



Strengthening sustainable Tuna fisheries in India: Research, Policy, and Livelihood goals

Rajesh K.M., Shoba Joe Kizhakudan*, K Mohammed Koya, Sijo Varghese, Anulekshmi C., Surya S., Manas H.M., Abdul Azeez P., Veera Venthan K.R., Mini K.G., Manas Kumar Sinha, Shinoj P., J Jayasankar, Sreenath K.R, Sanjay Pandey, Surabhi Rai and Grinson George

Purpose, expectation and action intended (select one or more and include corresponding text)

Discussions (for information and open discussion):

The paper is to inform meeting members about India's research & policy roadmap integrating socio-economic stability with its marine fisheries management frameworks to achieve sustainable tuna fisheries in India while securing the interests of artisanal communities dependent on marine capture fisheries for food and livelihood security. The paper provides information on several conservation and management measures that form part of the roadmap are already in place (Section3).

The paper is also to discuss the possibility of using Minimum Legal Size as a metric for regulation and conservation of tunas and other fishes caught in association with tuna fisheries across IOTC areas as set out in Section 4.1.4.

Feedback (to collect input and suggestions)

[The paper is to request review and comments on..., as set out in Section X]

Conclusion (to record a concluded position or summary)

[The paper is to seek confirmation that..., as set out in Section X]

Recommendation (to ask the meeting to endorse a recommendation)

[The paper is to seek endorsement on..., as set out in Section X]

Decisions (to request formal approval of actions)

[The paper is to seek approval on..., as set out in Section X]

Abstract

India's Exclusive Economic Zone (EEZ), spanning over 2.02 million km² in the northern Indian Ocean, holds significant potential for oceanic tropical tuna fisheries, particularly yellowfin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*). While these resources represent a crucial frontier for economic growth, India's tuna fisheries sector is dominated by traditional, artisanal, and small-scale fisheries. India's marine fisheries provide food and livelihood security to over 28 million stakeholders. Any management action implemented for a particular resource within the ambit of India's multi-species fisheries will thus have visible impacts on the coastal communities that depend on these fisheries for income and food. To align with national goals of strengthening livelihood security and with the objectives of the Indian Ocean Tuna Commission (IOTC), India proposes a policy roadmap that integrates socio-economic stability with its marine fisheries management frameworks.

A major challenge is the multi-gear, multi-species nature of India's fisheries, with over 30 craft-gear combinations, which complicates accurate species-specific Catch Per Unit Effort (CPUE) and length-frequency data recording. In addition to the existing mechanisms, we propose extended monitoring frameworks tailored to small-scale landings across the coastal regions. Intensive sampling coverage, low-cost Vessel Monitoring Systems (VMS), Electronic Monitoring (EM) systems and genetic stock structure analysis will strengthen data fidelity for regional stock assessments while ensuring data collection methods and reporting protocols do not add liability to artisanal operations. Climate-induced spatial shifts in tropical tuna distribution, including seasonal abundance and their impact on traditional fishing grounds, will also be a priority research subject in the next five years. To balance ecological imperatives with coastal welfare, the policy framework focuses on sustainable exploitation strategies that protect small-scale livelihoods. A major recommendation is a livelihood-centric fleet upgrade, converting traditional artisanal craft into safer, fuel-efficient, longline-capable vessels equipped with onboard cold-chain storage, for extended operational range into deeper waters. This would support a gradual reduction in fishing pressure in sensitive coastal habitats while improving market value per catch.

A well-framed Catch Documentation Scheme (CDS), which enables end-to-end traceability, together with enhanced value chain integration and strengthened post-harvest infrastructure, would unlock premium export markets. A sustainability certification framework would be a mandatory compliance measure for any fisheries recommended for global certification assessments. Certification of community-based fisheries such as pole-and-line skipjack fisheries in Lakshadweep would be prioritised to ensure direct economic returns to local island communities. India plans an extensive deployment of Anchored Fish Aggregating Devices (AFAD) in island waters, which would certainly improve the CPUE of Tuna fisheries. Inclusive Governance and EAFM, through co-management models that involve local fishing cooperatives in policy design and implementation, would be central to India's tuna fisheries management framework.

India aims to balance IOTC conservation measures with equitable allocation mechanisms while protecting the rights of developing coastal states and the socio-economic status of their coastal communities. By combining rigorous scientific monitoring with targeted socio-economic support, India aims to build a climate-resilient tuna fisheries sector that safeguards both regional marine biodiversity and the livelihoods of traditional fishing communities.

Keywords: coastal livelihoods, Exclusive Economic Zone (EEZ), *Katsuwonus pelamis*, small-scale fisheries, *Thunnus albacares*, tropical tunas

Strengthening sustainable Tuna fisheries in India: Research, Policy, and Livelihood goals

Rajesh K.M.^A, Shoba Joe Kizhakudan^{A*}, K Mohammed Koya^C, Sijo Varghese^B, Anulekshmi C. ^A, Surya S.^A, Manas H.M.^A, Abdul Azeez P.^A, Veera Venthan K.R.^A, Mini K.G.^A, Manas Kumar Sinha^B, Shinoj P.^A, J Jayasankar^A, Sreenath K.R.^B, Sanjay Pandey^C, Surabhi Rai and Grinson George^A

A- ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala, India

B-Fishery Survey of India, Dept. of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, Govt. of India, India

C- Dept. of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, Govt. of India, New Delhi, India

* shoba.joe@icar.org.in ; jkshoba@gmail.com

Abstract

India's Exclusive Economic Zone (EEZ), spanning over 2.02 million km² in the northern Indian Ocean, holds significant potential for oceanic tropical tuna fisheries, particularly yellowfin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*). While these resources represent a crucial frontier for economic growth, India's tuna fisheries sector is dominated by traditional, artisanal, and small-scale fisheries. India's marine fisheries provide food and livelihood security to over 28 million stakeholders. Any management action implemented for a particular resource within the ambit of India's multi-species fisheries will thus have visible impacts on the coastal communities that depend on these fisheries for income and food. To align with national goals of strengthening livelihood security and with the objectives of the Indian Ocean Tuna Commission (IOTC), India proposes a policy roadmap that integrates socio-economic stability with its marine fisheries management frameworks.

A major challenge is the multi-gear, multi-species nature of India's fisheries, with over 30 craft-gear combinations, which complicates accurate species-specific Catch Per Unit Effort (CPUE) and length-frequency data recording. In addition to the existing mechanisms, we propose extended monitoring frameworks tailored to small-scale landings across the coastal regions. Intensive sampling coverage, low-cost Vessel Monitoring Systems (VMS), Electronic Monitoring (EM) systems and genetic stock structure analysis will strengthen data fidelity for regional stock assessments while ensuring data collection methods and reporting protocols do not add liability to artisanal operations. Climate-induced spatial shifts in tropical tuna distribution, including seasonal abundance and their impact on traditional fishing grounds, will also be a priority research subject in the next five years. To balance ecological imperatives with coastal welfare, the policy framework focuses on sustainable exploitation strategies that protect small-scale livelihoods. A major recommendation is a livelihood-centric fleet upgrade, converting traditional artisanal craft into safer, fuel-efficient, longline-capable vessels equipped with onboard cold-chain storage, for extended operational range into deeper waters. This would support a gradual reduction in fishing pressure in sensitive coastal habitats while improving market value per catch.

A well-framed Catch Documentation Scheme (CDS), which enables end-to-end traceability, together with enhanced value chain integration and strengthened post-harvest infrastructure, would unlock premium export markets. A sustainability certification framework would be a mandatory compliance measure for any

fisheries recommended for global certification assessments. Certification of community-based fisheries such as pole-and-line skipjack fisheries in Lakshadweep would be prioritised to ensure direct economic returns to local island communities. India plans an extensive deployment of Anchored Fish Aggregating Devices (AFAD) in island waters, which would certainly improve the CPUE of Tuna fisheries. Inclusive Governance and EAFM, through co-management models that involve local fishing cooperatives in policy design and implementation, would be central to India's tuna fisheries management framework.

India aims to balance IOTC conservation measures with equitable allocation mechanisms while protecting the rights of developing coastal states and the socio-economic status of their coastal communities. By combining rigorous scientific monitoring with targeted socio-economic support, India aims to build a climate-resilient tuna fisheries sector that safeguards both regional marine biodiversity and the livelihoods of traditional fishing communities.

Keywords: coastal livelihoods, Exclusive Economic Zone (EEZ), *Katsuwonus pelamis*, small-scale fisheries, *Thunnus albacares*, tropical tunas

1. Introduction

The Indian Ocean is home to some of the world's most productive tropical tuna fisheries, with the northern Indian Ocean providing essential habitats for key species such as yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*). India, with a coastline of ~11099 km and an Exclusive Economic Zone (EEZ) of ~2.4 million km², is positioned as a key coastal state in the northern Indian Ocean region, bounded by the eastern Arabian Sea along its west coast and the western Bay of Bengal along its east coast.

India is one of the top contributors to global fish production; marine capture fisheries continue to significantly support the livelihoods of over 28 million stakeholders and the nation's economy. While the sector remains predominantly small-scale, traditional, and artisanal, it is of prime importance to stakeholders, ranging from active fishers to downstream supply chain actors. Consequently, fisheries management in India cannot be viewed strictly through a stock-conservation lens; any regulatory interventions, quota allocations, or operational restrictions directly impact the socio-economic equilibrium of vulnerable coastal communities. Moreover, typical of many tropical fisheries with a highly diverse fleet of craft-gear combinations, India's marine fisheries is a complex multifaceted system which makes management a great challenge.

As a Contracting Party to the Indian Ocean Tuna Commission (IOTC), India faces the dual imperative of fulfilling regional conservation and management measures (CMMs) while advancing national socio-economic

objectives. Aligning these mandates requires a transition from conventional management paradigms toward an integrated policy framework. While there are several generic regulatory and/or conservation measures in place, resource or species-specific measures are yet to find a strong footing in India, primarily due to the complexities of the sector.

Although marine fisheries management has a long history in India, there has been a recent increased focus on sustainable fisheries and food and livelihood security. The Government of India has launched schemes such as the Pradhan Mantri Matsya Sampada Yojana (PMMSY, which translates as Prime Minister's Scheme for Fish Wealth), which aims to modernise infrastructure and double fishers' incomes through sustainable development and responsible fisheries management.

This paper presents a profile of India's tuna fisheries and outlines a comprehensive roadmap to enhance data collection fidelity, modernise fleet capabilities without compromising small-scale rights, establish transparent traceability systems, and embed inclusive co-management principles to ensure a climate-resilient, ecologically sustainable tuna fishery.

2. Trends in India's tuna fisheries

Tuna fishing in India has a long history in the artisanal sector and a development track record alongside the marine fisheries sector, particularly in the Lakshadweep Islands and the southernmost states of Kerala, Karnataka, and Tamil Nadu. Tunas form <0.4% of India's total marine fish landings; these are supported by coastal, nearshore multi-species fisheries. Oceanic tunas constitute less than 30% of India's total tuna landings.

Tuna fishing is mainly supported by the traditional/artisanal small-scale fishing sector, with craft ranging from tied-log *catamarans* to motorised and mechanised vessels, all below 24 m LOA (Table 1). There are no large industrial vessels engaged in marine fishing. Current fishing patterns indicate use of different gear combinations. Line gear (Hook & line, pole & line, longline), pelagic gillnets, drift gillnets, seines, and trawl nets are widely used. Almost 70% of the landings are by the mechanised sector using a combination of gillnets, seines and line gear.

Table 1. Specifics of motorised, motorised and mechanised fishing sectors involved in the harvest of tunas from Indian coastal and EEZ waters

Descriptors	Non-motorised	Motorised	Mechanised
Length of vessel (OAL)	8-12 m	8-12 m	12-24 m
Motor/engine	none	Outboard motor	Inboard engine
Gears used	Gillnet, Hook-&-line	Gillnet, Hook-&-line	Gillnet, seines, line gear
Fishing area	Coastal, in Territorial waters (TW)	Coastal, mostly in TW	Coastal and offshore (TW & EEZ)

2. Species composition

Tuna landings in India are dominated by coastal/neritic tunas, namely - bullet tuna *Auxis rochei*, frigate tuna *Auxis thazard*, little tuna *Euthynnus affinis*, longtail tuna *Thunnus tonggol*, and bonito *Sarda orientalis*. Skipjack tuna *Katsuwonus pelagicus*, Yellowfin tuna *Thunnus albacares*, and Big-eye tuna *Thunnus obesus* support the tropical tuna landings. In the last five years, tropical tunas formed 41% (Fig. 1) of the total tuna landings, with skipjack leading accounting for more than 50% of this (Fig. 2).

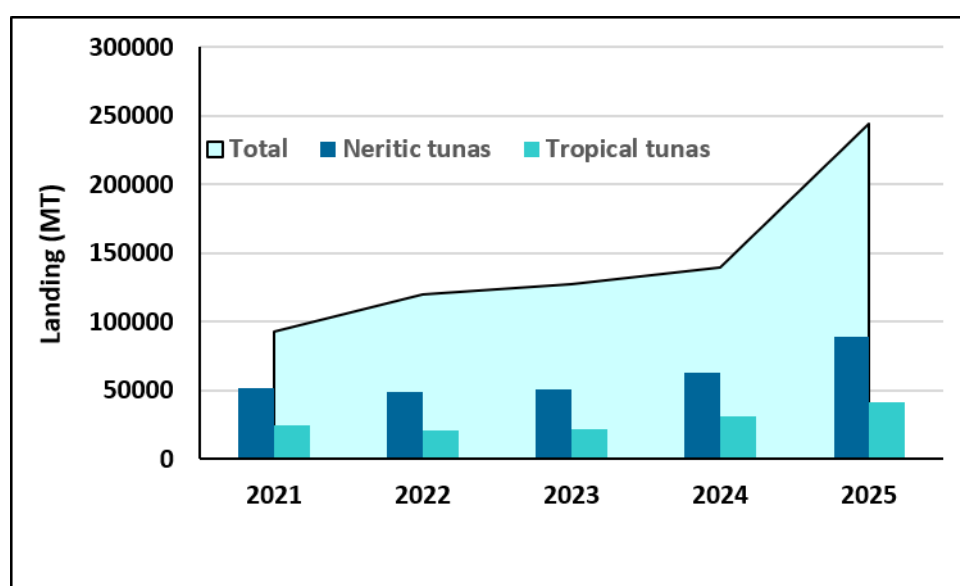


Fig. 1. Annual landing of tunas in India (2021-2025)

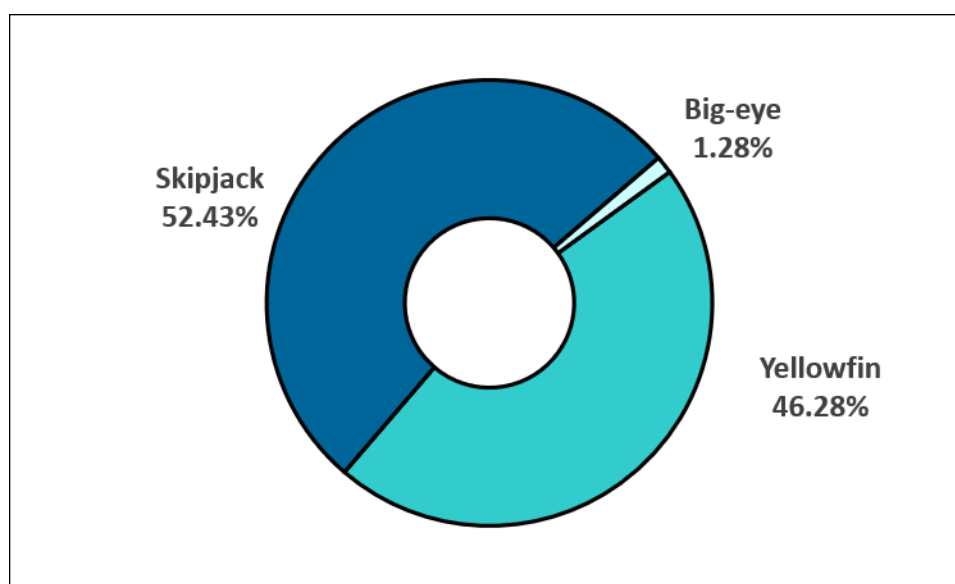


Fig. 2. Composition of total landing of tropical tunas in India during 2021-2025

3. Fisheries management and conservation measures in India

India's marine fisheries are typically multi-species, harvested by multiple craft-gear combinations, and never singularly directed for the entire year. Targeted species often vary with spatiotemporal seasonality and movement. A major chunk of the commercial landing is often constituted by several non-targeted species. There is no large tuna fishing fleet in India focussed only on the harvest of tuna and allied resources. More often than not the same boats that harvest tuna also engage in other coastal fisheries, and in many cases, tunas, particularly the neritic species, occur as bycatch in other fisheries. Owing to the broad spectrum of species in the fishery and the huge population of coastal fishers and allied stakeholders depending on marine capture fisheries for food and livelihood security, exclusively species-specific management or conservation actions are practically difficult to formulate or implement.

Despite the complex nature of India's marine fisheries, India has several fisheries management and conservation measures in place. Many of them are generic, but are quite effective in supporting the end goal of sustainability. Mesh size regulation, regulations and bans on detrimental harvest methods, spatio-temporal closure, including seasonal closure of mechanised fishing coinciding with peak spawning activity in many fish species, and size-based harvest regulations are some which have been successfully implemented. India's National Policy on Marine Fisheries (2017) provides a strategic framework for the sustainable use of marine resources to improve the livelihoods of fishers while protecting the marine ecosystem. All the

maritime states and union territories have their own Marine Fishing Regulation Acts (MFRA) designed to regulate marine fishing within the 12-nautical mile strip of Territorial Waters.

India also has a strong conservation tool in the form of the Wildlife (Protection) Act, 1972 and its recent Amendment Act (2023) which accords the highest level of protection to several critically endangered marine fauna including sharks and rays, through its Schedules I and II whereby fishing and trade of such species are prohibited and punishable offences. In addition to this, Schedule IV of the Act includes all CITES-listed species to ensure effective implementation of CITES regulations.

In tandem with existing measures, and to align with national goals of strengthening livelihood security and with the objectives of the Indian Ocean Tuna Commission (IOTC), India proposes a policy roadmap that integrates socio-economic stability with its marine fisheries management frameworks. The roadmap will move through interventions by two major groups of institutions responsible for fisheries managements – the research organizations and the policy development and implementation agencies- with strong handholding with stakeholders.

4. Policy Roadmap for an Integrated Framework For Sustainable Tuna Fisheries in India

4.1. Research and Monitoring

4.1.1. Addressing Data Deficits in Multi-Gear, Multi-Species Operations: A foundational obstacle to accurate stock assessment in Indian waters is the operational complexity of its marine fisheries sector. The small-scale fleet utilizes more than 30 craft-gear combinations that more often than not target multiple species simultaneously. This operational heterogeneity presents severe challenges for capturing standardized, species-specific Catch Per Unit Effort (CPUE) metrics and length-frequency distributions needed for regional stock assessment models.

To resolve these deficits without placing an undue reporting burden on small-scale fishers, an extended, multi-tiered monitoring framework is being developed which will include:

- **Intensive Stratified Sampling:** Expansion of shore-based catch monitoring across primary and secondary fish landing centers using standardized digital reporting apps.
- **Low-Cost Vessel Monitoring Systems (VMS) & Electronic Monitoring (EM):** Phased deployment of scalable, low-cost solar-powered VMS units and spatial tracking devices tailored for small-scale motorized vessels to map spatial fishing effort.

- **Genetic Stock Structure Analysis:** Application of advanced molecular tools (e.g., high-throughput single nucleotide polymorphism [SNP] genotyping) to resolve population structure, migratory corridors, and stock connectivity of *T. albacares* and *K. pelamis* across the EEZ and adjacent high seas.

4.1.2. Assessing Climate Change Impacts and Spatial Dynamics: Ocean warming, marine heatwaves, and shifting oxygen minimum zones (OMZs) in the Arabian Sea and Bay of Bengal are increasingly modifying the spatial temporal distribution of tropical tunas. Oceanographic shifts directly affect primary productivity, prey availability, and thermocline depths, leading to altered migration patterns and unpredictable seasonal abundances. Over the next five years, priority research will focus on predictive distribution modelling, integrating remote sensing data (SST, chlorophyll-*a*, sea surface height anomalies) with localized catch logs to forecast climate-induced displacement of tuna stocks and evaluate its socioeconomic consequences for traditional fishing grounds.

A study by Zacharia et al. (2016) assessed the relative vulnerability of four species of tunas (among other resources) to climate change *vis-a-vis* fishing pressure. The study indicated higher vulnerability of tropical tunas in the Bay of Bengal than in the Arabian sea. (Table 2).

Table 2. Relative vulnerability of tunas in Indian waters – results of an earlier study (Zacharia et al., 2016)

Species	Arabian Sea		Bay of Bengal	
	North-west zone	South-west zone	South-east zone	North-east zone
<i>Euthynnus affinis</i>	Medium Vulnerability	Medium Vulnerability	Low vulnerability	No major fishery
<i>Katsuwonus pelamis</i>	No major fishery	Low vulnerability	High Vulnerability	High Vulnerability
<i>Thunnus albacares</i>	No major fishery	Medium Vulnerability	High Vulnerability	High Vulnerability
<i>Thunnus tonggol</i>	High Vulnerability	No major fishery	No major fishery	No major fishery

High Vulnerability	Low vulnerability
Medium Vulnerability	No major fishery

4.1.3. Stock status assessment: Stock assessment of tunas in India in 2023 (CMFRI, 2023) indicated sustainable fishing of skipjack along the SW coast of India and Lakshadweep and of yellowfin along the SW coast. A new assessment is being done, and the status is expected to be updated by December 2026. Management advisories are provided based on the status observed in different geographical (management)

units, namely, the North-west and the south-west coasts on the eastern boundary of the Arabian Sea, and the north-east and the south-east coasts on the western boundary of the Bay of Bengal. For tunas, the seas around the Lakshadweep Islands and the Andaman & Nicobar Islands are also considered. With intensified data collection and reporting stock assessment exercises are expected to become more robust, particularly with the use of multiple methods integrating biological data with catch dynamics. While acknowledging the migratory status of tunas, we rely on our stock assessments for locally managing the fisheries as (i) the fishing occurs within the boundaries of the country's EEZ, (ii) over the years there have been no indications of reduction in the inflow-outflow of these fishes in the known fishing grounds (iii) and there is suggestive evidence of more than one stock.

4.1.4. Size-based regulations - Minimum Legal Size as a measure to regulate indiscriminate exploitation of juvenile fish: The continuous extraction of juvenile fish leads to *growth overfishing*, a state in which fish are captured before achieving their maximum growth potential. This causes substantial loss in cumulative yield and economic value. Left unmanaged, severe growth overfishing degrades spawning biomass, ultimately resulting in *recruitment overfishing*, when the reproductive capacity of the stock falls below the threshold needed for population replenishment. Harvest of juveniles thus presents one of the most severe biological and economic threats to capture fisheries. Minimum Legal Size (MLS) is an input/output regulatory instrument to establish a threshold length below which a given species cannot be legally captured, retained, landed, transported, or traded (FAO, 1984). Implementing a size-based limit would increase economic efficiency while protecting juveniles and allowing them to grow in weight and length (Mohamed et al., 2014).

MLS regulations specifically aim to:

1. Ensure First Spawning: Guarantee that a sufficient proportion of the cohort reaches sexual maturity and reproduces at least once before capture (FAO, 1981; Froese, 2004).
2. Maximise Biomass Yield: Allow individuals to pass through their exponential growth phase, optimising the yield-per-recruit (Beverton & Holt, 1957; Sparre & Venema, 1998).
3. Suppress Juvenile Markets: Disincentivise targeted fishing on nursery grounds and reduce market demand for low-value, high-quantity juvenile fish by illegalising their capture and trade (Caddy & Mahon, 1995).

The Size at First Maturity (SFM) and the Minimum Size at Maturity (MSM) are often used as the criterion to estimate the MLS. The MSM works better for larger and long-lived fishes, with due consideration to their growth and reproductive potential. India has proposed MLS for eight species of tunas, including two tropical



tunas (skipjack and yellowfin), estimated using the MSM (Table 3). These MLS have been notified and adopted by many of the maritime states in the country (fisheries being regulated and managed by these states rather than by the Central Government as most of India's fishing activities are in the Territorial Waters under the governance of the maritime states).

Table 3. Minimum Legal Size (MLS) advised for capture of tunas in India

Scientific name	Common name	MLS (cm, FL)
<i>Thunnus albacares</i>	Yellowfin tuna	50
<i>Katsuwonus pelamis</i>	Skipjack tuna	35
<i>Gymnosarda unicolor</i>	Dogtooth tuna	50
<i>Thunnus tonggol</i>	Longtail tuna	44
<i>Auxis rochei</i>	Bullet tuna	18
<i>Auxis thazard</i>	Frigate tuna	25
<i>Euthynnus affinis</i>	Little tuna	31
<i>Sarda orientalis</i>	Bonito	35

Effective implementation of MLS would require extensive awareness campaigns among stakeholders. While implementing fisheries management measures is challenging, over the last decade (since the first roll-out of MLS as a mandatory measure in the southern Indian state of Kerala), we have seen indications of a positive impact of MLS in several fisheries. In 2025, only 16.6% of landed skipjack tuna and 18.9% of yellowfin tuna were below the recommended MLS, indicating good implementation.

4.2. Policy development and implementation

4.2.1. Livelihood-Centric Fleet Modernization and Infrastructure: The bulk of India's coastal fleet is restricted to nearshore waters, leading to localized overcapacity in coastal zones alongside the underutilization of offshore oceanic resources. To address this spatial mismatch, a targeted, livelihood-

centric fleet conversion plan is envisaged. Upgrading traditional craft into safer, fuel-efficient, selective longline-capable vessels enables traditional fishers to extend their operational range into deeper waters. Crucially, equipping these vessels with onboard cold-chain preservation systems protects fish quality, yielding higher market returns per unit of catch while simultaneously reducing fishing pressure in ecologically sensitive nearshore habitats.

4.2.2. Post-Harvest Value Chains, Traceability, and Certification: Unlocking high-value international markets for Indian tuna requires verifying legality, sustainability, and quality throughout the supply chain. Establishing a digitally integrated Catch Documentation Scheme (CDS) enables end-to-end traceability from the point of harvest to final export. By assigning digital identifiers at the point of landing, the CDS confirms compliance with national regulations and regional CMMs, preventing Illegal, Unreported, and Unregulated (IUU) catch from entering formal value chains.

To maximize socioeconomic returns for local communities, India must establish a national sustainability certification framework aligned with global standards (e.g., Marine Stewardship Council). Priority for certification will be directed toward low-impact, traditional, community-based operations to ensure direct economic returns to local artisanal and island communities:

1. Lakshadweep Pole-and-Line Skipjack Fishery: Recognized for its high selectivity and near-zero bycatch, this fishery represents an ideal candidate for early certification, driving premium pricing directly back to island cooperatives.
2. Small-Scale Handline & Longline Operations: Progressive improvements in data collection and bycatch mitigation will allow secondary coastal fleets to access certified sustainable supply networks over time.

4.3. Governance and International Alignment

4.3.1. Ecosystem Approach to Fisheries Management (EAFM) and Co-Management: Effective policy execution in complex multi-species contexts depends on inclusive governance. Transitioning to an Ecosystem Approach to Fisheries Management (EAFM) requires moving beyond top-down regulations toward co-management models. Integrating primary stakeholders—including fishing cooperatives, traditional community leaders, state fisheries departments, and scientific institutions—into formal decision-making ensures high policy compliance and reduces enforcement conflicts.

4.3.2. Balancing Regional Commitments with Coastal State Rights: As an active member of the IOTC, India advocates for allocation regimes that uphold the principles of equity and sovereign rights for developing coastal states, as recognized under international law (including UNCLOS). Conservation and Management Measures must recognize the socio-economic realities of small-scale fisheries, ensuring that catch limits, effort controls, and management burdens do not disproportionately impact coastal communities whose reliance on marine resources is essential for food security and poverty alleviation.

5. Conclusion

India's oceanic tropical tuna fisheries offer a vital path for economic growth and sustainable development. Realizing this potential requires a policy framework that harmonizes rigorous marine science with socio-economic protection. By modernizing monitoring systems, investing in fuel-efficient longline fleet conversions, and establishing robust traceability and certification systems, India can establish a climate-resilient, sustainable tuna sector. This integrated approach ensures compliance with IOTC obligations while safeguarding the livelihoods of millions who depend on the nation's marine resources.

References

- Beverton, R. J. H., & Holt, S. J. (1957). *On the Dynamics of Exploited Fish Populations*. Ministry of Agriculture, Fisheries and Food. Fishery Investigations Series II, Vol. XIX.
- Caddy, J. F., & Mahon, R. (1995). *Reference points for fisheries management*. FAO Fisheries Technical Paper No. 347. Rome, FAO.
- FAO. (1981). *Fishing regulations and controls: Size Limitation*. Food and Agriculture Organization.
- FAO. (1984). *Mesh size regulation and its role in fisheries management: Minimum landing sizes*. [Food and Agriculture Organization](#). [FAO Mesh Size and MLS Regulations](#).
- Froese, R. (2004). Keep them big: fish for life. *Fisheries Research*, 67(1), 111-114.
- Mohamed, K.S., Zacharia, P.U., Maheswarudu, G., Sathianandan, T.V., Abdussamad, E.M. et al. (2014). Minimum Legal Size (MLS) of capture to avoid growth overfishing of commercially exploited fish and shellfish species of Kerala. *Mar. Fish. Infor. Serv., T & E Ser.*, No. 220, 3-7.
- Sparre, P., & Venema, S. C. (1998). *Introduction to tropical fish stock assessment. Part 1: Manual*. FAO Fisheries Technical Paper No. 306.1. [FAO Stock Assessment](#).
- Zacharia, P.U., Dineshbabu, A.P., Thomas, S., Kizhakudan, S.J., Vivekanandan, E. et al. (2016). *Relative vulnerability assessment of Indian marine fishes to climate change using impact and adaptation attributes*. CMFRI Special Publication No. 125, (CMFRI-NICRA Publication no. 5), Central Marine Fisheries Research Institute, Kochi, India pp. 192.