SAMPLING DESIGN FOR MONITORING AND ASSESSING THE MARINE FISHERY RESOURCES

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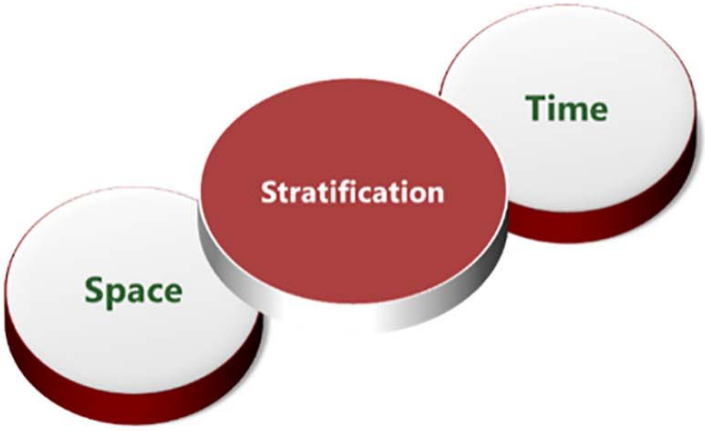
Introduction

Marine fisheries contribute significantly to India's food production, employment, and export earnings. In India, marine fisheries support the livelihood of approximately 3.79 million fishermen (CMFRI-FSI-DoF, 2020) and provide nutritional security for a sizable proportion of the population. India's coastline stretches about 8129 km and it has a rich and diverse marine biodiversity, with over 2,000 species of fish recorded. The marine fisheries of India is characterized by open access, multi-species and multi-gear fishery. The resources are exploited using a variety of gears employing various fishing methods, including traditional methods like shore seine, gill nets, and longlines, as well as modern techniques such as trawling and purse seining. Fish landings occur at different points along the Indian coastline at all times of day and night and throughout all seasons (Srinath et al., 2005). For the complex fisheries in tropical regions, the collection of statistics by complete enumeration would involve a very large number of enumerators and a huge amount of money apart from the time involved in the collection of data. Therefore, a possible solution for quantifying marine fish landings is the adoption of a suitable sampling technique. India established suitable institutional mechanisms for resource monitoring and assessment in 1947 after realizing the need to sustain the highly diverse marine fish resources along its coast. Hence, the Central Marine Fisheries Research Institute of the Indian Council of Agricultural Research (ICAR-CMFRI) made efforts to develop a suitable sampling methodology for collecting information on catch and effort as one of its primary mandates is the monitoring and assessment of India's exploited marine fisheries resources.

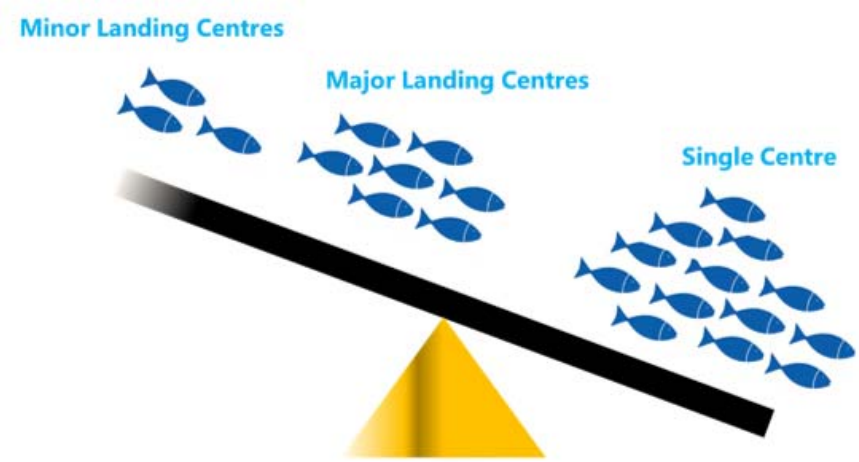
Stratified multistage random sampling

The ICAR-CMFRI and ICAR-Indian Agricultural Statistics Research Institute conducted pilot surveys and the stratified multistage random sampling design (SMRSD) was developed, and implemented across the country in 1961, excluding Lakshadweep and Andaman Nicobar Islands (Mini et al., 2023). The adopted SMRSD based on space-time stratification, which evolved after years of field trials is a solid system for obtaining reliable fishery data, both theoretically and practically, to suit the very special conditions prevailing in the country (Srinath et al., 2005).

Marine fish landings in India are estimated from the sampling of commercial landings. Currently, SMRSD — which stratifies over both space and time — is used by ICAR-CMFRI to estimate marine fish landings along the coastline of India. Based on geographic factors and fishing intensity, each marine state is separated into appropriate, non-overlapping zones. Each zone has a different number of landing centres. Every zone is regarded as a stratum over space, and a calendar month is regarded as a stratum over time. A zone and a calendar month, therefore, make up a space-time strata.



Furthermore, a zone is further stratified into substrata, namely major, minor, and very minor, because the fish landings in a multi-centre zone vary significantly among the landing centres, mostly in various seasons. The centres in which either mechanised crafts or 100 or more non-mechanised/motorised crafts are operating are considered major centres. Likewise, other strata are defined based on the number and type of fishing crafts operating.

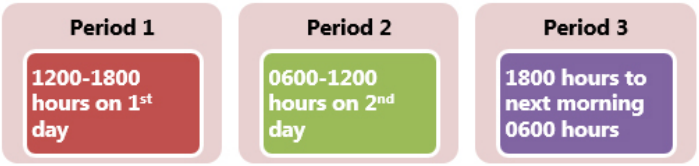


The stratification over time is a calendar month. For data collection, a month is split into three groups of ten days each. From the first five days of a month, one day is chosen at random, and the next five days are chosen automatically. The days that were chosen are divided into three clusters of two consecutive days. To illustrate the selection of landing centres and days, let us consider a fishing zone in a month. First, choose a date at random from the first five days; for example, choose day 3. Three clusters of two days (3,4), (5,6), and (7,8) can then be formed from the first group of ten days. Clusters are systematically selected at 10-day intervals from the second group of 10 days. The days that formed into clusters are (13, 14), (15, 16), and (17,18). A similar selection can be done for the next group of ten days. Accordingly, 9 clusters of two days can be formed in a month. Afterwards, nine centres are selected with replacements from the total number of landing centres in a zone and allotted to the 9 cluster days as explained before.

As a result, the Primary Stage Units are made up of a landing centre and a day (the landing centre day). If a zone had five landing centres and thirty fishing days in a particular month, the primary stage units (PSU) would be five times thirty, or 150 landing centre days. The second stage units (SSU) are the fishing vessels that arrive on a landing centre day.

Time strata	Days in a month									
1	1	2	3	4	5	6	7	8	9	10
2	11	12	13	14	15	16	17	18	19	20
3	21	22	23	24	25	26	27	28	29	30

According to the SMRSD, a landing centre day is split into three periods. It follows that a landing centre day has a 24-hour duration, beginning at noon on the first day and ending at noon on the second.



The ICAR-CMFRI technical staff - field observer -is typically assigned to gather marine fish landing data from each zone. On the chosen landing centre day, data collection begins with period 1. The observer will be at the centres for the duration of periods 1 and 2. Period 3 (night landings) landing data is typically obtained by contacting the landing centre early the next day. The observations on the 3 periods contribute the data for one landing centre day (24hrs). Thus, data from three centre days are sampled over ten days, resulting in nine landing centre days sampled over a month. It might not be feasible to record the catches of every craft landed during an observation period if there are a lot of crafts that have landed after arriving at the landing centre.

Once at the landing centre, recording the catches of all landed crafts during an observation period might not be feasible if a large number of crafts are landed. The sampling of crafts is then crucial in that scenario. The total landings from all the crafts are totalled for catch composition and other details when the total number of crafts landed is 15 or less. The process below is used to sample the number of crafts when the total number exceeds fifteen.

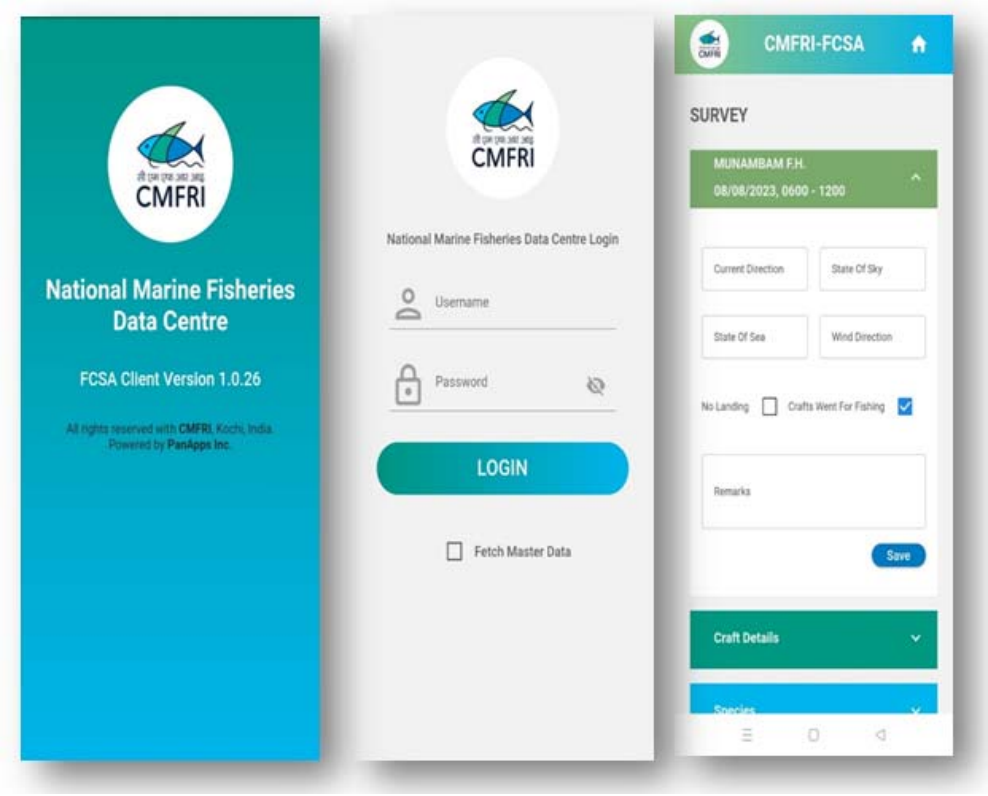
At each landing centre, they observe and record key information regarding the fishery, such as the species-wise catch, fishing gear details, fishing effort in terms of trip duration, manpower and fishing location from fishing boats selected as per the SMRSD. The quantity landed for a day (24 hours) at a centre, which is the landings for each centre day included in the sample, is estimated by adding the quantities landed during the two 6-hour periods and the night (12 hours). From these, the monthly zonal landings are estimated. The landings are arrived at district-wise, state-wise, and throughout India based on the zonal estimates. The corresponding sampling errors are also estimated. For single-centre zones, the landing centre day selection processes and the crafts that land on that day follow the same procedures as for strata in multi-

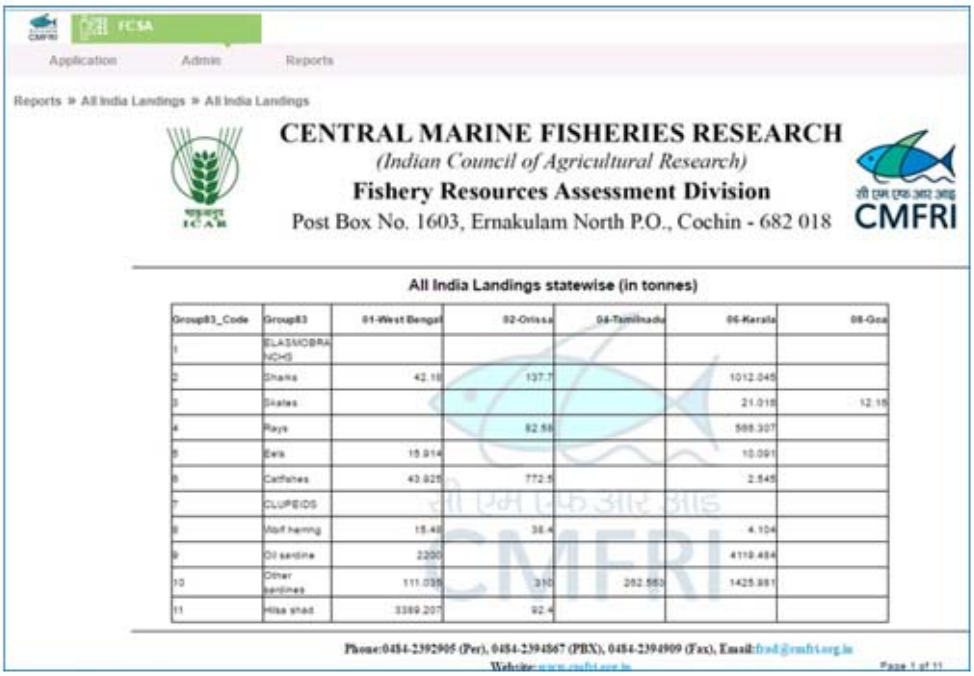
centre zones. Estimates are made for all the units landed during the observation period based on the landings of the observed fishing units. The process of estimation is explained in detail in Srinath et al. (2005).

Initially, data collection was carried out on paper-based forms and estimates of landings were made manually. Developments in information and communication technology have created new avenues for a change in the approach to conducting research and data collection and ICAR-CMFRI developed a web-based application software called Fish Catch Survey and Analysis (FCSA), which provides a technologically advanced scientific marine fisheries data collection, processing and reporting system for India where the fishery is highly complex due to its multi-species and multi-gear nature. The web application prototype developed enables online data collection from the landing centres and transmits real-time marine fishery data based on SMRSD.

FCSA consists of different segments, which include tablet-based online data entry, estimation and various report generation options. It enables a multi-level user system, with the system administrator having overall authority over the system as well as those who gather real-time data from landing centres. FCSA consists of one back-end, which is the database server, and two different kinds of front-ends. One front-end is a mobile client that works on a tablet, while the other is a web application that runs on a desktop computer through a browser. Mini et al. provide a thorough explanation (2023).

The country has a long history of fishing and there is a growing awareness of the need to manage these resources sustainably. It would be virtually impossible to assess the status of the resources without reliable fishing data. With the use of digital image identification, artificial intelligence, and machine learning, significant advancements have been achieved in monitoring marine fishing activities. The institute's National Marine Fishery Resources Data Centre (NMFDC) maintains the database, which has been generated through field data collection over decades following the SMRSD at ICAR-CMFRI. The species-wise, gear-wise, month-wise and region-wise database is used largely to aid fisheries management by national and international organizations. The marine fish landings data generated through SMRSD of ICAR-CMFRI provides required inputs to augment research activities on various aspects of marine fisheries in the country, such as stock status, ecosystem diversity, economics of fisheries, income and social welfare of fishers, impacts of interventions by government, market studies and revenue from the sector.





Further reading

CMFRI-FSI-DoF, 2020. Marine Fisheries Census 2016 - India. ICAR-Central Marine Fisheries Research Institute, Indian Council of Agricultural Research, Ministry of Agriculture and Farmers Welfare; Fishery Survey of India and Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India.

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