on non-target and associated or dependent species. All data should be verified to ensure accuracy. Confidentiality of non-aggregated data shall be maintained. The dissemination of such data shall be subject to the terms on which they have been provided.

4.16 Thus keeping in view the recommendations and suggestions made by different national and international bodies, DAHD&F, MOA, Govt. of India can play a leading role in strengthening statistical systems in the marine fisheries sector drawing scientific and technical support for research organizations like CMFRI, IASRI and with active collaboration with the respective maritime states. The CMFRI with its rich experience in marine fisheries research can play a pivotal role by offering its services by developing methodologies for marine fisheries data collection including catch statistics, socio-economic statistics, frame surveys. The institute will also be able to conduct training programmes in data collection methodology, analysis, compilation and reporting. The institute will also give guidance in establishment of data centres, advice on procurement of hardware and software support and also for training the staff.

4.17 Thus, as rightly observed by the National Statistical Commission, there is an urgent need to strengthen and improve the marine fishery statistical system through concerted efforts of all the agencies concerned so that the information thus emanating from the system is used in management of the rich marine fishery resources of the country for ensuring better livelihood of the coastal rural folk.

Chapter - V

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APPENDIX A

ESTIMATION PROCEDURES

Monthly estimate of landings for a zone

I. Without stratification of a zone (also applicable to single centre zone)

Let N be the number of days (fishing days) in a month, Q be the number of centres in the zone and ***n*** be the number of selected landing centre days.

Let p be the number of periods of observation for the selected landing centre day.

p = 1 corresponds to 12.00 – 18.00 hrs on the first day of observation

p = 2 corresponds to 06.00 – 12.00 hrs on the second day of observation

p = 3 corresponds to night landings obtained by enquiry of the boats, landing after 18.00 hrs on the first day and before 06.00 hrs on the second day

Let N_{gdp} be the total number of craft (boat) of gear type g (hereinafter referred to as unit) landed during d^{th} selected landing centre day in the p^{th} period of observation.

Let n_{gdp} be the number of selected units of type g on the d^{th} landing centre day during the p^{th} period of observation.

Let y_{sgdpi} be the catch of the species s landed by the i^{th} selected unit of g^{th} type of unit on d^{th} selected day during p^{th} period of observation.

An estimate of total landings of species s by unit of type g on the d^{th} landing centre day during p^{th} period of observation is given by

$$\hat{Y}_{sgdp} = \frac{N_{gdp}}{n_{gdp}} \sum_{i=1}^{n_{gdp}} y_{sgdpi} \qquad \ldots\ldots\ldots\ldots\ldots (1)$$

An estimate of total landings of species ***s*** by g^{th} type of unit on d^{th} day is given by

$$\hat{Y}_{sgd} = \sum_{p=1}^{3} \hat{Y}_{sgdp} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

[Note: The night landings (p=3) are obtained by enquiry and usually estimated by enquiry from the number of each type of unit landed and average catch per unit]

An estimate of total landings of species s by g^{th} type of unit for the month is obtained as

$$\hat{Y}_{sg} = \frac{NQ}{n} \sum_{d=1}^{n} \hat{Y}_{sgd} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

An estimate of total landings for the selected landing centre day is obtained as

$$\hat{Y}_d = \sum_s \sum_g \hat{Y}_{sgd} \text{ (summed over all gear and for all species)} \qquad \ldots\ldots\ldots\ldots\ldots \text{(4)}$$

An estimate of total landings of all species by g^{th} type of unit for the month is obtained as

$$\hat{Y}_g = \sum_s \hat{Y}_{sg} \qquad \text{(summed over all species landed by } g^{th} \text{ type of unit)} \qquad \ldots\ldots\ldots \text{(5)}$$

An estimate of total landings of species s landed by all types of units for the month is obtained as

$$\hat{Y}_s = \sum \hat{Y}_{sg} \qquad \text{(summed over all types of units)} \qquad \ldots\ldots\ldots \text{(6)}$$

An estimate of total landings for the month over all types of units and for all species is given by

$$\hat{Y} = \sum \hat{Y}_g = \sum \hat{Y}_s \qquad \ldots\ldots\ldots \text{(7)}$$

Monthly estimate for a region (State)

Let $\hat{Y}_{jsg}$ be an estimate of monthly landings of species s by g^{th} type of gear in the j^{th} zone. Then, an estimate of total landings of species s by the g^{th} type of unit for the region (State) is given by

$$\hat{Y}'_{sg} = \sum_{j=1}^{nz} \hat{Y}_{jsg} \qquad \ldots\ldots\ldots \text{(8)}$$

where nz is the number of zones in the region and $\hat{Y}_{jsg}$ is given by the equation (3).

An estimate of total landings of all species landed by g^{th} type of unit in the region for the month is given by

$$\hat{Y}'_g = \sum_s \hat{Y}'_{sg} \quad \text{(summed over all species landed by } g^{th} \text{ type of unit)} \qquad \ldots\ldots\ldots \text{(9)}$$

An estimate of total landings of species s by all types of units in the region for the month is given by

$$\hat{Y}'_s = \sum_g \hat{Y}'_{sg} \quad \text{(summed over all types of units)} \qquad \ldots\ldots\ldots\ldots \text{(10)}$$

An estimate of total landings for the month in the region is given by

$$\hat{Y}' = \sum_g \hat{Y}'_g = \sum_s \hat{Y}'_s \qquad \ldots\ldots\ldots\ldots \text{(11)}$$

Estimate of fishing effort in the zone during a month

The fishing effort can be expressed by (1) the number of unit operations by a craft-gear combination (unit) (2) the fishing hours expended by the unit during the month, (3) the man-hours expended by the units during the month. Here, estimation procedure for (1) and (2) are given and procedure for (3) will be exactly the same as for (2).

Number of unit operations

Let N_{gdp} be the total number of units landed of type g on the d^{th} landing centre day during the p^{th} period of observation. Then, the total number of g^{th} type of units during d^{th} day of observation is obtained as

$$N_{gd} = \sum_{p=1}^{3} N_{gdp} \qquad \text{………….. (12)}$$

An estimate of number of unit operations of g^{th} type of unit for a month is given by

$$\hat{U}_g = \frac{NQ}{n} \sum_{d=1}^{n} N_{gd} \qquad \text{……………(13)}$$

Estimated effort in fishing hours

Let f_{gdpi} be the effort expended in actual fishing hours expended by the i^{th} selected unit of the g^{th} type of unit (craft-gear) observed on the d^{th} landing centre day during p^{th} period of observation.

Let $\hat{f}_{gdp}$ be an estimate of total effort expended by the g^{th} type of unit on d^{th} selected landing centre day during p^{th} period of observation, then

$$\hat{f}_{gdp} = \frac{N_{gdp}}{n_{gdp}} \sum_{i=1}^{n_{gdp}} f_{gdpi} \qquad \text{……………. (14)}$$

Let $\hat{f}_{gd}$ be an estimate of effort expended by the g^{th} type of unit on d^{th} landing centre day and is given by

$$\hat{f}_{gd} = \sum_{p=1}^{3} \hat{f}_{gdp} \qquad \text{…………… (15)}$$

An estimate of total effort by the g^{th} type of unit for the month is given by

$$\hat{f}_g = \frac{NQ}{n} \sum_{d=1}^{n} \hat{f}_{gd} \qquad \text{……………. (16)}$$

An estimate of total effort by all types of units in a month is a zone is given by

$$\hat{f} = \sum_{g} f_g \ \text{(summed over all types of units)} \qquad \text{……………. (17)}$$

II. Stratification in a zone

Let the zone be divided into L strata (in practice a zone is divided into 2 or 3 strata as groups of major, minor and very minor centres depending on intensity of fishing operations).

(Assumption: The number of fishing days in a month N remains the same for all strata)

Let Q_l be the number of centres in the l^{th} stratum of a given zone and n_l be the number of selected landing centre days belonging to l^{th} stratum.

An estimate of total landings of species s landed by g^{th} type of unit in the l^{th} stratum of a zone for the month is given by

$$\hat{Y}_{sgl} = N \frac{Q_l}{n_l} \sum_{d=1}^{n_l} \hat{Y}_{sgld} \qquad \text{.………………. (18)}$$

where $\hat{Y}_{sgld}$ is an estimate as explained in the earlier section pertaining to zone without stratification.

An estimate of total landings of species *s* landed by g^{th} type of unit in the zone for the month is given by

$$\hat{Y}_{sg} = \sum_{l=1}^{L} \hat{Y}_{sgl} \quad \text{and } \hat{Y}_s,\ \hat{Y}_g \text{ and } \hat{Y} \text{ are as given in equations (5), (6) and (7).}$$

An estimate of total number of unit operations during the month by g^{th} type of unit in the l^{th} stratum is given by

$$\hat{U}_{gl} = N \frac{Q_l}{n_l} \sum_{d=1}^{n_l} N_{gld} \qquad \text{....…………. (19)}$$

An estimate of total number of unit operations for the zone in a month is given by

$$\hat{U}_g = \sum_{l=1}^{L} \hat{U}_{gl} \qquad \text{……………. (20)}$$

An estimate of total effort expended in terms of actual fishing hours by g^{th} type of limit in the l^{th} stratum of a zone in a month is obtained as

$$\hat{f}_{gl} = N \frac{Q_l}{n_l} \sum_{d=1}^{n_l} \hat{f}_{gld} \qquad \text{……………. (21)}$$

where $\hat{f}_{gld}$ is obtained as given in equation (15) in the case of no stratification.

An estimate of effort by g^{th} type of unit for the zone is given by

$$\hat{f}_g = \sum_{l=1}^{L} \hat{f}_{gl} \qquad \text{…………….. (22)}$$

An estimate of total effort ($\hat{f}$) for the zone by all types of units is as given in equation (17).

Estimate of variance of total landings over all species and gear

It is assumed that variance between boats of the same gear to be negligible (Sukhatme *et al.* 1958; Panse and Sastry, 1960) on a selected landing centre day. Thus, the variance is estimated as the variance between days and is given by

$$\hat{V}(\hat{Y}) = \frac{N^2 Q^2}{n} \hat{V} \qquad \ldots\ldots\ldots\ldots\ldots\ldots..\ (23)$$

$$\hat{V} = \frac{1}{n-1} \left\{ \sum_{d=1}^{n} \hat{Y}_d^2 - \frac{\left(\sum_{d=1}^{n} \hat{Y}_d \right)^2}{n} \right\} \qquad ..\ldots\ldots\ldots..\ldots\ldots(24)$$

where $\hat{Y}_d$ is given by equation (4).

The standard error of the estimate can be found out from the above formula.

APPENDIX B

Symbols and abbreviations

Nz	Number of zones in a region
d	Day
f	Effort
g	Type of unit
l	Stratum
L	Number of strata
n	Number of selected landing centre days
nl	Number of selected landing centre days in l^{th} stratum
N	Number of days (fishing days) in a month
p	Period of observation
Q	Number of centres in a zone
s	Species
U	Number of unit operations
V	Variance
$\hat{Y}_d$	Estimate of total landings for selected landing centre day for all species and over all gears
y	Landings (catch)
$\hat{Y}$	Estimate of total landings for a month for all species and over all gears
FAO	Food and Agriculture Organization
ICAR	Indian Council of Agricultural Research
DAHD&F	Department of Animal Husbandry, Dairying & Fisheries
CMFRI	Central Marine Fisheries Research Institute
FRAD	Fishery Resources Assessment Division
ARIS	Agricultural Research Information System
FSI	Fishery Survey of India
IASRI	Indian Agricultural Statistics Research Institute
UN	United Nations
UNCSD	United Nations Commission for Sustainable Development
SCZ	Single Centre Zone

APPENDIX C

Types of Craft and Gear commonly used in Marine Fisheries

Craft

Mechanized

- Trawler
- Purse-seiner
- Gillnetter
- Liners
- Dolnetters

Motorized & Non-motorized

- Dugout canoes
- Catamarans
- Plank-built
- Fibre-glass boats

Gear

Trawl nets (Bottom, midwater and pelagic)

Gillnets

Trammel nets

Seine nets (Purse-seine, Ring seine, Boat seine, shore seine, etc.)

Hooks & Lines (Hand lines, long lines etc.)

Bag nets (Dol nets, fixed bagnets, stake nets)

Mechanized craft: A craft that uses mechanical power/devices not only for propulsion but also for catching the fish.

Motorized craft: A craft that employs mechanical power used for propulsion only.

APPENDIX D

List of commercially exploited marine fishery resources

- ELASMOBRANCHS
  - Sharks
  - Skates
  - Rays
  - Eels
- Catfishes
- CLUPEOIDS
  - Wolf herring
  - Oil sardine
  - Other sardines
  - Hilsa shad
  - Other shads
  - Anchovies
  - Coilia
  - Setipinna
  - Stolephorus
  - Thrissina
  - Thryssa
  - Other clupeids
- BOMBAYDUCK
- LIZARD FISHES
- HALF BEAKS & FULL BEAKS
- FLYING FISHES
- PERCHES
  - Rock cods
  - Snappers
  - Pig-face breams
  - Threadfin breams
  - Other perches
- GOATFISHES
- THREADFINS
- CROAKERS
- RIBBON FISHES
- CARANGIDS
  - Horse Mackerel
  - Scads
  - Leather-jackets
  - Other carangids
- SILVERBELLIES
- BIG-JAWED JUMPER
- POMFRETS
  - Black pomfret
  - Silver pomfret
  - Chinese pomfret
- MACKERELS
  - Indian mackerel
  - Other mackerels

SEER FISHES

S. commersoni

S. guttatus

S. lineolatus

Acanthocybium spp.

TUNNIES

E. affinis

Auxis. spp

K. pelamis

T. tonggol

Other tunnies

BILL FISHES

BARRACUDAS

MULLETS

UNICORN COD

FLAT FISHES

Halibut

Flounders

Soles

CRUSTACEANS

Penaeid prawns

Non-penaeid prawns

Lobsters

Crabs

Stomatopods

MOLLUSCS

Bivalves

Gastropods

Cephalopods

Squids

Cuttlefish

Octopus

Seacow

Whale

SEAWEEDS

APPENDIX E

Forms Used for Data Collection

R E G I S T E R E D

Central Marine Fisheries Research Institute, Cochin – 18

FISHERIES RESOURCES ASSESSMENT DIVISION

No……………….. Date: ………………….

Work programme of Shri ____

Month & year _____________ Zone __________District ______________State _____________

Place	Date
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	

Timings : 12.00 hrs. to 18.00 hrs. on the first day and 06.00 hrs. to 12.00 hrs on the second day

To

Shri ____

____

Head of Division

Copy to:

1. Scientist-in-Charge _______________Regional/Research Centre of CMFRI _____________
2. The Field Officer, FRAD, CMFRI, Cochin.
3. Concerned Technical staff at Headquarters____

--✂--

ACKNOWLEDGEMENT

(To be detached and returned)

To

The Head
F.R.A. Division
C.M.F.R.I., Cochin-18

Received work programme for the month of _____________for the zone _____________

Place:
Date : (Signature)

Fishery Survey Form C

NATIONAL MARINE LIVING RESOURCES DATA CENTRE

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE (ICAR), COCHIN – 18

CONSOLIDATED STATEMENT OF NUMBER OF MECHANIZED/NON-MECHANIZED FISHING UNITS LANDED

Zone ……………… Name of observer …………….…………

Month ……………. Year …………… Date of submission ………………………..

Period →		Afternoon (12-18 hrs)	Night (18-06 hrs)	Forenoon (06-12 hrs)	TOTAL
Centre	Gear → / Date ↓				

Remarks Signature

Fishery Survey Form T

NATIONAL MARINE LIVING RESOURCES DATA CENTRE

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE (ICAR), COCHIN – 18

RECORD OF TIME OF LANDINGS

Name of landing centre ………..…

Type of unit – Mechanized/Non-mechanized (Shoreseine/others)

Date ……………

Number of fishing units landed during the Previous night ……………

Period of observation …………………..

Serial No.	Time of landing	Remarks	Serial No.	Time of landing	Remarks	Serial No.	Time of landing	Remarks
1			34			67		
2			35			68		
3			36			69		
4			37			70		
5			38			71		
6			39			72		
7			40			73		
8			41			74		
9			42			75		
10			43			76		
11			44			77		
12			45			78		
13			46			79		
14			47			80		
15			48			81		
16			49			82		
17			50			83		
18			51			84		
19			52			85		
20			53			86		
21			54			87		
22			55			88		
23			56			89		
24			57			90		
25			58			91		
26			59			92		
27			60			93		
28			61			94		
29			62			95		
30			63			96		
31			64			97		
32			65			98		
33			66			99		
						100		

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE, COCHIN

FISHERY RESOURCES ASSESSMENT DIVISION

Trend of fisheries for the month of …………………………….

State ……..………………… **District** ………………………….. **Zone** ……………..

1. Account of the fisheries in the zone as a whole for the month. (This should cover commencement/closure of important fishery.

2. Comparative assessment of catch with that of previous month.

3. Relative abundance of different species of fish in different nets.

4. Occurrence of Juveniles of commercially important species.

5. Any unusual phenomenon such as bumper catch of fish and prawns, large scale mortalities, diesel shortage agitations, cyclones etc.

6. Information on the capture of marine mammals like whales and dugong and marine turtles.

7. Additional points, if any.

Name and signature of the Assistant

Place :

Date :

Fishery Survey Form 2
Trawler (A) /Gillnetter (B) /Longliner (C) /Dolnetter (D)/Country craft with O.B.(E).

NATIONAL MARINE LIVING RESOURCES DATA CENTRE

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE (ICAR), COCHIN – 18

DAILY RECORD OF CATCH AND EFFORT OF SMALL MECHANIZED FISHING CRAFT

State ……………….…… [ ] District …………….. [ ] Zone ……………..…… Centre ……………………………….

Date [ ] [ ] [ ] Period……………… [ ] Number of units landed [ ]…….. No. of units selected ………… [ ]

State of sea ……………………………. [ ] State of sky ……………………. [ ] Direction of wind …………… [ ] Current ……………… [ ]

Serial number	Allotted No. of selection of units examined	Name and/or craft number	Type of craft		Type of gear		Length of craft	Horse power	Absence from shore			Fishing ground			No. of hauls	Duration of actual	Man power employed	Av. Trawling speed in case of trawler (km/hr)	Name, code and weight (kg) of fish landed										Total
			Name	Code	Name	Code			Dep. Time & Date	Arr. Time	Duration of absence (hrs)	Distance (km) from shore	Direction from L.C.	Depth (m)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
														Price in Rs. per Kg															

Special attention : Report incidental catch/stranding of cetaceans and turtles with details

Remarks

Fishery Survey Form 1

NATIONAL MARINE LIVING RESOURCES DATA CENTRE
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE (ICAR), COCHIN – 18
DAILY RECORD OF CATCH AND EFFORT OF NON-MECHANIZED FISHING CRAFT – SHORE SEINES/OTHERS

State ………………………….…… [ ] District ……………….. [ ] Zone ……….. [ ] Centre …………………………………… [ ]

Date [ ] [ ] [ ] Period……………….… [ ] Number of shore seines/other units landed ……..…. No. of units selected ………

State of sea ……………………………. [ ] State of sky …………… [ ] Direction of wind ………….. [ ] Current ……………………. [ ]

Serial number	Allotted No. of selection of units examined	Type of craft		Type of gear		Length of craft	Absence from shore			Fishing ground			No. of hauls	Duration of actual fishing (hrs. & mts)	Man power employed	Name, code and weight (kg) of fish landed										Total
		Name	Code	Name	Code		Dep. Time & Date	Arr. Time	Duration of absence (hrs)	Distance (km) from shore	Direction from L.C.	Depth (m)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Special attention : Report incidental catch/stranding of cetaceans and turtles with details													Price in Rs. per Kg													

Remarks

Name and signature of observer

Fishery Survey Form II
Trawler (A)

NATIONAL MARINE LIVING RESOURCES DATA CENTRE
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE (ICAR), COCHIN – 18
DAILY RECORD OF CATCH AND EFFORT OF SMALL MECHANIZED FISHING CRAFT

State ……………………………..…… [ ] District …………………………..[ ] Zone ………… [ ] Centre ……………………………………[ ]

Date [ ] [ ] [ ] Period……………………………[ ] Number of units landed ……………….. No. of units selected ………………

State of sea ……………………………. [ ] State of sky …………………… [ ] Direction of wind ………….. [ ] Current ………………..[ ]

Serial number	Allotted No. of selection of units examined	Name and/or craft number	Type of craft		Type of gear		Length of craft	Horse power	Absence from shore			Fishing ground			No. of hauls	Duration of actual fishing (hrs. & mts)	Man power employed	Av. Trawling speed in case of trawler (km/hr)	Name, code and weight (kg) of fish landed										
			Name	Code	Name	Code			Dep. Time & Date	Arr. Time	Duration of absence (hrs)	Distance (km) from shore	Direction from L.C.	Depth (m)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
															Price in Rs. per Kg														

Special attention : Report incidental catch/stranding of cetaceans and turtles with details

Remarks

Name and Signature

NATIONAL MARINE LIVING RESOURCES DATA CENTRE
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE (ICAR), COCHIN – 18
DAILY RECORD OF CATCH AND EFFORT OF SMALL MECHANIZED FISHING CRAFT

Fishery Survey Form II
Trawler (A)

Serial number	Serial number of the unit selected	**Name, code and weight (Kg) of fish landed**																					
1	2	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Price in Rs. Per Kg																							

Section-B

INLAND FISHERY

CHAPTER – I

INTRODUCTION

1.1 **Inland fisheries** enjoys prime of place in Indian economy. It provides employment and livelihood for fishers who solely depend on it. Fisheries are a renewable natural resource, subject to its own dynamics, acted upon by various forces. Open access system of exploitation of the resources lead to overcapitalization, resulting in decrease in the yield rates and unprofitability of operations and threatening the food security as well. Fish is a cheap and rich source of animal protein for the entire population of the country. The concomitant uncertainties make it imperative that the resources have to be scientifically developed, monitored and managed.

1.2 The global production of food fish from aquaculture, including finfishes, crustaceans, molluscs and other aquatic animals, reached 52.5 million tonnes in 2008. The contribution of aquaculture to the total production of capture fisheries and aquaculture continued to grow, rising from 34.5 percent in 2006 to 36.9 percent in 2008. In the period 1970–2008, the production of food fish from aquaculture increased at an average annual rate of 8.3 percent, while the world population grew at an average of 1.6 percent per year. The combined result of development in aquaculture worldwide and the expansion in global population is that the average annual per capita supply of food fish from aquaculture for human consumption has increased by ten times, from 0.7 kg in 1970 to 7.8 kg in 2008, at an average rate of 6.6 percent per year. Production from aquaculture is mostly destined for human consumption. Globally, aquaculture accounted for 45.7 percent of the world's fish food production for human consumption in 2008, up from 42.6 percent in 2006 (FAO, 2010).

1.3 Inland water resources in India are diverse and comprised of 29,000 km of rivers, 0.3 million ha of estuaries, 0.19 million ha of backwaters and lagoons, 3.15 million ha of reservoirs, 0.2 million ha of floodplain wetlands and 0.72 million ha of upland lakes. These water bodies altogether contribute about 1.05 million t annual fish production. Inland fish production has shown remarkable increase from 0.218 million t in 1950-51 to about 4.930 million t in 2009-10 (ICAR, 2011). Freshwater aquaculture is the major contributor in inland fish basket where its share has increased from 46% in 1980s to over 85% in recent years. It has evinced ten-fold growth from 0.37 million t in 1980 to about 3.85 million t in 2009-10 with mean annual growth of about 6% (Table 3).

1.4 Development of the resources should comprise measures to augment the abundance level of the resources, strategies to exploit them in such a manner that food security is ensured, the exploitation process being economically viable and the resources conserved at a steady state allowing maximum potential for exploitation. This calls for strategic planning on the basis of scientific assessment of various biological, social and economic indicators.

1.5 For example, administration may be interested to ascertain whether there is scope of increasing the yield or the yield realized is commensurate with the investments made or whether profitability is affected or whether there is scope of further employment. Answers to these questions lie in assessing a multitude of indicators of biological and economical nature. We need to know the catch taken, size of fleet employed, present level of employment, per capita yield and so on. The assessment of these parameters is made by application of scientific methods which call for volumes of basic data on fishery, employment and operational details including costs and returns. The collection of such data is an enormous task often beset with hurdles owing to the sporadic spatial and temporal distribution of the resources. Since the independence, particularly with the start of the five year plans, Planning commission and R & D organizations were seized of the problems and made many attempts to schematize, scientifically, the collection of basic fishery data. Nevertheless, unlike marine sector, inland fisheries cannot claim a satisfactory status with regard to data collection.

1.6 The absence of basic data often set limitation to the planning process. The National Commission on Agriculture (1976) in their report pointed out that the inland fisheries statistics in India are compiled on the basis of information on market arrivals furnished by the states, water area leased, stocking of seed etc., which are not considered satisfactory. India has vast potential inland resource with all India distribution. However, the data collected from these resources are sometimes neither comparable nor aggregated at national level as their concepts and definitions vary from region to region. Hence, there is a strong need for evolving a scientific methodology of data collection with uniform concepts and definitions.

Measurement needs of the sector

1.7 The success of any planning largely depends upon the availability of reliable data based on which it has been worked out. However, in inland fisheries sector the catch statistics throughout the world including India are far from reliable as they are not generally based on any sound statistical methodology. The National Commission on Agriculture (1976) also in their report pointed out the inland fisheries statistics in India are compiled on the basis of information furnished by the states, who are estimating on the data of market arrivals, water area leased, stocking of seed etc. which are not considered to be satisfactory. India has vast potential inland resource scattered through out the country. However, their concepts and definitions vary from one region to another region. So the data collected from these resources are sometimes neither comparable nor compilable at Central Level. There is a strong need for uniform concepts, definition, collection and compilation of methodology for this sector.

Development of statistical system of the sector

1.8 A pilot investigation was launched in 1955-56 by ICAR in two districts of erstwhile Hyderabad state for developing sampling techniques suitable for inland fisheries resource estimation. Later on, in April, 1956, Government decided to transfer the work to the National Sample Survey Organization (NSSO). In September, 1958, Directorate of National Sample Survey Organization (NSSO) took up the survey in Orissa to evolve suitable sampling techniques for estimation of fish production. By the end of 1958, certain basic information such as variety of resources, their relative importance, formation of sampling frame, fishing practices and identity of suitable agency for field work were collected, which later on formed the basis of the pilot survey in Orissa during 1962-63.

1.9 The NSSO undertook pilot survey of Inland fisheries in 1962-63 in three districts of Orissa namely, Cuttack, Sambalpur and Mayurbhanj, based on the technical programme given by IASRI, New Delhi. The primary objective of the survey was to gather preliminary information to develop suitable methodology for the estimation of (i) number & area of ponds, tanks & swamps and (ii) total catch of fish therefrom. The information was collected mainly by enquiry and by physical observation.

1.10 An attempt was made by ISI, Calcutta, for evolving sampling methodology for Inland Fisheries during 1960-61.The sampling work was seriously disturbed and no estimation was attempted though it brought out problems encountered in the field.

1.11 The Central Inland Fisheries Research Institute, Barrackpore, made an attempt to estimate the area and catch from ponds in the district of Hoogly, West Bengal during 1962-63 but it did not lead to accomplishment of the task at hand. In 1973-75, the NSSO conducted a survey covering three districts, one each in West Bengal, Tamil Nadu and Andhra Pradesh with the aim of obtaining estimate of catch both from impounded water and riverine resources by enquiry. The estimates worked out were not satisfactory, particularly from riverine resources.

1.12 In another pilot survey conducted by IASRI, New Delhi and CIFRI, Barrackpore in one district of West Bengal during 1978-81, the data were collected both by enquiry and by physical observation. The main objectives of the survey were (1) to evolve suitable sampling methodology for estimation of (a) inland water resources, (b) total catch for inland fisheries and (2) to study the prevailing practices of pisciculture. The study covered only ponds in the district of 24-Parganas in West Bengal. The catch estimate of other important resources like estuaries, rivers, brackish water impoundments, beels could not be attempted due to limited manpower. In spite of all these attempts, there is no scientifically designed and accepted method for collection and estimation of all types of inland fishery resources.

1.13 However, the Department of Animal Husbandry and Dairying, Ministry of Agriculture, Govt. of India, during 8th Plan, entrusted the development of uniform concepts, definitions and terminologies for various inland fishery resources and a suitable and standardized methodology for collection and estimation of inland fishery resources and catch there from to Central Inland Fisheries Research Institute, Barrackpore in collaboration with the States. The methodologies have been developed and tested in various States during 8th and 9th Plans. The States have been provided training and guidance for estimation of catch from various inland resources during 10th Plan and continuing in 11th Plan.

Scope and purpose of the manual

1.14 The manual will serve as a ready reckoner for all the user organizations and help them in following uniform definitions, data collection procedures and methodology for the analysis of data. It is hoped that this manual will also be useful to administrators, planners and researchers for evolving new policies and developmental programs for the fisheries sector.

Contents and organization

1.15 The manual consists of four chapters and appendices. Chapter I highlights the significance of the sector, need for statistical standards and development of statistical system of the sector. Concepts and definitions are placed in Chapter II. Chapter III presents sources of data and details of methodology being adopted for generating these data. Chapter IV conveys the suggestion for ensuring quality standards. Lastly, appendices include estimation methods, schedules and instruction for filling schedules.

CHAPTER - II

DEFINITIONS

Pond

2.1 A pond is a small body of water usually earthen, though masonry dykes are also included, and shallow made through excavations which represents a restricted environment without a continual interaction with populations of neighboring biotopes.

Tank

2.2 A shallow water unit, usually larger than a pond, created by constructing earthen or masonry barricades, which receives water either from tube wells or rain. Small excavated community ponds and temple tanks and small irrigation impoundments below 10 ha of water spread at full tank level (FTL) are included in this category.

2.3 The above water bodies namely ponds and tanks up to 10 ha water spread are considered highly productive owing to inherent nutrient status of soil and water, and to a great extent, the nutrient leaching from the surroundings. These water units, in the natural conditions, are found to yield 500-2000 kg per ha. Scientific farming, however, has resulted in yield exceeding 10 tones per ha. per year and, hence, has vast potential for enhancing fish production per unit area through scientific fish farming.

Large irrigation tank

2.4 Ponds and tanks larger than 10 ha area fall under this class. Separate database is needed for this group as the productivity here is much less than the previous category of ponds and tanks.

Lake/ floodplain lake

2.5 Lakes are lentic water bodies of natural origin which are formed due to tectonic movements of earth crust, volcanic or glacial action or wind action in the arid zones, depression from land slides or basin formed due to stream action, silt deposition or erosion or change in stream course (flood plains). These natural lakes constitute an impressive resource for fishery development in the country. Flood plain lakes cover extensive areas in the states of Eastern Uttar Pradesh, Northern Bihar, West Bengal, valley districts of Assam, Manipur, Tripura, and foothills of Arunachal Pradesh, and Meghalaya. They are commonly referred to as beels, jheels, chaurs, tals, pats and kols depending on the States in which they are located. The lakes formed due to inundation of low-lying stretches during flood also fall under this category.

Reservoir

2.6 A large reservoir is a man made impoundment of varying magnitude created by erecting bunds, dams, barrages or other hydraulic structures across streams or rivers serving one or more purposes such as irrigation, power generation, flood control or other water resource development projects. Each reservoir is a separate ecological entity and varies from another in its morphometry, area, and productivity status.

2.7 For the purpose of execution of the methodologies and obtaining reliable estimates, the large irrigation tanks (LT)), lakes (L) and flood plain lakes, beels (B) and reservoirs (R) are further sub-classified on the basis of area under the following:

1. Small

    a) Group I: 10 to 50 ha of water area at FTL

    b) Group II: 50 to 500 ha of water area at FTL

2. Medium reservoir

    500 to 1000 ha of water area at FTL

3. Large reservoir

    Above 1000 ha of water area at FTL

2.8 Categorization into above three sub groups is essential for estimating the yield with permissible degree of accuracy as the yield rates show high variation between these sub-groups due to different approaches adopted for fishery management. Small reservoirs are highly productive and they usually permit a near total exploitation of the stock due to depletion of water level during summer. An annual stocking and cropping policy is adopted in these water bodies with other management measures. In medium reservoirs too, stocking forms the mainstay in management but yields are substantially lower than the smaller ones. Large reservoirs on the other hand are managed to get maximum sustainable yield on a long term basis. Endemic fish fauna is generally the chief contributor in such water bodies and stocking is aimed at rectifying population imbalances based on natural food spectrum available in the water body. The average productivity from large group is the least.

Rivers and Canals

2.9 A river, by definition, is a large body of flowing water constrained in a channel. All the small and large rivers along with the major irrigation canals arising out of them are considered under riverine resources for the sake of fishery resources. In Indian context, the resources under this category are grouped under five major river systems *viz.* the Ganga, the Brahamputra, the Indus, the East coast and the West coast river system.

Estuary and Lagoons

2.10 An estuary is a semi-enclosed coastal body of water which has free connection with the sea and within which the seawater is measurably diluted by freshwater derived from land drainage. This ecotone is a buffer zone between fresh water and saline water of the sea. The river and sea water are mixed by the action of the tidal motion, wind stress on the surface and the river discharge facing its way into the sea. Salinity pattern is a good indicator of the estuarine mixing and pattern of water circulation in an estuary. This resource mainly comprises the Hooghly-Matlah, the Mahanadi, the Godavary and the Narmada estuary.

2.11 Estuary associated coastal water bodies are essential components of this system, often taking the shape of lagoons, creeks, backwaters and so on. The lagoons are usually shallow and the secondary production is often concentrated in the sediments rather than in the water column. The coastal lagoons like Chilka, Pulicat and the chain of backwaters of Kerala fall under this category.

Brackish water impoundments

2.12 They are estuarine man made impoundments where fresh water is mixed with sea water. Due to tidal action, the beds of many rivers and creeks in the estuarine areas get silted up and in due course they are reclaimed for agricultural purposes by constructing bunds to safeguard against floods and tidal water. Some portions of these reclaimed areas are too low for agriculture and are utilized for fish culture. The brackish water tidal wetlands namely mud flats, swamps, marshes, paddy fields *etc*. which are known as ‘bheries’ in West Bengal are included in this class.

For collection of data for estimation of fish catch from various inland fishery resources there is need to be acquainted with some terms which are described below:

Culture type

2.13 Production of fish from the body of water depends on the type of culture adopted by fish farmers. Hence, to measure this aspect more precisely, we can classify this into three types of operations:

1. Intensive
2. Semi intensive
3. Extensive/Traditional

2.14 When culture is done adopting scientific procedure with seed, feed and fertilizer we call it intensive culture. If all the inputs are not used and only a few inputs without any rational basis, we call it semi-intensive. While in extensive/traditional culture no input is used or some occasional stocking is done, which is age-old practice in rural areas.

2.15 Here, it is essential to follow uniform criteria for categorization of culture ponds into one of the above three.

Duration of crop

2.16 Production from pond to pond varies also on account of the period of culture operations. So, it is necessary to collect the data on this aspect to study the variability of production and its reasons.

Depth

2.17 Recording of depth may pose some problems as it may be difficult to gauge the depth by the enumerator. Hence, it may be recorded by inquiry from either the owner of the water body or through authoritative sources. Here, by maximum depth we mean the depth of the water body during post monsoon period and minimum which occurs during pre monsoon period.

Seasonality

2.18 The fish productivity depends on the period of culture, which ultimately relates to period of retention of water by the water unit. Hence, all the water bodies should be uniformly classified into few sub-classes on seasonality scale for proper estimation of production. They may be categorized as perennial (P), if water is retained and fish can survive for the whole year. If water is not for the whole year we call them seasonal water bodies. They may be further sub-divided as long seasonal (LS) if water retention is more than nine months and less than twelve months, seasonal(S) if water retention is between six and nine months. Short seasonal (SS) if retention is less than six months. These short seasonal water bodies are generally unsuitable for fisheries activities.

FFDA

2.19 Fish Farmer’s Development Agency (FFDA) is a programme launched by the Ministry of Agriculture, Govt. of India to enhance the fish production in States by adopting scientific technology of intensive culture.

Fishery Control and Management

2.20 In case of large water bodies, the information is necessary on the above two aspects. One relates to the controlling authority of the water body who takes all the decisions about the water body; for example, maintaining the water level, repairing, release of water for irrigation *etc*. The other aspect is fishery management. This is monitored by the agency that is looking for the management of fish biomass in the water body including decision pertaining to stocking, harvesting, auctioning *etc*. There may be situations where both these operations lie with a single agency.

Fishing Crafts and Gears

2.21 Inland fishery is basically a multi-species fishery exploited by artisanal fishermen. They use nets of varying type, length and mesh size. Collection of data from above categories may pose real problem due to these bottlenecks and uniform criteria are needed for recording statistics in the field. Data are needed on these varying types of tackles but to maintain uniformity and simplicity, we may restrict them to the following:

1. Gill net
2. Drag net
3. Cast net
4. Hook
5. Others

Fishing village

2.22 Concept of a fishing village varies from state to state and it is therefore, essential to define a fishing village to maintain uniformity throughout A fishing village is defined as one, which is located on the periphery of the water system and professional fishing parties/fishermen who are engaged in fishing operations either on full time or part time basis reside there.

Mode of exploitation (Fishing rights)

2.23 There are diverse ways in which a water body is put to fish harvesting. The right of fishing may be free, through licensing, royalty, and lease or departmental. Hence, water bodies may be uniformly categorized into the following:

1. Free fishing
2. Outright auctioning
3. Licensing (fishermen, boats or nets)
4. Royalty system
5. Departmental fishing

Name of water body

2.24 In case of large water bodies such as beels, lakes and reservoirs, which extend their water spread from one district to other or from one state to another are known locally by different names. This poses real problem in enlistment of a water body in the state or at the national level. Discrepancy, if any, may be ensured that the name recorded in the official records should be jotted down with local name in the brackets.

Ownership

2.25 Categorization of water bodies in terms of their ownership will help to assess the contribution of private and public ponds to fish production. For simplicity we classify this parameter into two different categories;

(i) Private, means that the water body belongs legally to an individual or group who has title individually or jointly.

(ii) Public, includes all these water bodies which are owned by Central or State Governments, Corporation, Cooperatives, Gram Panchayats or municipality *etc*.

(iii) Disputed, includes all those water bodies for which the ownership is in dispute between individuals or between an individual and public.

Reasons of non-utilization

2.26 Many water units although suitable for fishery may not be under this activity due to various reasons. The reasons may be title, ecological and others.

(a) Title: The title may be either

1. Multiple ownership or
2. Disputed

(b) Ecological.

1. Weed problem
2. Tidal imbalances

(c) Others

Soil type

2.27 Quality of soil is helpful in culture management and hence each water body is categorized as per the following soil types:

1. Sandy
2. Clayey
3. Loamy
4. Rocky

Weed infestation and silting

2.28 Infestation of weeds in large number of water bodies has become hazardous and inhibits the growth of fish whereas silt reduces the available water area. These parameters need to be investigated for the point of view of developing them into potential fishery resource. Hence, information about them will be quite useful. Since, these are qualitative in nature, are measured in terms of percentages as follows:

(a) Siltation

Character	
Not silted	0-25%
Partially silted	25 to 50%
Heavily	50% onwards

(b) Weed infestation

Character	
Marginally	0-25%
Moderate	25-50%
Highly infected	50-75%
Full	75-100%

Source of seed

2.29 Information on source of seed may be grouped into the following classes:

1. State Govt.
2. Private parties within the state
3. Outside the state

Source of water

2.30 Information on source of water is needed in order to have an understanding of the dependence of the unit on the source of water. Main sources are:

1. Rain
2. River
3. Irrigation canal
4. Ground water
5. Sewage
6. Estuary/coastal
7. Others

Water Spread Area

2.31 Water spread area of a water body changes due to water derived from it for other purposes and due to evaporation. Secondly, the water area recorded in the land utilization records also are unsatisfactory as they are outdated and at variance with the actual situation in the field. Due to various reasons such as silt load and human intervention, it has undergone shrinkage and therefore this statistics need to be planned and collected with caution. Keeping in view the above factors the following three recording procedures may be maintained:

(i) Water spread area from the land utilization records along with its identification number.

(ii) Water spread area by actual physical observation on the date of sampling and minimum and maximum area, which normally reached during pre and post monsoon period

(iii) Area should be recorded in uniform units in hectares.

CHAPTER – III

SOURCES AND SYSTEMS

National Status

3.1 Fisheries management within territorial waters wrests solely with State Governments and thus any information on fish catch from those waters and landed within the state has to emanate from the State. Fisheries Departments in various states have been collecting statistics on fish catch and other fishery related information. National level inland fish production statistics are compiled and published by the DAHD&F, MoA, Govt. of India. The DAHD&F, MoA Govt. of India, during 8th Plan, entrusted the development of uniform concepts, definitions and terminologies for various inland fishery resources and a suitable and standardized methodology for collection and estimation of inland fishery resources and catch there from to Central Inland Fisheries Research Institute(CIFRI), Barrackpore in collaboration with the states. The methodologies have been developed and tested in various states during 8th and 9th Plans. The states have been provided training and guidance for estimation of catch from various inland resources during 10th Plan.

3.2 The Central Sector Scheme on "Strengthening of Database and Information Networking for the Fisheries Sector" is in operation during the Tenth and Eleventh Plan. As per the Scheme, the respective State Governments collect the inland fish catch statistics and transmit the estimates to the Department of Animal Husbandry and Dairying (DAHD), Ministry of Agriculture, Government of India These estimates are then submitted before the Technical Monitoring Committee of the DAHD&F. The Director, IASRI, New Delhi is the Chairman of the Committee consisting of subject matter experts. The Committee reviews the estimates submitted by the various states and approves the national level estimates of inland fish production, after incorporating necessary validations. The Committee also suggests, wherever necessary, methodological changes for estimation of inland fish production to improve the precision of the estimates. The DAHD&F then publishes the national inland fish production statistics. The methodological support is given by the CIFRI as when required.

Classification of inland fisheries resources for production assessment

3.3 Inland water bodies are broadly classified into two categories: (1) fresh water resources like ponds and tanks, large irrigation tanks, lakes, reservoirs, beels, river, streams and (2) brackish water resources like estuaries, lagoons, "bheries". Many of the water bodies contribute only marginally to the total fish production and hence may not be of much importance in formulating strategies for the purpose of production assessment. Hence all those potential class of water bodies need coverage under catch assessment programs are being classified below for the execution of the methodology in order to provide firm, reliable and statistically sound data base on inland fisheries.

Group I (Water bodies up to 10 ha at full tank level)

1. Aquaculture ponds and tanks
2. Brackish water impoundments
3. Waterlogged areas

Group II (Water bodies above 10 h at full storage level)

1. Large Irrigation Tanks
2. Reservoirs and check dams
3. Lakes
4. Ox-bow lakes / Meanders / Channel Scars

Group III

1. Rivers
2. Canals
3. Estuaries
4. Lagoons
5. Back waters

3.4 Sampling methods devised for estimation of resource area, fish production and other parameters of importance will be discussed in the latter part of the estimation procedure.

3.5 It is often confusing to associate a water body uniquely with either of the above categories, especially with regard to large tanks, reservoirs and lakes. A water body considered a tank in one state is known and grouped as reservoir in another state. There are no uniform criteria adopted by the States. This lacuna makes the data incohesive and non-comparable between the States and to pool at the national level. Hence, each resource type is defined in the succeeding sections in order to facilitate uniform criteria through out the country.

Sampling methodology

3.6 Since the productivity varies from type to type of water bodies, separate sampling methodologies, type specific, are followed and they are outlined below. The whole state is divided into three nearly homogeneous groups called strata (each stratum containing a number of districts) on the basis of certain characteristics such as climate, rainfall, soil quality etc. Strata should be formed in such a way that geographical contiguity of districts within stratum is maintained. From each stratum a sample of 30% districts may be selected at random for the survey. Further, sampling within each selected district is discussed for each group separately in the succeeding paragraphs.

Sampling procedure for Group I water bodies

3.7 There may be two situations: (1) resource may be estimated and (2) resource data may be available from inventory or some other source. In both the cases stratified three-stage sampling where districts, clusters and ponds are first, second and third stage units of selection respectively is adopted. However, in the first case we need to collect data on resource whereas in the second case we need not do it.

Collection of Resource data

3.8 Sampling frame should be prepared for each selected district by making a list of villages. This can be achieved by using the census records as revised from time to time by revenue departments. In a particular district, villages having water bodies of this group may be highlighted and clusters of five nearby villages may be formed from among the pond bearing villages. From these clusters a sample of nine clusters is selected by random sampling for assessment of water spread area. The detailed information will be collected only once in a year.

Collection of catch data (monthly)

3.9 A further sampling of five ponds (under utilization for fishery) in each cluster is recommended for estimation of fish production. The data are collected only once in a month.

3.10 The whole selection procedure may be encompassed under stratified three-stage sampling where districts, clusters and ponds are first, second and third stage units of selection, respectively.

(2) Alternative procedure

3.11 It happens sometimes that information on the total resource is available from other sources. In that case there is no need of estimation of area under different categories of water bodies. The data on (i) Total no of ponds, (ii) Harvested no. of ponds, (iii) Total area, (iv) Total harvested area are available.

3.12 In such cases the catch data will be collected as per the same procedure outlined above, *i.e.* sampling of five ponds in each cluster is recommended for estimation of fish production. The data are collected only once in a month.

Sampling procedure for group II water bodies

3.13 As far as area statistics is concerned, a total inventory of resource under each stratum for Group-II should be prepared and a sub group of small, medium and large units as defined earlier may be made. 25 to 30% sample water bodies at random from each sub group of each stratum should be selected for collection of data on fish catch. Catch data from selected water bodies is recorded in the following manner:

3.14 Investigations have shown that two types of exploitation pattern are adopted in these water bodies.

(1) Water bodies, which are harvested for a short interval extending from a fortnight to about a month during the year. These water bodies are mostly small reservoirs and lakes which fall under the purview of state departments and exploitation is affected either by auctioning them to private contractors under certain terms and conditions or exploited departmentally by engaging contract labour. Hence, the bulk of harvest is a one time operation. Data from such water bodies are collected on total enumeration basis.

(2) Water bodies, which are exploited round the year by fishermen cooperatives or individual fisherman on the basis of licenses, free fishing, royalty or any other such mode.

3.15 There are two types of approaches for estimation of monthly, quarterly and annual catch depending on the exploitation practices and disposal of catch. If individual fisherman exploits the water bodies and catch record may be available for each operating unit separately, the fishing village approach is adopted. If the catch cannot be recorded by units operated and only total catch, which is landed for disposal, can be assessed, then landing centre approach is adopted. However, first we will try to get the information about the water body and then we have to specify the “choice of sampling units” which may be either “Fishing village” or “Landing centre”. Based on this information the monthly, quarterly and the annual catch will be estimated adopting the appropriate technique.

Fishing Village Approach

Collection of Inventory Data

3.16 As stated earlier, the inventory of village-wise operating units is made in fishing village approach. Here data from all the fishing villages by the side of the water body have to be collected. Information should be collected from each household of the village regarding "head of the household", "family size (adult & children)", "Fishing as occupation", "number and type of boats", "type of gears and their number" used by the household and lastly the "mode of disposal" of the catch.

Collection of catch data

3.17 A few villages (25%-30% with a minimum of two villages) are selected at random to record the catch on sampling days of a month. Fortnightly, systematic sampling is followed in selection of days, if fishing is done everyday in the month; otherwise random sample of fishing days is taken from each fortnight. On the day of sampling, the investigator is required to record the no. of units operated, total catch as well as species-wise catch along with other details from selected water units.

3.18 In brief, this procedure can be described as stratified three stage sampling where selection of fishing villages is the first stage, sample days as second stage and units observed as third stage of selection

Landing Centre Approach

Collection of Inventory Data

3.19 Here, data from all the landing centres of the water body under the district have to be collected.

Collections of catch data

3.20 In landing centre approach, it is difficult to record the catch unit-wise. A few landing centres will be selected for collection of catch data. From each selected landing centre, the total catch as well as species-wise catch for the day can be noted. The observation of catch is made by the following procedure:

3.21 A few landing centres (25%-30% with a minimum of two) are to be selected from the total landing centres of that water body. Further, sampling of days in months is made fortnightly adopting systematic sampling of two consecutive days for collection of catch data, if fishing is done everyday in the month; otherwise random sample of days is taken from fishing days in each fortnight. Each selected landing centre is physically observed on two consecutive days in each of the first and second fortnight during the month. On a selected day of sampling at a centre, data are collected during 12.00 to 18.00 hr and on second day from 06.00 to 12.00 hrs. Data on night landings, if any, in between the consecutive days are collected by inquiry on the second day. On the selected day of observation, the investigator should collect information on the total catch landed and species composition. He should also ascertain the number of fishing holidays observed during the last month. However, the sampling days in a month may be increased depending on the available resources and the unit's potential in fish landings.

Sampling procedure for Group III water bodies (rivers, streams, canals, estuaries etc.)

3.22 The water bodies under this group sustain multi gear and multi species fishery exploited by artisanal fishermen operating on the entire area of the system making the estimation rather cumbersome. Most of the water bodies do not have well established landing centres where fishermen may land their catch. In some of the cases, entire bank of the river act as landing point for them and they directly take the catch to the wholesale or retail market for final disposal. However rivers like Ganga and estuaries like Hooghly-Matlah have some landing centres at some points which can be considered for collection of data. Fish catch from this group of water bodies is generally negligible in most of the states.

3.23 Sampling frame for this group is prepared by enlisting district-wise, all the fishing villages/landing centres in each of the strata. 25 to 30% of these units are selected by random sampling from amongst the selected districts of each stratum at the second stage. For each selected unit 2 to 4 sampling days within a month are further selected at the third stage for collection of catch data.

3.24 Hence, the above procedure may be termed as stratified three stage sampling where district-wise villages, days of sampling and units observed form the first, second and the third stage of sampling respectively. The observation of catch is made by the same procedure as adopted for Group II water bodies, where fishing is done throughout the year. However, they are again described below:

3.25 There are two types of approaches for estimation of monthly, quarterly and annual catch depending on the exploitation policies and disposal of catch. If individual fisherman exploits the water body and catch record may be available for each operating unit separately, the fishing village approach is adopted. If the catch cannot be recorded by units operated and only total catch that is landed for disposal can be assessed, then landing centre approach is adopted. However, first the information about the water body is collected and there we have to make the choice of sampling units which may be either "Fishing village" or "Landing centre". Based on this information the monthly, quarterly and annual catch will be estimated adopting the appropriate technique.

Fishing Village Approach

Collection of Inventory data

3.26 a) As stated earlier, the inventory of village-wise operating units is done in fishing village approach. Here, data from all the villages of the water body under the district are collected. Information should be collected from each household of the village regarding "head of the household", "family size (adult & children)", "fishing as occupation", "number and type of boats", "type of gears and their number" used by the household and lastly the "mode of disposal" of the catch.

Collections of Catch data

3.27 In fishing village approach, the inventory of village-wise operating units is done. A few fishing villages (25%-30% with a minimum of two) are selected at random to record the catch on sampling days of a month. Fortnightly, systematic sampling for days is followed in selection of days if fishing is done everyday; otherwise random sample of fishing days in each fortnight is taken. On the day of sampling the investigator is required to note the no. of units operated, total catch as well as species-wise catch from selected units and other details.

3.28 In brief, this procedure can be described as stratified three stage sampling where selection of fishing villages is the first stage, sample days as second stage and fishing units observed as third stage units of selection.

Landing Centre Approach

Collection of Inventory Data

3.29 In landing centre approach, it is difficult to record the catch unit-wise. The catch from several units are collected by some middleman and brought to the landing centre for disposal.. Here data from all the landing centres of the water body under the district have to be collected.

Collection of catch data

3.30 A few landing centres (25%-30% with a minimum of two) are to be selected. Further, sampling of days in a month is made fortnightly adopting systematic sampling of two consecutive days for collection of catch data, if fishing is done everyday; otherwise random sample of fishing days in each fortnight is taken. Each selected landing centre is physically observed on two consecutive days in each of the first and second fortnight during the month. On a selected day of sampling at a centre, data is collected during 12.00 to 18.00 hr and on second day from 06.00 to 12.00 hrs. Data on night landings, if any, in between the consecutive days are collected by inquiry on the second day. On the selected day of observation, the investigator should collect information on the total catch landed and species composition. He should also ascertain the number of fishing holidays observed during the last month. However, the sampling days in a month may be increased depending on the available resources and the potential in fish landings.

International Status

3.31 Information on total fish catch, species-wise catch and its value are fundamental to all studies of fisheries dynamics. Most of the countries have developed mechanism for collection of basic data on their fisheries, but the way in which the responsibility for data collection and analysis is organized varies greatly. Most of the available literature is centered on capture fisheries, specifically from marine resources or large water bodies. A full treatment of the general problems of setting up and monitoring a national statistical system are developed within a "Handbook of statistical organization" published by the United Nations, New York (studies in method series F, No. 6). The particular problems of fishery statistical system are dealt with by FAO, Fisheries Divisions (1965). Brander (1975) has discussed data requirement and guidelines for collection and compilation of fisheries statistics in general.

3.32 In the wake of recent international initiatives to promote responsible fisheries emphasizing the obligation on states to conserve stocks and avoid over-exploitation, FAO has revised the guidelines for the routine collection of capture fisheries data (FAO, 1999).

3.33 Stamtopoulo (2002) has summarized experience gained over recent years in fishery statistical development by the Fishery Information, Data and Statistics Unit (FIDI) of FAO, and provides planners and users of fishery surveys with simple and step-by-step guidance for developing and implementing cost-effective and sustainable fishery surveys. The methodological and operational concepts discussed here apply equally to both marine and inland capture fisheries and are presented in a manner that is generic enough to make them adaptable to most commonly used data collection systems. Statistical aspects are presented in a descriptive rather than theoretical manner. Emphasis is placed on the understanding and interpretation of the statistics and related indicators collected, rather than on the computations producing them.

3.34 Inland capture fisheries in South-east Asia are characterized by great diversity in the range of gears used, environment in which they are used and the socially and culturally complex societies within which they operate. These complexities lead to typical problems in collection of inland fisheries statistics. On recognition of the short-comings of the current inland fisheries information and statistics world-wide, a review of the status of inland fisheries statistics in south-east Asia was commissioned by the Asia-Pacific Fishery Commission in 2001, and the recommendations have been discussed in detail by Coates (2002).

3.35 Lack of funds and man-power is always a serious problem in collection of fisheries data, specifically in case of inland fisheries. The problem can be solved up to some extent by involvement of local population. Hosch (2000) presented the results obtained from the field study, testing the validity of subsistence fisheries data collected by secondary school students from Aleipata, the coastal district of East Upolu, Samoa, Pacific islands. From the analysis of the observed results, it emerges that a carefully designed survey of students can generate a wealth of low-cost and appropriate data.

3.36 Rane (1997) has provided guidelines for the collection of structural aquaculture statistics. Aquaculture is one of the fastest growing food producing sectors, growing at an average annual rate of about 10% at global level. The result of increased competition of aquaculture with traditional farming for the land and aquatic resources and feeds and fertilizers has focused the attention of governments in many countries on the need to collect reliable quantitative data on the structure, performance and output of the aquaculture sector.

Chapter - IV

ISSUES AND SUGGESTIONS

Issues and constraints of the existing inland fishery statistical system

4.1 Issues:

- Unlike marine sector, inland fisheries cannot claim a satisfactory status with regard to data collection;
- Open access system nature of inland open-waters;
- Multiple usages & multiple-ownership;
- Poor understanding of requirements of users;
- Inadequacy in basic database at the state level;
- The data collected from inland fishery resources of different states are sometimes neither comparable nor compilable at Central Level;
- Unregulated fishing practices;
- Lack of relevant and usable information;
- Rapid shift in biodiversity and fish stock;
- Lack of environmental consideration in open-water fishery management;
- Difficulty in Application of policy regulations and integration ;

4.2 Constraints:

- Incomplete and incorrect or unreliable data at state level
- Lack of coordination among stakeholders
- Lack of uniform policy for resource management
- Incompatibility of data
- Lack of standardized/compatible data collection and compilation methodologies and tools.
- Poor accessibility to fishery resources in upland regions
- Lack of adequate skilled manpower
- Lack of priority on HRD in open-water issues

Suggestions

4.3 Some suggestions for improving and strengthening of inland fish statistical system are summarized below:

Reliable Database

4.4 There is no complete database of riverine fisheries or estuaries of India. A reliable and updated catch data along with other relevant details of fisheries are necessary for stock assessment and fisheries management in open waters. Therefore, it is necessary to review the present methods of data collection and establish reliable database.. Monitoring of the ecosysytems in terms of productivity, catch, catchment ecology, landing centres, crafts and gears is very essential to evolve management policies and evaluate the efficiency of such policies from time to time when carrying capacity of riverine ecosystem is fast changing and affecting population dynamics and fish stocks. A regular monitoring is thus very essential for policy formulation for management and sustainable exploitation of riverine fisheries (Malhotra and Sinha, 2007).

Resource Generation from Open Water Fisheries

4.5 In Inland sector, water bodies are leased out for fishing only for the sake of revenue generation in line with land revenue which brings in added incentive for over fishing with no concern for sustainability of water body. The reservoirs and lake leasing are prime examples where fisheries resources were considered to be common property until they were harvested without affecting fish biodiversity. There is an urgent need to enforce strict measures to protect fish biodiversity in such leasing to maintain sustainable nature of these water bodies.

Man-made changes in the morphology of rivers and fish biodiversity

4.6 Most of the rivers in India are being drained, diverted, polluted and blocked which has degraded the freshwater ecosystems. When a river is blocked, its self purification capacity gets affected. Deforestation and watershed modifications disrupt the protective cover of the soil, resulting in the alteration of the styream flow, increased upstream erosion, turbidity of water, increased water temperature and finally low oxygen which adversely affects fisheries of the river systems.

4.7 A reduction of flood land and change in the flow of water from fluviatile to lecustrine conditions imposed serious constraints on riverine fish habit and habitat and particularly on their breeding. While, it affects their natural recruitment in the river systems, many fish species get perished. Impact of these destructive factors can be ascertained only by regular scientific data collection prior and after these changes. These valuable fauna and flora must be allowed to rejuvenate in natural ecosystema (Malhotra and Sinha, 2007).

Chapter - V

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APPENDIX A

ESTIMATION PROCEDURES

(i) Ponds and tanks: Group – I

Notations:

Let

N_h = Number of districts in h[th] stratum

n_h = Number of districts selected in h[th] stratum

M_{hi} = Number of clusters in i[th] district of h[th] stratum

m_{hi} = Number of clusters selected in i[th] district of h[th] stratum

$M_{h0} = \sum_{i=1}^{N_h} M_{hi}$ = Total clusters in h[th] stratum

$\overline{M}_h = \frac{1}{N_h}\sum_{i=1}^{N_h} M_{hi}$ = Average no. of clusters per district in h[th] stratum

B_{hij} = Total number of ponds in j[th] cluster of i[th] district in h[th] stratum

B'_{hij} = Number of ponds harvested in j[th] cluster of i[th] district in h[th] stratum

b'_{hij} = Number of ponds selected in j[th] cluster of i[th] district in h[th] stratum

a_{hijk} = Area of k[th] pond in j[th] cluster of i[th] district in h[th] stratum

A_{hij} = Total area in j[th] cluster of i[th] district in h[th] stratum

$$A_{hij} = \sum_{k=1}^{B_{hij}} a_{hijk}$$

(a) Estimation of total area (Two stage sampling)

Average area per cluster in h[th] stratum is given by

$$\overline{A}_h = \frac{\sum_{i=1}^{N_h}\sum_{j=1}^{M_{hi}} A_{hij}}{\sum_{i=1}^{N_h} M_{hi}} = \frac{1}{N_h}\sum_{i=1}^{N_h} w_{hi}\overline{A}_{hi} \qquad \ldots\ldots\ldots\ldots\ldots(1)$$

where $\overline{A}_{hi} = \frac{1}{M_{hi}}\sum_{j=1}^{M_{hi}} A_{hij}$; $\overline{M}_h = \frac{1}{N_h}\sum_{i=1}^{N_h} M_{hi}$; $w_{hi} = \frac{M_{hi}}{\overline{M}_h}$

Average area harvested per cluster in hth stratum is given by

$$\overline{A}'_h = \frac{\sum_{i=1}^{N_h}\sum_{j=1}^{M_{hi}} A'_{hij}}{\sum_{i=1}^{N_h} M_{hi}} = \frac{\sum_{i=1}^{N_h} w_{hi}\overline{A}'_{hi}}{N_h} \qquad \text{..................(2)}$$

$$\text{where} \quad \overline{A}'_{hi} = \frac{1}{M_{hi}}\sum_{j=1}^{M_{hi}} A'_{hij}; \quad \overline{M}_h = \frac{1}{N_h}\sum_{i=1}^{N_h} M_{hi}$$

Total water area and total area harvested in hth stratum are obtained as

$$A_h = \overline{A}_h * M_{h0} \qquad \text{..................(3)}$$

and $A_{h'} = \overline{A}_{h'} * M_{h0}$ ....(4)

Estimate of average area per cluster is given by

$$\hat{\overline{A}}_h = \frac{\sum_{i=1}^{n_h} M_{hi}\,\bar{a}_{hi}}{n_h \overline{M}_h}; \quad \text{where } \bar{a}_{hi} = \frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}} A_{hij} \qquad \text{....................(5)}$$

Estimate of average area harvested per cluster is given by

$$\hat{\overline{A}}'_h = \frac{\sum_{i=1}^{n_h} M_{hi}\bar{a}'_{hi}}{n_h \overline{M}_h}; \quad \text{where } \bar{a}'_{hi} = \frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}} A'_{hij} \qquad \text{.................... (6)}$$

Estimate of total area in hth stratum is obtained as

$$\hat{A}_h = \hat{\overline{A}}_h * M_{h0} \qquad \text{......................(7)}$$

Estimate of total harvested area in hth stratum is obtained as

$$\hat{A}'_h = \hat{\overline{A}}'_h * M_{h0} \qquad \text{......................(8)}$$

Estimate of variance for estimated total area is given by

$$\hat{V}\left(\hat{\overline{A}}_h\right) = \left(\frac{1}{n_h} - \frac{1}{N_h}\right)s^2_{hb} + \frac{1}{N_h n_h}\sum_{i=1}^{n_h} w^2_{hi}\left(\frac{1}{m_{hi}} - \frac{1}{M_{hi}}\right)s^2_{hwi} \qquad \text{......................(9)}$$

$$\text{where} \quad s^2_{hb} = \frac{1}{n_h - 1}\left[\sum_{i=1}^{n_h}\left(w_{hi}\bar{a}_{hi}\right)^2 - n_h\hat{\overline{A}}^2_h\right] \;\&\; s^2_{hwi} = \frac{1}{m_{hi} - 1}\sum_{j=1}^{m_{hi}}\left[A_{hij} - \bar{a}_{hi}\right]^2$$

Estimate of variance for estimated harvested area is given by

$$\hat{V}\left(\hat{\bar{A}}'_h\right) = \left(\frac{1}{n_h} - \frac{1}{N_h}\right) s'^2_{hb} + \frac{1}{N_h n_h} \sum w^2_{hi} \left(\frac{1}{m_h} - \frac{1}{M_h}\right) s'^2_{hwi} \qquad \text{………………(10)}$$

where $s'^2_{hb} = \frac{1}{n_h - 1}\left[\sum_{i=1}^{n_h} \left(w_{hi}\bar{a}'_{hi}\right)^2 - n_h \hat{\bar{A}}'^2\right]$ & $s'^2_{hwi} = \frac{1}{m_{hi} - 1} \sum_{j=1}^{m_{hi}} \left[A'_{hij} - \bar{a}'_{hi}\right]^2$

Estimate of variance of total harvested area is obtained as

$$\hat{V}(\hat{A}'_h) = M^2_{h0}\, \hat{V}(\hat{\bar{A}}'_h) \qquad \text{..……………(11)}$$

(b) Estimation of total number of ponds:

Average number of ponds per cluster in h[th] stratum is given by

$$\bar{B}_h = \frac{\sum_{i=1}^{N_h} \sum_{j=1}^{M_{hi}} B_{hij}}{\sum_{i=1}^{N_h} M_{hi}} = \frac{1}{N_h} \sum_{i=1}^{N_h} w_{hi} \bar{B}_{hi} \qquad \text{..……………(12)}$$

where $\bar{B}_{hi} = \frac{1}{M_{hi}} \sum_{j=1}^{M_{hi}} B_{hij}$; $\bar{M}_h = \frac{1}{N_h} \sum_{i=1}^{N_h} M_{hi}$; $w_{hi} = \frac{M_{hi}}{\bar{M}_h}$

Average number of ponds harvested per cluster in h[th] stratum is given by

$$\bar{B}'_h = \frac{\sum_{i=1}^{N_h} \sum_{j=1}^{M_{hi}} B'_{hij}}{\sum_{i=1}^{N_h} M_{hi}} = \frac{1}{N_h} \sum_{i=1}^{N_h} w_{hi} \bar{B}'_{hi} \quad \text{where } \bar{B}'_{hi} = \frac{1}{M_{hi}} \sum_{j=1}^{M_{hi}} B'_{hij}\ ; \qquad \text{……………(13)}$$

$\bar{M}_h = \frac{1}{N_h} \sum_{i=1}^{N_h} M_{hi}$; $w_{hi} = \frac{M_{hi}}{\bar{M}_h}$

Number of total ponds and total harvested ponds in h[th] stratum is obtained as

$$B_h = \bar{B}_h * M_{h0} \qquad \text{…………….(14)}$$

and $$B'_h = \bar{B}'_h * M_{h0} \qquad \text{…………….(15)}$$

Estimate of average number of ponds per cluster is given by

$$\hat{\bar{B}}_h = \frac{1}{n_h}\sum_{i=1}^{n_h} w_{hi}\bar{b}_{hi} \quad \text{where} \quad \bar{b}_{hi} = \frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}} B_{hij} \qquad \text{................(16)}$$

Estimate of average number of ponds harvested per cluster is given by

$$\hat{\bar{B}}'_h = \frac{1}{n_h}\sum_{i=1}^{n_h} w_{hi}\bar{b}'_{hi}; \quad \text{where} \quad \bar{b}'_{hi} = \frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}} B'_{hij} \qquad \text{................(17)}$$

Estimate of total number of ponds in h[th] stratum is obtained as

$$\hat{B}_h = \hat{\bar{B}}_h * M_{h0} \quad \text{where} \quad M_{h0} = \sum_{i=1}^{N_h} M_{hi} \qquad \text{................(18)}$$

Estimate of total number of ponds harvested in h[th] stratum is obtained as

$$\hat{B}'_h = \hat{\bar{B}}'_h * M_{h0}\ ; \qquad \text{................(19)}$$

Estimate of variance may be given as

$$\hat{V}\left(\hat{\bar{B}}_h\right) = \left(\frac{1}{n_h} - \frac{1}{N_h}\right)s^2_{hb} + \frac{1}{N_h n_h}\sum w^2_{hi}\left(\frac{1}{m_h} - \frac{1}{M_h}\right)s^2_{hwi}$$

$$\text{where } s^2_{hb} = \frac{1}{n_h - 1}\left[\sum_{i=1}^{n_h}\left(w_{hi}\bar{b}_{hi}\right)^2 - n_h\hat{\bar{B}}^2\right] \ \& \ s^2_{hwi} = \frac{1}{m_{hi} - 1}\sum_{j=1}^{m_{hi}}\left(B_{hij} - \bar{b}_{hi}\right)^2 \qquad \text{........(20)}$$

Estimate of average area per pond is given by

$$\frac{(\hat{\bar{A}}_h)}{(\hat{\bar{B}}_h)} \qquad \text{............(21)}$$

(c) Estimation of fish yield (Three stage sampling):

Let

y_{hijk} = Yield of k^{th} ponds in j^{th} cluster of i^{th} district in h^{th} stratum

x_{hijk} = Area of k^{th} pond in j^{th} cluster of i^{th} district in h^{th} stratum

Average yield per pond of j^{th} cluster of i^{th} district in h^{th} stratum is given by

$$\overline{Y}_{hij} = \frac{1}{B'_{hij}} \sum_{k=1}^{B'_{hij}} Y_{hijk} ; \qquad \ldots\ldots\ldots\ldots\ldots(22)$$

Average yield per cluster of i^{th} district in h^{th} stratum is given by

$$\overline{Y}_{hi} = \frac{1}{M_{hi}} \sum_{j=1}^{M_{hi}} \sum_{k=1}^{B'_{hij}} Y_{hijk} = \frac{1}{M_{hi}} \sum_{j=1}^{M_{hi}} B'_{hij} \overline{Y}_{hij} ; \qquad \ldots\ldots\ldots\ldots\ldots(23)$$

Average yield per cluster of h^{th} stratum is given by

$$\overline{Y}_h = \frac{\sum_{i=1}^{N_h} \sum_{j=1}^{M_{hi}} \sum_{k=1}^{B_{hij}} Y_{hijk}}{\sum_{i=1}^{N_h} M_{hi}} = \frac{\sum_{i=1}^{N_h} M_{hi} \overline{Y}_{hi}}{N_h \overline{M}_h} = \frac{1}{N_h} \sum w_{hi} \overline{Y}_{hi} \text{, where } w_{hi} = \frac{M_{hi}}{\overline{M}_h} \qquad \ldots\ldots(24)$$

Similarly, average area per cluster of h^{th} stratum is given by

$$\overline{X}_h = \frac{1}{N_h} \sum w_{hi} \overline{X}_{hi} , \qquad \text{where } w_{hi} = \frac{M_{hi}}{\overline{M}_h} ; \qquad \ldots\ldots\ldots\ldots\ldots(25)$$

Estimate of yield per pond in j^{th} cluster is given by

$$\bar{y}_{hij} = \frac{1}{b'_{hij}} \sum_{k=1}^{b'_{hij}} y_{hijk} ; \qquad \ldots\ldots\ldots\ldots\ldots(26)$$

Estimate of yield per cluster in i^{th} district is given by

$$\hat{\overline{Y}}_{hi} = \frac{1}{m_{hi}} \sum_{j=1}^{m_{hi}} B'_{hij} \bar{y}_{hij} ; \qquad \ldots\ldots\ldots\ldots(27)$$

Estimate of yield per cluster in h^{th} stratum is given by

$$\hat{\overline{Y}}_h = \frac{1}{n_h} \sum w_{hi} \hat{\overline{Y}}_{hi} ; \qquad \ldots\ldots\ldots\ldots(28)$$

Estimate of variance of the above estimate is given by

$$\hat{V}\left(\hat{\bar{Y}}_h\right) = \left(\frac{1}{n_h} - \frac{1}{N_h}\right) s^2_{hby} + \frac{1}{N_h n_h} \sum_{i=1}^{n_h} w^2_{hi} \left(\frac{1}{m_{hi}} - \frac{1}{M_{hi}}\right) s^2_{hiy}$$

$$+ \frac{1}{N_h n_h} \sum \frac{w^2_{hi}}{M_{hi} m_{hi}} \sum B'^2_{hij} \left(\frac{1}{b_{hij}} - \frac{1}{B'^2_{hij}}\right) s^2_{hijy} \qquad \ldots\ldots\ldots\ldots\ldots(29)$$

where $s^2_{hby} = \frac{1}{n_h - 1} \sum \left(w_{hi} \overline{\hat{Y}}_{hi} - \overline{\hat{Y}}_h \right)^2$; $s^2_{hiy} = \frac{1}{m_{hi} - 1} \sum \left(B'_{hij} \overline{y}_{hij} - \overline{\hat{Y}}_{hi} \right)^2$;

$$s^2_{hijy} = \frac{1}{b_{hij} - 1} \sum \left(y_{hijk} - \overline{y}_{hij} \right)^2$$

Estimate of total yield in h[th] stratum is given by

$$\hat{Y}_h = \hat{\bar{Y}}_h * M_{h0}$$

Similarly, estimate for area based on selected ponds is obtained as under:

Estimate of area per cluster is given by

$$\left(\hat{\bar{A}}_h\right) = \frac{1}{n_h} \sum_{j=1}^{n_{hi}} w_{hi} \left(\hat{\bar{A}}_{hi}\right), \quad \text{where } \left(\hat{\bar{A}}_{hi}\right) = \frac{1}{m_{hi}} \sum_{j=1}^{m_{hi}} B'_{hij} \bar{a}_{hij} \qquad \ldots\ldots\ldots\ldots\ldots(30)$$

and $\bar{a}_{hij} = \frac{1}{b_{hij}} \sum_{k=1}^{b_{hij}} a_{hijk}$

The above estimates assume that M_i's and B_{hij}'s are known.

Estimate of yield per hectare (Ratio Estimate) is given by

$$\hat{R} = \left(\hat{\bar{Y}}_h\right) \Big/ \left(\hat{\bar{A}}_h\right) \qquad \ldots\ldots\ldots\ldots\ldots(31)$$

Estimate of total yield from h[th] stratum based on the ratio estimate is given by

$$\left(\hat{Y}_{hR}\right) = \hat{R}.A'_h \quad \text{or} \quad \left(\hat{\bar{Y}}_{hR}\right) = \hat{R}.\bar{A}'_h \qquad \ldots\ldots\ldots\ldots\ldots(32)$$

where A'_h = total area harvested under ponds and tanks in h[th] stratum . This may be replaced by $\hat{A}'_h$.

The above estimate is efficient but biased. The bias will be negligible.

Estimate of variance of the estimate is given by

$$\hat{V}\left(\hat{\bar{Y}}_{hR}\right)=\left(\frac{1}{n_h}-\frac{1}{N_h}\right)\left(s^2_{hby}-2\hat{R}_h s_{hbay}+\hat{R}^2_h s^2_{hba}\right)+$$
$$\frac{1}{n_h}\frac{1}{N_h}\sum_{i=1}^{n_h} w^2_{hi}\left(\frac{1}{m_{hi}}-\frac{1}{M_{hi}}\right)\left(s^2_{hiy}-2\hat{R}_h s_{hiay}+\hat{R}^2 s^2_{hia}\right)+ \qquad \ldots(33)$$
$$\frac{1}{N_h}\frac{1}{n_h}\sum_{i=1}^{n_h}\frac{w^2_{hi}}{M_{hi}m_{hi}}\sum_{j=1}^{m_{hi}}\left(\frac{B'_{hij}}{B'_{hi0}}\right)^2\left(\frac{1}{b_{hij}}-\frac{1}{B'_{hij}}\right)\left(s^2_{hijy}-2\hat{R}_h s_{hijay}+\hat{R}^2_h s^2_{hija}\right)$$

where $s_{hbay}=\dfrac{1}{n_h-1}\sum\left(w_{hi}\bar{y}_{hi}-\hat{\bar{Y}}_h\right)\left(w_{hi}\bar{a}_{hi}-\hat{\bar{A}}_h\right)$

$$s_{hiay}=\frac{1}{m_{hi}-1}\sum\left(B_{ij}\bar{y}_{hij}-\hat{\bar{Y}}_{hi}\right)\left(B_{ij}\bar{a}_{hij}-\hat{\bar{A}}_{hi}\right);$$

$$s_{hijay}=\frac{1}{b_{hij}-1}\sum\left(y_{hijk}-\bar{y}_{hij}\right)\left(a_{hijk}-\bar{a}_{hij}\right)$$

$s^2_{hby}, s^2_{hiy}, s^2_{hijy}$ can be obtained from (29) and $s^2_{hba}, s^2_{hia}, s^2_{hija}$ can be obtained by replacing y by 'a' in (29).

(ii) Reservoirs, lakes and large irrigation tanks: Group-II

Notations

Let

N_{hi} = Total number of water bodies of the i^{th} sub-group in h^{th} stratum

n_{hi} = Number of water bodies selected from N_{hi}

x_{hij} = Area of j^{th} water body of the i-th sub-group in h^{th} stratum

y_{hij} = Yield of j^{th} water body of i^{th} group in h^{th} stratum

X_{hi} = Total area of i^{th} sub-group of water body in h^{th} stratum

(Month/year will depend on whether estimates are prepared monthly or yearly) in h^{th} stratum

Value of y_{hij} is obtained by recording total fish catch in cases where water body is harvested during a short interval of the year. However, water bodies which are harvested during the entire year as discussed in the sampling procedure, y_{hij} is estimated by further sampling as under:

First the catch from each selected water body is estimated. Then catch from each group of water bodies is worked out. The estimates are combined to get the estimated catch for the State.

(1) If total fish catch is recorded at a centre on each sampling day

(Landing Centre Approach):

Here, the entire water body is surveyed for inventory of well-defined landing centres. A few landing centres are randomly selected. Then 2 consecutive days are selected by systematic sampling at fortnightly interval for recording catch from the selected centre if fishing is done every day. Otherwise select randomly 2 consecutive days from the fortnight when fishing is done. The catch is recorded in the following manner: On the selected first day of observation in a centre, data are collected during 06.00 to 12.00 hrs. Data on night landings, if any in between the consecutive days, are collected by inquiry on the second day. Thus in a two-days cluster, 24 hrs. observation is taken. This forms a landing centre day, the first-stage sampling unit.

The monthly catch estimate for j^{th} water body of i^{th} sub-group in h^{th} stratum is worked out as

$$\hat{Y}_{hij} = \frac{N}{n}\sum_{k=1}^{n} y_{hijk},$$

where N is the total number of landing centre days and n is the number of landing centre days selected and y_{hijk} is the catch on the k^{th} landing day for the j^{th} water body of i^{th} group in h^{th} stratum.

Estimate of the variance of the estimate is given by

$$\hat{V}(\hat{Y}_{hij}) = \frac{N^2 s_{hij}^2}{n}$$

where s_{hij}^2 is the sample mean square between landing centre days for the month.

$$s_{hij}^2 = \frac{1}{n-1}\left[\sum_{k=1}^{n} y_{hijk}^2 - \frac{\left(\sum_{p=1}^{n} y_{hijk}\right)^2}{n}\right]$$

(2) If fish catch is recorded by observing few gears out of the total gears used on the sampling day (Fishing Village Approach):

Let

y_{hijg} = yield from g^{th} gear operated on j^{th} water body of i^{th} group in h^{th} stratum.

y_{hijgk} = yield on k^{th} centre from g^{th} gear operated on j^{th} water body of i^{th} group in h^{th} stratum.

y_{hijgkl} = yield on l^{th} day in k^{th} centre from g^{th} gear operated on j^{th} water body of i^{th} group in h^{th} stratum.

$y_{hijgklm}$= yield from m^{th} observed net on l^{th} day in k^{th} centre from g-th gear operated on j^{th} water body of i^{th} group in h^{th} stratum

D_{hijgk} = total fishing days in the k^{th} centre for the g^{th} gear operated in j^{th} water body during the month/year in h^{th} stratum

d_{hijgk} = sample days selected out of D_{hijk} during the month/year in h^{th} stratum

Value of y_{hij} is obtained by recording total fish catch in cases where water body is harvested during a short interval of the year. However, water bodies which are harvested during the entire year as discussed in the sampling procedure, y_{hij} is estimated by further sampling as under:

Average catch at k-th fishing village per day from g^{th} gear of j^{th} water body of i^{th} group in h^{th} stratum

$$\bar{y}_{hijgk} = \frac{1}{d_{hijgk}} \Sigma M_{hijgkl} \bar{y}_{hijgkl}; \quad \text{where} \quad \bar{y}_{hijgkl} = \frac{1}{m_{hijgkl}} \Sigma y_{hijgklp}$$

Estimate of average catch at k^{th} fishing village during the month/year = $D_{hijgk} \times \bar{y}_{hijgk}$

Estimate of total catch for g^{th} gear at j^{th} water body of i^{th} group in h^{th} stratum is given by

$$\hat{Y}_{hijg} = \sum_{k=1}^{M_{hi}} D_{hijgk} \bar{y}_{hijgk}$$

Estimate of total catch at j^{th} water body of i^{th} group in h^{th} stratum is given by

$$\hat{Y}_{hij} = \sum_{g} \sum_{k=1}^{M_{hi}} D_{hijgk} \bar{y}_{hijgk}$$

where,

M_{hijgkl} = Total no. operated on l^{th} day of k^{th} centre of g^{th} type of nets in j^{th} water body of i^{th} sub-group in h^{th} stratum

m_{hijgkl} = Total no. sampled on l^{th} day of k^{th} centre of g^{th} type of nets in j^{th} water body of i^{th} sub-group in h^{th} stratum

$y_{hijgklp}$ = Yield on l^{th} day in k^{th} centre from g^{th} gear operated on j^{th} water body of i^{th} group in h^{th} stratum during p^{th} period of observation

where p be the number of periods of observation for the k^{th} centre day.

Estimation of total yield from reservoirs, lakes etc.:-

Average area per water body is given by

$$\bar{X}_{hi} = \frac{1}{N_{hi}} \sum_{j=1}^{N_{hi}} X_{hij}$$

Average yield per water body is given by

$$\bar{Y}_{hi} = (1/N_{hi}) \Sigma Y_{hij}$$

Yield per hectare (Ratio Estimate) given by

$$R_{hi} = \bar{Y}_{hi} / \bar{X}_{hi}$$

Total yield of water bodies of i[th] sub-group of h[th] stratum is given by

$$Y_{R_{hi}} = R_{hi} * X_{hi}$$

Production from group-II water bodies is obtained as

$$Y_g^2 = \sum_{h=1} \sum_{i=1} R_{hi} * X_{hi}$$

Estimate of average yield per selected water body of i[th] sub-group of h[th] stratum is given by

$$\bar{y}_{hi} = \frac{1}{n_{hi}} \sum_{j=1}^{n_{hi}} y_{hij}$$

Similarly, estimate of average area per selected water body is given by

$$\bar{x}_{hi} = \frac{1}{n_{hi}} \sum_{j=1}^{n_{hi}} x_{hij}$$

Estimate of yield per hectare (Ratio Estimate) is $\hat{R}_{hi} = \frac{\bar{y}_{hi}}{\bar{x}_{hi}}$

$\hat{Y}_{R_{hi}} = (\hat{R}_{hi}) * X_{hi}$, where X_{hi} is the total area of i[th] sub-group of water body in h[th] stratum

Here, the variance at second stage of sampling adopted in case of water bodies exploited throughout the year is considered to be negligible. However, in certain cases it may not be negligible but to avoid further complications in analysis, it may be assumed negligible.

$$\hat{V}(\hat{Y}_{R_{hi}}) = \frac{N_{hi}(N_{hi} - n_{hi})}{n_{hi}(n_{hi} - 1)} \sum_{j=1} [y_{hij} - (\hat{R}_{hi}) x_{hij}]^2$$

Estimate of total fish production for the state under Group-II is given by

$$(\hat{Y}_g^2) = \sum_{h=1} \sum_{i=1} (\hat{R}_{hi}) * X_{hi}$$

Estimate of variance of the estimate is given by

$$\hat{V}(\hat{Y}_g^2) = \sum_{h=1} \sum_{i=1} \frac{N_{hi}(N_{hi} - n_{hi})}{n_{hi}(n_{hi} - 1)} \sum_{j=1} \left[y_{hij} - (\hat{R}_{hi})\, x_{hij} \right]^2$$

(iii) Rivers, streams, canal, estuaries etc.: Group-III

<u>Estimation of Catch</u>

The estimate is worked out for each water body. As per the formulated programme the state is divided into three approximately equal strata each comprising a number of geographically contiguous districts. Two types of approaches are suggested depending on the availability of data for recording. In fishing village approach, catch record may be available from each operating units. But it is sometimes difficult rather impossible to collect data on catch unit-wise. Here, the total catch may be available, because some middlemen are involved in trading the fish after gathering the catch from several units. The procedure is termed as landing centre approach, which is explained below, provides estimates of total monthly catches. The catch from each stratum is added to calculate the total production of the state. It may be noted that tidal effect should be considered while estimating the catch from estuaries and lagoons.

<u>Notations</u>

N_h = Number of landing centres/fishing villages in h^{th} stratum (h=1, 2, 3)

n_h = Number of landing centres/fishing villages selected in h^{th} stratum

G_{hj} = Types of nets/gears used in j^{th} village in h^{th} stratum

D_{hij} = Number of fishing days during the month of i^{th} type net in j^{th} village of h^{th} stratum ($i=1,2,\ldots,G_{hj}$; $j=1,2,\ldots,N_h$)

d_{hij} = Number of sample days during the month for i^{th} type net in j^{th} village of h^{th} stratum ($i=1,2,\ldots,G_{hj}$; $j=1,2,\ldots,N_h$)

M_{hijk} = Number operated on k^{th} day for i^{th} type net in j^{th} village of h^{th} stratum

m_{hijk} = Number observed on k^{th} day for i^{th} type net in j^{th} village of h^{th} stratum

y_{hijkl} = Fishing yield of l^{th} unit on k^{th} day for i^{th} type net in j^{th} village of h^{th} stratum

<u>Fishing Village Approach</u>

Monthly fish production gear-wise:

Average catch per unit gear/net of i^{th} type on k^{th} day in j^{th} village of h^{th} stratum is given by

$$\overline{Y}_{hijk} = \frac{1}{M_{hijk}} \sum_{l=1} y_{hijkl}$$

Average catch per day for i-th type of gear in j^{th} village of h^{th} stratum is given by

$$\overline{Y}_{hij} = \frac{1}{D_{hij}} \sum_{k} Y_{hijk}$$

Catch for i^{th} type of gear in j-th village on k^{th} day of h^{th} stratum is given by

$$Y_{hijk} = M_{hijk} * \overline{Y}_{hijk}$$

Total catch for i^{th} type of gear/net in h^{th} stratum for the month is given by

$$Y_{hi} = \sum_{j}\sum_{k} Y_{hijk} = \sum_{j} D_{hij}\overline{Y}_{hij}$$

Monthly estimates of fish catch:

Estimate of total monthly catch for h^{th} stratum is given by

$$Y_h = \sum_{i} Y_{hi}$$

Estimate of average catch per unit (net/net-tide) of i^{th} type on k^{th} day in j^{th} village of h^{th} stratum is given by

$$\overline{y}_{hijk} = \frac{1}{m_{hijk}} \sum_{l=1} y_{hijkl}$$

Estimate of average catch of i^th^ type of net per day in j^th^ village of h^th^ stratum is given by

$$(\hat{\bar{Y}}_{hij}) = \frac{1}{d_{hij}} \sum_{k=1} M_{hijk}\bar{y}_{hijk}$$

Estimate of monthly catch of i^th^ type net in h^th^ stratum $\hat{Y}_{hi} = R_{hi} \sum_j \frac{D_{hij}}{d_{hij}} \sum M_{hijk}\bar{y}_{hijk}$

$$\text{where } R_{hi} \text{ (Raising Factor)} = \left(\frac{\text{Total no. of i-th type of net for all centres}}{\text{Total no. of i-th type of net for selected centres}} \right)$$

Variance of the estimate is given by

$$V(\hat{Y}_{hi}) = R_{hi}^2 \left[\sum_j D_{hij}^2 \left(\frac{1}{d_{hij}} - \frac{1}{D_{hij}} \right) S_{hijy}^2 + \sum_{j=1} \frac{D_{hij}}{d_{hij}^2} \sum_{k=1} M_{hijk}^2 \left(\frac{1}{m_{hijk}} - \frac{1}{M_{hijk}} \right) S_{hijky}^2 \right]$$

$$\text{where} \quad S_{hijy}^2 = \frac{1}{D_{hij}-1} \sum (M_{hijk}\bar{Y}_{hijk} - \bar{Y}_{hij})^2 \; ; \quad S_{hijky}^2 = \frac{1}{M_{hijkl}-1} \sum (y_{hijkl} - \bar{Y}_{hijk})^2$$

Estimate of total monthly catch in h^th^ stratum is given by

$$(\hat{Y}_h) = \sum R_{hi} \sum \frac{D_{hij}}{d_{hij}} \sum M_{hijk}\bar{y}_{hijk}$$

Estimate of variance of the estimate given by

$$\hat{V}(\hat{Y}_{hi}) = R_{hi}^2 \left[\sum_j D_{hij}^2 \left(\frac{1}{d_{hij}} - \frac{1}{D_{hij}} \right) s_{hijy}^2 + \sum_{j=1} \frac{D_{hij}}{d_{hij}^2} \sum_{k=1} M_{hijk}^2 \left(\frac{1}{m_{hijk}} - \frac{1}{M_{hijk}} \right) s_{hijky}^2 \right]$$

$$\text{where} \quad s_{hijy}^2 = \frac{1}{d_{hij}-1} \sum \left(M_{hijk}\bar{y}_{hijk} - \hat{\bar{Y}}_{hij} \right)^2 ; \quad s_{hijky}^2 = \frac{1}{m_{hijkl}-1} \sum_{k=1} \left((y_{hijkl} - \bar{y}_{hijk} \right)^2$$

<u>Landing Centre Approach</u>

Here, the entire stretch falling in h^th^ stratum is surveyed for identification of landing centres. A few landing centres are randomly selected. Then 2 consecutive days are selected by systematic sampling at fortnightly interval for recording catch from the selected centre if fishing is done every day. Otherwise select 2 consecutive days randomly from the fortnight when fishing is done. The catch is recorded in the following manner: On the selected first day of observation in a centre, data are collected during 06.00 to 12.00 hrs. Data on night landings, if any in between the consecutive days, are collected by inquiry on the second day. Thus, in a two days cluster, 24 hrs. observation is taken.

The monthly catch estimate for i^{th} stratum is worked out as

$\hat{Y}_i = \frac{N_i}{n_i} \sum_{p=1}^{n_i} y_{ip}$, where N_i is the total number of landing centre days for the entire stretch and n_i is the number of landing centre days selected and y_{ip} is the catch on the p^{th} landing centre day of the i^{th} stratum.

Estimate of the variance of the estimate is given by

$$\hat{V}(\hat{Y}_i) = \frac{N_i (N_i - n_i) s_i^2}{n_i}$$

where s_i^2 is the sample mean square between landing centre days of i^{th} stratum for the month

$$s_i^2 = \frac{1}{n_i - 1}\left[\sum_{p=1}^{n_i} y_{ip}^2 - \frac{\left(\sum_{p=1}^{n_i} y_{ip}\right)^2}{n_i}\right]$$

APPENDIX B

Schedule 1.1: Resource estimation under ponds and tanks (Units of area up to 10 ha at full tank level) (Group- I)

1. Sample Code: [ ] 2. State: [ ] 3.Stratum: [ ]

4. District: [ ] 5. Cluster: [ ] 6.Tehsil: [ ]

7. Village: [ ]

8. Total No of water bodies in the village: [ ]

9. Total area (ha) in the village: [ ]

10. Date of observation: [ ][ ][ ][ ][ ][ ][ ][ ]

11. Details of water unit:

No./ Pond code	Revenue record		Physical observation					Name of the farmer
	Plot No.	Pond area (ha)	Pond area (ha)	Max Area (ha)	Min Area (ha)	Depth (m)		
						Max	Min	
1	2	3	4	5	6	7	8	9

If leased give details		Type Fresh/ Brackish	Water Retention (month)	Source of water	Soil type	Extent of silting	Aquatic (%) Weeds
Duration (years)	Rent/ year in Rs.						
10	11	12	13	14	15	16	17

No./ Pond code	Ownership Private/ Public	Utilization of water bodies		Culture type Intensive/ Semi intensive/ Traditional	Whether under FFDA (yes/no)
		Fishery (state type)	If no, give reasons		
	18	19	20	21	22

Inputs used (say Yes/ No)			Duration of Crops (in months)	Months of Fishing	Av. Production (in Kgs) By enquiry)	Remarks (if any)
Manure/ Fertilizer	Supplementary Feed	Stocking				
23	24	25	26	27	28	29

Schedule 1.2: Resource inventory of large irrigation tanks, reservoirs, beels and lakes: (Area above 10 ha at full level) (Group II)

1. Sample Code: [ ] 2. State: [ ] 3. Stratum No. [ ]

4. District: [ ] 5.Referenc Year: [ ]

6. Details of water bodies:

i) Name of water body: [ ]

ii) Type: | IT | R | B | L |

iii) Main purpose: [ ] iv) Source of water: [ ]

v) Controlled by: [ ] vi) Seasonality: | P | LS | S | SS |

vii) Type and Shape (For beels only): Type [ ] Shape [ ]

viii) Area at FRL [| | |] Area at MRL [| | |]

ix) Utilised for fishery: Yes [ ] No [ ]

If not used for fishery, give reasons: [ ]

x) Fishery exploited by: Individual/ Society/ Corporation/

xi) Mode of exploitation: Free/ Licensing / Lease/ Royalty/

xii) If given on lease: Duration (yrs) [ ] Lease amount: (Rs./Yr) [ ]

Lease: Individual/ Society

xiii) Water Retention: From [|] To [|]

xiv) Choice of sampling units: Landing center/ Fishing village/ others

xv) Annual fish production: (in Kgs) (By inquiry) [| | | | | |]

xvi) Average fishing days per year [ ]

7. Inventory details:

*S.No.	*Fishing Village/Landing Centre	Head of the Household	Family size		Fishing as occupation Full time/ Part time/ None
			A	C	
1	2	3	4		5

Boats		Gears (No's)					*Mode of disposal
No	Type	Gill	Drag	Cast	Others	Total	
6		7					8

If the choice of sampling unit is "Landing Centre" then in Inventory details only the fields with (*) marks have to be filled.

Schedule 1.3: Resource inventory of rivers and canals, estuaries and lagoons: (Group III)

1. Sample Code: [ ] 2. Stratum No. [ ] 3. Date of sampling [ ]

4. Reference Year: [ ]

5. State [ ] 6. District [ ]

7. Name of the stream [ ]

8. Type [Main/Tributary /Estuary/Others] 9. Seasonality:

P	LS	S	SS

10. Water retention [ ][ ] to [ ][ ]

11. Length [ ]

12. Breadth (m): Min [ ] Max [ ]

13. Area (ha): Max [ ] Min [ ]

14. Fishery exploitation: Yes [ ] No [ ]

15. Exploited by: [Individual/ Society/ Corporation/ State]

16. Mode of exploitation: [Free/ Licensing / Lease/ Royalty/ Others]

17. Choice of sampling units: Landing center/ Fishing village/ others/ both

18. Fishing period: From [ ] To [ ]

19. Inventory details:

*S. No.	*Fishing village/ Center	*Head of the Household	Family size		Fishing occupation Full time/ Part time/ None	Boats		Gears (No's.)					*Mode of disposal
			A	C		No's	Type	Gill	Drag	Cast	Others	Total	
1	2	3	4		5	6		7					8

If the choice of sampling unit in No. 17 is "Landing Centre" then in Inventory details (No.19) only the fields with (*) marks have to be filled.

In case of “Fishing village” all fields are to be filled in.

Schedule 2.1: Fish Catch statistics for ponds and tanks (Group I)

(Units up to 10 ha. water area at FTL.)

1. Sample code (Leave Blank) [ ] 2. Stratum No. [ ] 3. State [ ]

4. District [ ] 5. Cluster [ ] 6. Tehsil [ ]

7. Village [ ] 8. No. Harvested (0-0.5 ha) [ ]

9. Area harvested (0-0.5 ha) [ ] 10. No harvested (0.5-10 ha) [ ]

11. Area harvested (0.5-10 ha) [ ] 12. Date [ ]

13. Details of area and production

	1 (F/B)	2(F/B)
(i) Water unit (Fresh/ Brackish)		
(ii) Name of the fish farmer:		
(iii) Whether under FFDA pond (Yes/No):		
(iv) Water area at stocking (ha):		
(v) Culture type: (Intensive, semi intensive, traditional, none)		
(vi) Water retention (months):		
(vii) Crop no (1/2/3):		

(viii) Date of stocking								
(ix) Species stocked								
(x) No stocked								
(xi) Size stocked								
(xii) Source of seed								

(xiii) Date of harvesting:

(xiv) Culture duration:
(Months)

(xv) Production (kg): Sporadic Bulk (Inq/obs) | Sporadic Bulk (Inq/obs)

Catla		
Rohita		
Mrigala		
Minor carps		
Cat fish		
Others		
Exotic carps		
Total fish		
Prawn		

Catla		
Rohita		
Mrigala		
Minor carps		
Cat fish		
Others		
Exotic carps		
Total fish		
Prawn		

(i) Water unit (Fresh/ Brackish) 3 (F/B) 4(F/B)

(ii) Name of the fish farmer:

(iii) Whether under FFDA pond (Yes/No):

(iv) Water area at stocking (ha):

(v) Culture type:
(Intensive, semi intensive, traditional)

(vi) Water retention (months):

(vii) Crop no (1/2/3):

(viii) Date of stocking								
(ix) Species stocked								
(x) No stocked								
(xi) Size stocked								
(xii) Source of seed								

(xiii) Date of harvesting:

(xiv) Culture duration:
(Months)

(xv)Production (kg):

Sporadic	Bulk (Inq/obs)	
Catla		
Rohita		
Mrigala		
Minor carps		
Cat fish		
Others		
Exotic carps		
Total fish		
Prawn		

Sporadic	Bulk (Inq/obs)	
Catla		
Rohita		
Mrigala		
Minor carps		
Cat fish		
Others		
Exotic carps		
Total fish		
Prawn		

12. Details of area and production

(i) Water unit (Fresh/ Brackish) 5(F/B)

(ii) Name of the fish farmer:

(iii) Whether under FFDA pond (Yes/No):

(iv) Water area at stocking (ha):

(v) Culture type:
(Intensive, semi intensive, traditional)

(vi) Water retention (months):

(vii) Crop no (1/2/3):

(viii) Date of stocking:				
(ix) Species stocked:				
(x) No stocked:				
(xi) Size stocked:				
(xii) Source of seed:				

(xiii) Date of harvesting:

(xiv) Culture duration:
(Months)

(xv) Production (kg):

	Sporadic (Inq/obs)	Bulk
Catla		
Rohita		
Mrigala		
Minor carps		
Cat fish		
Others		
Exotic carps		
Total fish		
Prawn		

Schedule 2.2: Catch assessment survey for reservoirs, lakes, and large irrigation tanks (Area above 10 ha. at full level) (Group II). (Fishing Village)

1. Sample code: (Leave Blank) [ ]　　2. State: [ ]

3. Reference Year: [ ]　　4. District: [ ]

5. Stocking details during the reference year:

	I	II	III
Date:			
Species			
No. Stocked			
Size (cm)			
Source			

6. Name of the water body: [ ]

7. Type: LIT/R/L/B

8. Name of fishing village: [ ]

9. Tehsil: [ ]

10. Date of Sampling: [ ]

11. Nets operated:

Type				
No.				

12. Fish catch details from sampled fishing units:

Sl. No.	Nets Observed Type	Operation Time From To	Total Catch	Species-wise catch (in kg)				Non – fishing days	
			In Kgs	Major Carps	Minor Carps	Cat-fishes	Others	Last month	Current month
1	2	3	4	5				6	7

Schedule 2.2: Catch assessment survey for reservoirs, lakes and large irrigation tanks (Area above 10 ha. at full level) (Group II)

(Landing Centre)

1. Sample code: (Leave Blank) [ ] 2. State: [ ] 3. Reference Year: [ ]

4. District: [ ]

5. Name of the water body: [ ]

6. Type: [ ]

7. Name of the Landing Centre: [ ]

8. Tehsil: [ ]

9. Date of Sampling: [ ][ ][ ][ ][ ][ ][ ][ ]

10. Fish catch details:

Sl. No.	Total Catch (in kg)	Major Carps			Species-wise catch (in kg)					Non – fishing days	
		Catla	Rohita	Mrigala	Exotic carps	Minor Carps	Cat-fishes	Others	Prawn	Last month	Current month

Schedule 2.3: Catch assessment survey for rivers, canals, estuaries and lagoons (Group III) (Fishing Village)

1. Sample code: [ ] 2. State: [ ] 3. Stratum No.: [ ] 4.Year: [ ]
   (Leave Blank)

5. District: [ ]

6. Stocking, if done, details during the year of sampling:

	I	II
Month:		
Species		
No. Stocked		
Size (cm)		
Source		

7. Date of visit: [ ] 8. Time: From [ ] To [ ]

9. Name of the water body: [ ]

10. Type: [ ]

11. Name of the fishing village [ ]

12. Tehsil: [ ]

13. Nets operated:

Net Type					
Operated (no.)					

14. Fish catch details from sampled fishing units:

Sl. No.	Nets Observed Type	Operation Time From To	Tide 1/2/3/4		Total Catch	Species-wise catch (in kg)				Non – fishing days	
			Obser-ved	Oper-ated	In Kgs	Major Carps	Minor Carps	Cat-fishes	Others	Last month	Current month
1	2	3	4		5	6				7	8

Schedule 2.3: Catch assessment survey for rivers, canals, estuaries and lagoons (Group III) (Landing Centre)

1. Sample code: ______ 2. State: ______ 3. Stratum No.: ______ 4.Year: ______
(Leave Blank)

5. District: ______ 6. Date of visit: ______

7. Time: From ______ to ______

8. Name of the water body: ______

9. Type: ______

10. Name of the Landing Centre: ______

11. Tehsil: ______

12. Fish catch details:

Sl. No.	Total Catch (in kg)	Major Carps			Species-wise catch (in kg)					Non – fishing days	
		Catla	Rohita	Mrigala	Exotic carps	Minor Carps	Cat-fishes	Others	Prawn	Last month	Current month

LIST OF INDICATORS