Marine Capture Fisheries sustainability in India– the challenges and way forward

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Wild marine capture fisheries provide nutritional security and livelihoods to millions of people globally. The global marine capture fisheries harvest was an estimated 78.8 million t in 2019 (State of World Fisheries and Aquaculture , SOFIA, 2022) and sustainably fished stocks contributed 82.5% . of this, which was up by 4% as compared to year 2017. The right to fish and manage the fisheries in the Exclusive Economic Zone comprising a 200 nautical miles boundary (declared in the mid 70s and incorporated in UNCLOS by the 90s) is the prerogative and responsibility of each coastal nation. The fisheries resources within the EEZ, however, are public resources which means that individuals will seek to maximize their own benefits, giving rise to sustainability issues and social discontent, unless there are regulatory mechanisms and collective stakeholders' action based on social values and responsibilities within any management unit or state. Healthy levels of fish stocks, positive social impacts (sustaining and enhancing livelihoods, ensuring nutritional security) and profits (for fishers, seafood based industries) thus become the cornerstone of any successful Fisheries Management Plan, that should ideally be based on best available science. The High Seas or Areas Beyond National Jurisdiction (ABNJ) fall within the purview of Regional Fisheries Management Organizations (RFMOs) for managing fishing activities in such areas.



A picture depicting a typical fish landing centre for small scale fishers. An estimated 10 million people are actively involved in the Indian marine fisheries sector (Marine Fisheries Census 2015). Source: Jayaprakash, 2016, Glimpses of Indian Fisheries- A caricature

Compared to land-based food production systems, seafood can be considered as a relatively benign and less environment impacting method. In India, the marine fisheries production has increased from around 0.5 million tonnes in the 1950s to around 4 million tonnes during the last decade. A multispecies, multi-gear tropical fishery that it is, it is powered by a marine fisher population of 3.8 million, of which around 25% are active fishers. In 2021-22 the Indian seafood exports of 1.3 million t was worth US\$ 7.76 billion, in which the contribution of the wild capture fisheries was 51% and 30% in terms of volumes and value, respectively. This underlines the importance of sustainable fisheries backed by science from national fisheries research institutions and active collaboration of the primary stakeholders, the fishers.

ICAR-CMFRI as a pioneer marine fisheries research institute established in 1947, has contributed significantly to the development of a knowledge base on the taxonomy and biology of several important marine organisms. This facilitated several policy outcomes (eq, seasonal fishing ban through Marine Fishing Regulation Acts of the various maritime states, Minimum Legal Sizes, species wise advisories such as for sharks, endangered species such as dugongs and marine mammals) aimed at conserving fish stocks and other valuable marine biological resources in the Indian EEZ. Rapid developments in craft and gear technologies post 80s could tap the largely underutilized marine fishery resources. Simultaneously, there was a proactive approach to fisheries management, with the enactment of Marine Fisheries Regulation Acts in the various maritime states of India. These acts were concerned with fisheries conservation by advocating regulations on fishing methods and gears



This picture depicts a popular and innovative gear developed by fishermen in Alleppey (Kerala) on subsistence basis. Here, thermocole crafts powered only by sails for short fishing trips in inshore waters for shrimps and other coastal fishes.



Cartoon depicting the potential in producing value added products from tunas. Viewed from an angle of economic value and valueaddition possibilities, oceanic species such as yellowfin tuna are a largely under-utilised marine fishery resource in India. Post-harvest processing methods and value addition are crucial to ensure good returns to producers as market prices for traditional fresh, frozen or highly- fresh quality (Sashimi) products differ on huge scales. Better harvest techniques, fish handling and processing techniques, proper storage infrastructure and market linkages are crucial to ensure sustainability of the tuna value chain in India.

used, effort restrictions by seasonal fishing bans, gear regulations through mesh sizes and engine hp etc. At a later stage, certain regulations in output such as Minimum Legal Size of fish landed have also been added.

Maximum Sustainable Yield- the balancing act

The concept of Maximum Sustainable Yield (MSY) is that it is theoretically the largest yield (or catch) of a species that can be taken on a sustainable basis, for an indefinite period. The concept was laid down in the 1930s and gained acceptance globally. Yet, it also had among others, its share of strong criticism (Larkin, 1977; Sissenwine, 1978) which were classified into 3 categories by Mace (2001). The concepts of F_{MSY} (the fishing mortality that produces MSY of a stock) and B_{MSY} (long-term average biomass that can be achieved when fishing mortality rates equal to F_{MSY}) followed. In any case, the fishing effort is considered a critical factor, which has to be regulated effectively but considering the socio-economics aspects (livelihoods, nutritional security) this is often given less priority by management and enforcement agencies . As indicated in a typical single-species stock model, in the initial phase



Fig. 1. Timeline of a marine fisheries stock

The picture denotes a single species fisheries development time line. Initially the fishing effort inputs are small (number of boats, gear technology level) but develops with time (technology creep). Fisheries management strategies to maximize yield (MSY) use fishing effort controls via their effects on fishing mortality. This requires knowledge of the biology of the species whose yield is to maximized and the resulting response to effort controls. The multispecies, multi-gear tropical fisheries in India are subject to environmental factors affecting the fishery resources through the biological loop of ocean productivity, predator-prey dynamics, spawning and recruitment pulses etc., and adds to the complexity of assessing the fisheries.

of fisheries development, there are fewer boats, perhaps with most of them being artisanal and the resource is not tapped to optimum, with few fishes landed. As technology uptake improves and often more boats enter the fray, the yields increase and optimize (Maximum Sustainable Yield or MSY). Technology Creep (bigger and more efficient crafts and gears) is inherent to any developing fishery and fishing pressure on the resources increase over time (Fig. 1). If this fishing is managed efficiently through appropriate regulations to keep biomass levels high (B/Bmsy > 1), the resources can withstand the scaled up fishing pressure (F/ Fmsy>1) and the fishery will be sustainable, as the Kobe Plot indicates.

Today, another set of challenges, through the climate change phenomenon is manifesting globally causing disruptions in the lives of fishers and the industry. In the form of extreme weather events, global sea level rise, changes in species distribution and abundance patterns or regime shifts, the fishing activities and livelihoods are being impacted in complex and inter-related manner. Not subject to geopolitical boundaries, favorable environmental windows of temperature, preferred food availability and spawning/



Kobe plot is often used to depict the fisheries management needs following a traffic light signals method. Here, depending on the parameters and limits for F/F_{MSY} and B/B_{MSY} the Green (A) depicts a perfectly sustainable fishery; Yellow (B)- Rebuilding- Fishery may have been depleted due to fishing and non-fishing related causes, but is rebuilding with fishing curbs in place; Orange (C) indicates a fishery with relatively high fishing pressure, but since it is also having a relatively good biomass it is sustainable but proper monitoring of resource to be intensified; Red (D) unsustainable with biomass levels low as well as very high fishing pressure, which warrants urgent and drastic fishery management measures to prevent a fishery collapse.



The picture depicts the global warming phenomenon and its repercussions for marine fisheries sustainability have been flagged in numerous studies globally. In a recent study on impact of climate change on marine fisheries sector by ICAR-CMFRI, the carbon footprint in India's marine fisheries has been estimated at 1.32 t of CO₂ to produce one tonne of fish which is much lower than the global average of around 2 t CO₂. Yet, it is imperative that all actions to minimize the carbon footprint and work for sustainable production systems are taken up.



There are occasional huge population explosion of certain marine species such as that of puffer fishes in 2005-06 and the Red toothed Triggerfish Odonus niger in 2019 that is perhaps best explained with an ecosystem approach. Climate and environmental perturbations, changes in fishing pressure on apex predators in marine realm have been attributed to such phenomenon, but evidence provided largely remains coincidental. The cartoon humorously portrays the pufferfishes who were found to be destroying fishing nets and feeding on the fish catch as natural avengers for fishermen ignoring mesh size regulations.

larval survival dynamics are changing fish distribution and availability. With Climate Change impacting distribution and abundance of fish in the sea, availability of locally preferred species, fish catch volumes in the usual fishing grounds and possible new species interactions at the ecosystem level are being created and the patterns of fisheries are showing changes. Ocean-acidification and coral bleaching that affect marine biodiversity is another concern. Hence, focus on ecosystem approaches in fisheries research and management is being mooted but has its own shortcomings. Needles to say, capture fisheries research should look at all these challenges while assessing the marine fish stocks and bring forth innovative solutions so that it ensures sustainability.

Marine fish stocks can be assessed using different assessment models as biomass dynamic (only catch-effort data) or Analytical models with biology and fishery data (length frequency, gear selectivities, growth, maturity, fecundity, stockrecruitment relation etc.) used as inputs directly or indirectly. Both data availability and the goal for the management of the stocks concerned is to be considered. A study that surveyed 28 countries for a Fishery Management Index (based on metrics like research support, Management, Enforcement, Socio-economics and Stock status which in turn were assessed on various parameters) reported positive correlation between a well functioning fisheries management program



The five dimensional FMI was assessed from feedback of various stakeholders and used as an indirect indicator of the likely success of local fish stocks to be sustainable in the future also.

Source : Ray Hilborn @ https://sustainablefisheries-uw.org/

and the fish stocks status of the particular country. Needless to say, good funding support, skilled human resources and a receptive audience of fishery stakeholders are a pre-requisite for ideal outcomes.

Fish stock assessments require knowledge on the population biology as well as the fishing activity they are subject to and the institute has collected a vast knowledge base on the various marine fishery resources (eprints@cmfri.org. in). Scientific data collection including and analysis over past several decades on several species and groups has put India in a pole situation, over several developing nations as the above figure on the 5-dimension FMI indicates. The lacunae as reported in this study mainly appears to be in aspects of "enforcement" and "management" which falls under the purview of fishery managers who make suitable policies and legally enforceable regulations which are to be implemented with the support of the stakeholders. It is in this context, ICAR-CMFRI recently organized a brainstorming workshop on marine capture fisheries research to pave the way forward for meaningful research outcomes for the marine fisheries sector in India.