Survey Based Appraisal and Indian Marine Fisheries- Challenges and Opportunities

J. Jayasankar

ICAR-Central Marine Fisheries Research Institute, Kochi
Email: jjsankar@gmail.com

Introduction

India is the third-largest globally in terms of total fish production and ranks sixth in the world for marine capture fisheries production, with a contribution of 4.7% in 2020 (FAO, 2022). The marine fisheries sector contributes significantly to the food and nutritional requirements of the people and provide livelihood to a segment of the population rooted in tradition and skill. Fisheries sector play a significant role in the Indian economy. It supports the livelihood of nearly 3.8 million coastal population by providing income and employment (Sathianandan et al., 2021) and earns an annual foreign exchange worth US$8.1 billion through marine exports (MPEDA, 2023). One of the main responsibilities of the Central Marine Fisheries Research Institute (ICARCMFRI) is to assess and monitor India's exploited marine fish resources for deriving management measures to keep the harvest of the resources at sustainable levels.

As in vogue, continuing the process of monitoring of resource exploitation, nationallevel sample survey was conducted using a two-stage stratified random sampling design, facilitated by the online data collection application Fish Catch Survey and Analysis (FCSA). In the data collection system, dedicated technicians (harbour-based observers) with species identification skills visit the landing centres according to work schedules generated under the sampling scheme and record different aspects of the fishery from sampled boats. Regular taxonomy training is given to these observers in order to improve their ability to identify species in the field. The data gathered from 1250 landing sites around the coast was analyzed to derive species, fishing zone, and gear-wise monthly marine fish landings distributed along the Indian coast, encompassing the nine maritime states and three coastal union territories.

Since 2018 Fish Catch Survey and Analysis (FCSA) has been implemented at CMFRI in collaboration with various state governments like Kerala, Andaman and Nicobar UT and Maharashtra. This setup has two modules, first at the enumerator / field staff level and the second at the server level. This online process initiates with a work programme for a session of a landing centre day selected by adopting procedures mentioned above and has five stages of data entry using tablets/ smart phones viz. Landing centre

description, craft particulars, specieswise catch particulars, minimum and maximum price fetched in auction for each species at landing centre level and finally a set of unique observations that whether the session witnessed no landings, if so the reasons thereof and also distinctively whether the day was a fishing day or a holiday and reasons thereof. It also has provisions for quantifying the proportion of low-quality animals under each species, which could give a fair idea about the bycatches and even non- adult catches. This module also has a time and location tracker, which ensures that the data collection started at the stipulated location at the time the session was supposed to start. The server-end module has a combination of frontend and a database (PostgreSQL/ Oracle), which enables a systematic collation, verification, estimation and summarization of the landings as well as effort estimates. Various custom templates are available to derive the summaries from the database. The year 2023 witnessed a release of a new architecture based FCSA- FCSA-2.0, which has a fullfledged android app as its field module.

Pathways to stock assessment

Though generically divergent, exploited resource landing eminently feeds into assessment of stock health. The trends on landings are the best first level indicators of stock availability. Its modifications lead to what are popularly termed as Fish Stock Status (FSS) plots. Even the landings contrasted with the harvestable potential can lead to more efficient indices (Environmental Performance Index) based on FSS. Also they give the major canvas for conventional life history traits based stock assessment, wherever abundance numbers and effort as exponential factor are required. Thus landings, effort and catch per unit effort (CPUE) estimates hold up a major domain of quantitative fish stock assessment.

Marine Fish Landings in India - 2023

The year 2023 witnessed a major success to ICAR-CMFRI in its incessant pursuit of implementation of a common sampling design for estimating marine fish landings throughout the country. The institute could successfully implement the marine fish landings data collection system in Andaman & Nicobar Islands (ANI).

The marine fish landings from the coast of the mainland of India in 2023 were estimated as 3.53 million tonnes against 3.49 million tonnes in 2022, experienced an increase of almost 1.2%. Compared to the year 2021, an increase of 15.75% was reported in the marine fish landings. Gujarat and Tamil Nadu swapped their positions vis-à-vis 2022 and Gujarat climbed back to the first position in fish landings (8.23 lakh tonnes) followed by Kerala (6.33 lakh tonnes) and Karnataka (6.04 lakh tonnes).

Tamil Nadu, which occupied the top two places in preceding years, has moved to the fourth slot. These states contributed 23.3%, 17.9%, 17.1%, and 16.0%, respectively, to India's total marine fish landings. The decline in landings of Tamil Nadu was majorly due to severe cyclonic storm Michaung which was formed in the Bay of Bengal during the latter part of November and especially in December 2023 and subsequent spells of deluge that cut off key maritime districts from action, had an adverse impact to the number of fishing days.

There was a rise in landings of 63.7% in Gujarat, 24.3% in Maharashtra, 23.2% in Daman & Diu, 16.8% in Goa, and 2.3% in Puducherry as compared to the landings in 2022. Tamil Nadu (21.8%), Karnataka (13.1%), Andhra Pradesh (12.2%), West Bengal (8.8%), Kerala (7.8%) and Odisha (2.4%) were the marine states with reduction in landings than in 2022.

The region with the highest landings in 2023 was the southwest (SW), with 1.3 million tonnes, followed by the northwest (NW) with 1.12 million tonnes, the southeast (SE) with 0.81 million tonnes, and the northeast (NE) with 0.3 million tonnes.

Indian mackerel retained its status as the top landed resource in the country, with a total of 3.43 lakh tonnes. Compared to the landings in 2022, Indian Mackerel retained its first position with an increment of 4.7%. The other major marine fish resources in 2023 landings were Ribbon fishes (7.64%), Oil sardine (6.95%), Cephalopods (6.02%), non-penaeid prawns (5.98%), Threadfin breams (5.87%), Penaeid prawns (4.51%), Anchovies (4.33%), Lesser sardines (3.88%) and Scads (3.51%). There was a significant increase of 43.68% in the landings of non-penaeid prawns, while a decrease of 24.25% was observed in the landings of scads.

The three categories of fishing crafts - mechanized, motorized and non-motorized – that collectively make up the total effort expended in fishing. Their contribution to the total landings were 2.8 million tonnes (79%), 0.71 million tonnes (20%) and 0.03 million tonnes (1%) respectively. Compared to the previous year, mechanized fishing crafts (2.85 million tonnes) and non-motorized fishing crafts (0.04 million tonnes) exhibited a slight decline in the total landings, whereas motorized fishing crafts (0.61 million tonnes) showed a marginal increase.

The three types of fishing crafts—mechanized, motorized, and non-motorized—that add up to the total effort expended in fishing. They each contributed 2.8 million tonnes (79%), 0.71 million tonnes (20%), and 0.03 million tonnes (1%), respectively, to the total number of landings. There was a minor decrease in the total landings from the previous year for mechanized fishing crafts (2.85 million tonnes) and non-motorized fishing

crafts (0.04 million tonnes), while motorized fishing crafts (0.61 million tonnes) showed a slight gain.

The overall catch rate estimates in 2023 envisaged that mechanized fishing crafts accounted for 2863 kg/trip, motorized fishing crafts reported 149 kg/trip and nonmotorized fishing vessels recorded 46 kg/trip. With respect to the trips conducted and actual fishing hours observed, mechanized fishing crafts contributed a paramount share to the maximum landings.

Pelagic finfishes constituted the major portion of the landings in 2023 with 1.93 million tonnes with 55% of the national total followed by demersal finfishes with 0.93 million tonnes (26%), crustacea with 0.45 million tonnes (13%) and mollusca with 0.23 million tonnes (6%).

According to a quarter-wise breakdown of marine fish landings in 2023, the highest landings, 1.29 million tonnes (36.5%), occurred in the fourth quarter (October–December), which was also the same as in 2022. The second quarter held its fourth place (0.53 million tonnes, 15%) while the first and third quarters secured the next spots with 0.86 million tonnes (24.4%) and 0.85 million tonnes (24.1%).

Fish landings sampled throughout India's coastline revealed a total of 1155 species. The state of Tamil Nadu had the highest number of species (744), followed by Kerala (717), Andhra Pradesh (382) and Maharashtra (337).

Uniqueness of methodology and importance of tools

Despite being simple and straight forward at the core, the methodology to estimate landings and efforts as well as those enabling stock assessment have three salient traits to be a successful paradigm.

1. Exhaustivity
2. Evolutionary
3. Effective
4. Ease of use

While the kind of fishery witnessed by Indian waters and its complexity is well known, the coverage aimed by any survey to estimate the key indicators of resource removal and effort expended must cover all kinds of crafts and gears and combinations.The methodology being utilized views the craft-gear combination as a distinct population from the inferential perspective and thus steers clear of omitting or clubbing unique gears. Thus exhaustivity is intrinsically woven in this methodology and thus gets reflected in the estimates.

As regards advancement, Indian marine fishery is an epitome of high-speed change with fishers often outpacing researchers in innovating new means and methods. The outboard units and combination gears are a proof enough for this. Thus, a figure on the quantification of captured resources must have a room to accommodate these innovations. Though technically termed as effort creep such developments play a huge role in both the figures being estimated as well as the subsequent modelling to assess the stocks. A diachronic foundation is required to enact this in a methodology. Thus, the ICAR-CMFRI methodology as implemented through FCSA 2.0 has captured the essence of developments with the periodic review from the field getting reflected in the options that define the selection of craft and gear and also the effort measurements.

For a methodology or process to be effective, it has to be accurate and precise. Accuracy in terms of reflecting the ground reality and precision in terms of not being too much deviant are the hallmarks of an efficient system that's based on them. The methodology that aims at quantification exploited resources must be as much unbiased as possible and buoyant with respect to minor vagaries. ICAR-CMFRI's earnest efforts have lead to the enshrinement of this unique principle of "unbiased data and non-prejudiced enumerator" concept, which is a rare luxury for any sampling scheme. Well qualified and thoroughly trained field staff are stationed with the dedicated mandate of visiting selected landing centres and observing the landings with no favour or hesitation. This huge apparatus, which is in incessant action mode is the backbone of the efficacy of this methodology.

Ease of use is the last mile characteristic of any methodology. The more pliant and convenient the tool that implements the methodology is, better will be the adoption rate of the same. Thus the survey methodology has been converted into a workflow with ease of implementation and proliferation as the basic tenet. FCSA 2.0 coming out as a full-fledged App is the best point to argue the methodology's ease of use.

Challenges and opportunities

When a chain of events as contrasting and dynamic as fish supply chain is observed, the first thing to cross one's mind is the structuring of the chain followed by quantification of its key attributes. At the landing centre level although a methodology to estimate the quantum of resources landed is a major structured means of measuring a key attribute, the challenges are very many. The most important one has its genesis in the source itself. As the landings indicate the fishing activity in posterity, how much was caught and where remain shrouded in the realms of uncertainty.

The fishing grounds and the precise put forth for the capture for the systemic component of any model that has the quantum of resource availability at its nucleus. It is an established fact that seen from a gridded georeferenced angle, the availability of the resources is bound to vary. Further most of the common commercially exploited resources are dynamic in nature and have their niche either shifted or expanded. There comes the role of ecosystem, which is a broader and more challenging unit of study. Thus the key challenge in a methodology that measures commercial landings with an aim to make it as the starting point for assessing stock health is to have as much realistic assessment as possible. This paves the way for involving the inputs shared either by fishers themselves or those that are observed involuntarily. Electronic log sheets and shared electronic ledgers (blockchain concept) are the best way forward to enhance the coverage and relevance of estimating the resource exploitation. This makes more sense in situations wherein fishers are forced to get into binge fishing to make ends meet. This challenge also leads to the opportunity of installation of Artificial Intelligence based units for automated observation. Using the exhaustive information already available both on prospective resource availability as well as the market preferences and the gear capabilities, machine learnt algorithms that best summarize the input output relationship can be put to its best possible use in quantifying the resource exploitation in the marine fishery domain. With the thrust of fitting of MCS tools like VMS and AIS by the governments, coupling of these AI/ML tools is the logical extension.

Another major challenge is related to the innovations in fishing activities and arrangements that are initiated by fishers as part of their co-management arrangement. The formation of groups in a particular kind of fishery and sharing a fishing ground within the group need special focus. The *dolnet* fishery of Maharashtra is a classical example of this. About seven or eight fishers identify their grounds and put up their nets in this passive mode. They take turns to bring the entangled fish on daily basis for a week or so. Thus strictly going by the protocol to be followed from the landing centre, the effort both in terms of units and hours will be quite at variance from the reality. For these kinds of situations apart from pressing modern gadgets into service, a relook at the survey methodology itself would be of huge advantage.

Thus opting for synthesized estimators based on multiple sources could be the next major way forward. With various agencies into quantification of resources captured, for different purposes, although, an umbrella estimator that imbibes the key inputs with suitable weights will make the estimate more precise with reduced standard error.

Thus it can be safely stated that the imminent future would witness improvement of sampling strategies with shift from landing points to grids of grounds, identified wither by utilizing automated locators or passive modes of georeferencing alongside coming out with solutions that use rigorous computational setups. A balanced approach that has a proper admixture of methodological improvement alongside machine-based prowess will be the ideal way forward in obtaining the precise basis for assessment and policy initiatives of Indian marine sector.

A commentary of Maharashtra Marine Capture Fisheries

Maharashtra is one such major maritime states of India, which can be treated as bellwether states. Though the estimated landings in recent years show an average or sub average level post COVID trend is more promising. With more than 150 landing centres/ harbours, this state witnesses a couple of unique fisheries in *dolnet* fishery and gill net fishery, not forgetting the purse seine fishery in the southern parts. The following plot depicts the trend of fisheries of the state based on the data collated at National Marine Fisheries Data Centre (NMFDC) at CMFRI.

Major Resources
Indian Mackerel
Non-Penaeid Prawns
Ribbon Fishes
Lesser Sardines
Croakers
Penaeid Prawns
Cephalopods
Oil Sardine
Tunnies
Horse Mackerel
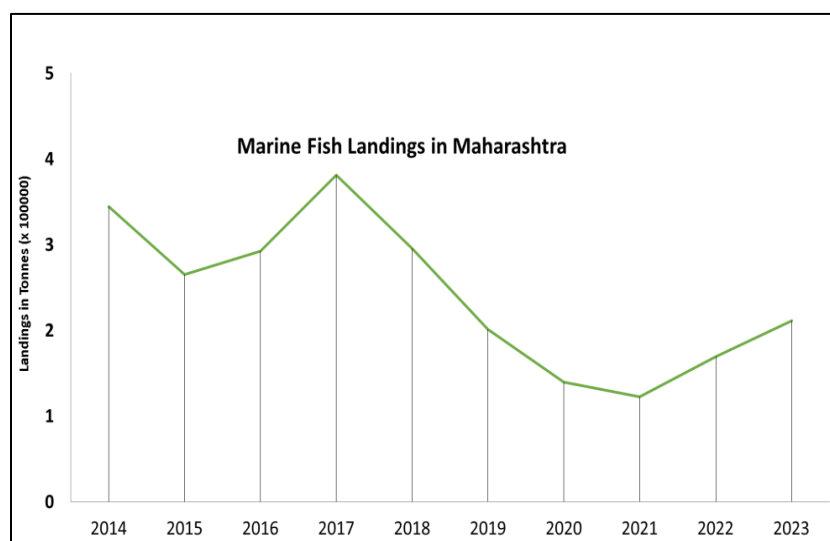
Major Harbours in Maharashtra

District	Zone	Harbours
Mumbai City	NFW	New Ferry Wharf
Mumbai City	SDN	Sassoon Dock(New)
Mumbai City	SDO	Sassoon Dock (Old)
Mumbai suburban	VER	Versova
Palghar	ARN	Arnala
Palghar	BAS	Bassin Kolliwada
Palghar	SAT	Satpati

District-wise landings
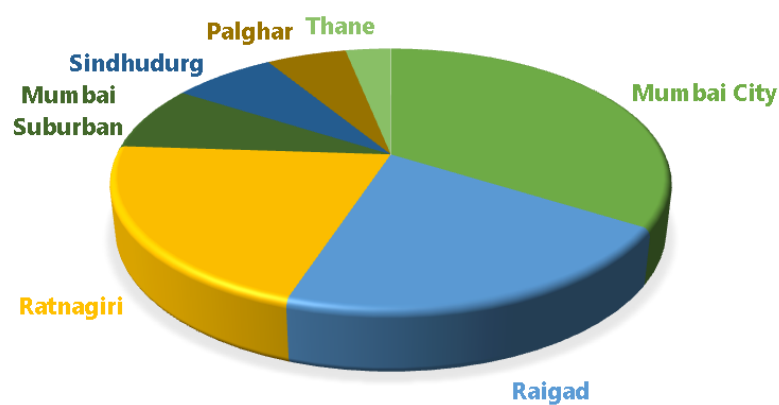
Landings in Major Harbours (tonnes)

In all with the kind of industrialization and related growth being witnessed by the state, the buoyancy of fisheries and stock health heavily hinges on the active collaboration of stakeholders and governing institutions. It is always a welcome move to have the regulations reviewed periodically and make them
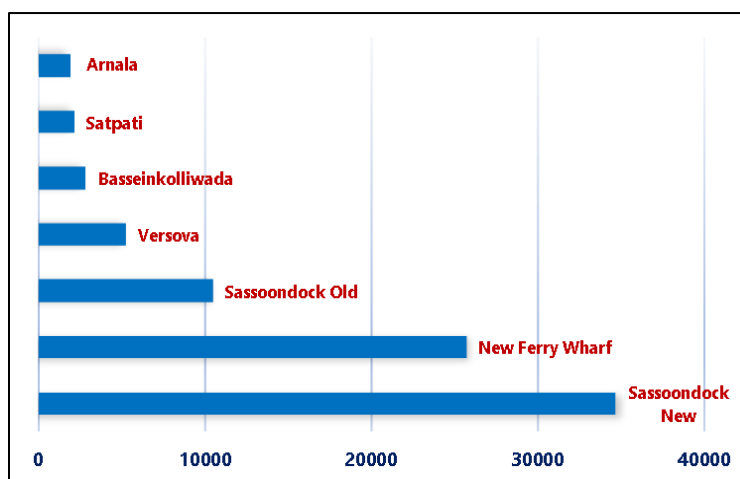
more strategy based, and evidence derived. Thus, with the new found impetus being given to the sampling coverage and initiation into stock assessment, Maharashtra state is well on track to break the 4 lakh tonnes mark that was once set as a bench mark.

Conclusion

In conclusion, it can be stated that networking and mutual assistance are the keys to the success of any mechanism to be planned to assess, predict and project dynamically changing resources like marine fish. With the number of families dependent on this sector substantial and their levels too varied from subsistence to business, it is always worthwhile to place both the resource and fisher at the core of any strategy that is out to measure the dynamics. Thus, the Ecosystems Approach to Fishery Management (EAFM) would get the proper launch in Indian waters, if a procedure that keeps both these as the fundamental driving forces is opted.