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Fishery in India: A Study with  
Special Reference to  
Lakshadweep**

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# ASSESSING THE STATUS OF TUNA FISHERY IN INDIA: A STUDY WITH SPECIAL REFERENCE TO LAKSHADWEEP

Muhammed Luqman O P<sup>1</sup>, Thomas Felix K<sup>2</sup> and Ramappa K B<sup>3</sup>

## Abstract

*This paper investigates the status of tuna fisheries in India, with a particular emphasis on Lakshadweep. Despite India's abundant oceanic tuna resources, the country has historically lacked organised commercial tuna fisheries, except for artisanal fisheries in Lakshadweep and a few parts of Kerala and Tamil Nadu. Employing Compound Annual Growth Rate (CAGR) and Composite Entropy Index (CEI), this study analyses the trends and diversification in Indian tuna fisheries from 1997 to 2022. The findings indicate a positive growth trend (CAGR: 3.08%) but a recent decline in diversification (CEI: 0.65-0.77). Lakshadweep demonstrates a favourable growth rate (CAGR: 3.80%) yet faces challenges such as overdependence on skipjack tuna and low diversification (CEI below 0.5). This study aims to elucidate the trends and dynamics of tuna fishing in India, with a special reference to Lakshadweep's role and scope, and recommends suitable measures to address challenges to enhance the potential of India's tuna fishery while ensuring ecological sustainability.*

**Keywords:** Tuna fishing, Compound Annual Growth Rate, Composite Entropy Index, Diversification

## Introduction

Fishing has been a major component of India's socio-economic fabric and a lifeline, that has intertwined the cultural heritage of a large population with the economic growth of the country, for ages. Spanning the vast coastline and rich territorial waters, India's marine fisheries stand as a testament to both historical continuity and adaptive resilience. According to the latest Handbook on Fisheries Statistics (GOI, 2023, 09), fisheries and aquaculture provide sustenance and employment to about 28 million fishers, directly involving 2.05% of India's population and impacting nearly twice that number along the value chain. The gross value added (GVA) of the fisheries sector in 2021-22 was Rs. 2,88,526 crore (GOI, 49, 2023). Moreover, the value of fisheries export of marine products for 2022-23 stood at Rs. 63,969.14 crore (GOI, 59, 2023). India's coastal and marine ecosystems display remarkable geographic diversity and abundant aquatic resources including various species of tunas. Situated within the Central Indian Ocean Region, India's vast coastline extends 8,118 kilometres, encompassing three distinct marine ecosystem zones: the Arabian Sea, the Bay of Bengal, and the Indian Ocean. These diverse

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marine waters, combined with India's Exclusive Economic Zones (EEZs) covering 2.37 million square kilometres, represent a significant fisheries resource potential estimated at 7.15 million metric tons annually (GOI, 2022, Padiyar *et al*, 2024). This extensive marine landscape supports a network of 1,547 fish landing centres and 3,461 fishing villages, complemented by seven major and sixty-three minor fishing harbours strategically located along India's coastline (GOI, 2023).

### **Overview of Global Tuna Fishery**

Tunas are highly commercially valued marine fish that belong to the tribe *Thunnini*, comprising around fifteen species varieties across five genera (Restrepo *et. al.*, 2016). They are extremely migratory in nature and found mainly in the tropical and temperate zones of our planet. The tunas are often classified into coastal/neritic tunas and oceanic tunas, and the fisheries of both categories largely vary in terms of the scale and the gears used. Little/Mackereltuna (also known as kawa kawa) (*Euthynnus affinis*), frigate tuna (*Auxisthazard*), bullet tunas (*Auxisrochei*) and longtail tuna (*Thunnus tonggol*) represent the major coastal/neritic tunas while oceanic tunas are yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*), dogtooth tuna (*Gymnosarda unicolor*) and bigeye tuna (*Thunnus obesus*).

Archaeological evidence indicates that tunas were harvested by early Europeans in the area around Sweden, by Native Americans near British Columbia, and by the people of the Jomon culture near Japan. However, industrial fishing for tunas began in the 1950s, with global production increasing steadily from 0.6 million tons in 1950 to over six million tons in 2008. Currently, the global tuna fishery is valued around \$40 billion annually (Pew, 2023). Internationally, tuna is traded for direct consumption (fresh/chilled and frozen) and serves as raw material for various products, including those for canning (sashimi, fresh and frozen loins, and frozen pre-cooked loins). Canned tuna comes in forms such as solid pack, chunks, flakes, and grated. Other tuna products include dried and smoked tuna, tuna steaks, tuna burgers, tuna sausage, and tuna roe. Also, animal feed and pet food are produced from the processing waste of tuna canneries (Abdussamad, 2012, 119)

### **Status of Tuna Fishery in India**

Tunas have been exploited along the Indian coast since time immemorial with neritic tunas being the mainstay of the tuna fishery till recently, primarily caught incidentally in various traditional coastal fisheries. Despite being bountiful with some oceanic tuna species, India lacked organised commercial tuna fishing operations for a long time. However, targeted artisanal tuna fisheries exist in Lakshadweep, and some parts of Kerala and Tamil Nadu. In recent years, the tuna fishery has evolved to include coastal-based fleets with varying specifications, utilising different craft-gear combinations and large LOP (line of position) vessels (NFDB, 2013). Tunas are harvested using a variety of fishing gears such as gillnets, longlines, handlines, pole and lines, troll lines, purse seines, ring seines, and even trawls, depending on the fishing grounds and the species targeted (IOTC, 2021). Tunas are in high demand in the domestic market due to their fleshy texture, being sought after both in their fresh form for preparing a variety of delicacies and in salt-dried forms. With the increased production of oceanic tuna,

demand from export markets also picked up. Major markets for Indian tuna include Japan and the US, with exports also going to Sri Lanka, Malaysia, and several Gulf countries (Abdussamad, 2012, 119).

In the Bay of Bengal, the Andaman and Nicobar Islands provide some of the best tuna fishing grounds within the Indian Exclusive Economic Zone (EEZ). However, due to insufficient capacity and weak forward and backward linkages in the Islands, the tuna resources in these waters have largely remained underexploited (NFDB, 2013). In contrast, Lakshadweep has a well-organised targeted fishery for skipjack tuna, utilising pole and lines and troll lines. Along the coast of Kerala, Vizhinjam sees significant local demand for bullet tuna, which are exploited using hand lines, small longlines, and gillnets. In Tuticorin, along the Tamil Nadu coast, traditional fishers target tunas and large pelagic using gillnets, troll lines, and longlines from artisanal crafts. Inspired by the traditional fisher's catches, several trawlers in the 1980s were modified for gillnetting tuna and other large pelagic in deeper waters (Abdussamad, 2012, 112).

### **Lakshadweep and Tuna Fishery**

Lakshadweep archipelago is the only region in India which thrives on a socio cultural and economic platform of a robust tuna fishery. Lakshadweep islands, the smallest Union Territory of India is located approximately 200 to 400 km off the southwestern coast of mainland India. As of the 2019-20 data, Lakshadweep has a total population of 73,183, with a fishing population of 6,518, including 5,138 men and 1,380 women (GOI, 2023). However, the Marine Census of 2016 reports that the marine fisher population, directly or indirectly dependent on fishing, is 27,934, which constitutes as high as 43.32% of the total human population, considering the total population to be 64,473 as per the 2011 Census (CMFRI, 2016). The majority of the population are indigenous Muslims and are classified as Scheduled Tribes. The socio-economic activities in Lakshadweep primarily revolve around fishing and allied activities, tourism, coconut plantation, and the service sector. Lakshadweep has a coastal length of 132 km, 20 landing centres, and 10 fishing villages, highlighting the critical role of fisheries in the local lifestyle (GOI, 2023). Fisheries play a crucial role in the local economy of Lakshadweep, providing a primary source of livelihood for many residents. The region is second only to the Andaman and Nicobar Islands in per capita fish consumption, with an average of 89 kg per person annually (GOI, 2023). The tuna constitutes around 80% of the total annual fish catches of Lakshadweep and it has been the single largest contributor of skipjack tuna species in India (Dhaneesh *et al*, 2011). The production of *Masmin* (dried and processed tuna) is also significant to the local economy.

### **Challenges Faced by Tuna Fisheries in India and Lakshadweep**

The most significant hurdle faced by tuna fishery across the world is the grave challenge of overfishing. Tunas, being one of the apex predators staying on top of the marine food chain, makes it more crucial to conserve their optimal numbers, at a time when some of its species face endangerment. Multinational industrial fleets, particularly large-scale operations, are currently threatening the sustainability of tropical tuna stocks in the Indian Ocean. This issue has become significant enough that the then Indian Union Minister of Fisheries raised concerns about it during a session of the Indian Ocean Tuna Commission (IOTC) in 2023 (Press Trust of India, 2023). Nonetheless, of the many seafood

resources available in the Indian EEZ, the tuna and tuna-like species are the least exploited (NFDB, 2013). Though tuna dominates the world marine finfish trade both in quantity and trade, the contribution from India is negligible compared to neighbouring countries like Sri Lanka and Maldives despite the rich resources in our water (ICAR, 2014). While there may be a limited domestic market for these species, there is an insatiable demand for premium quality tuna in countries such as Japan and China. With the growing market for sashimi grade tuna and tuna loins or steaks, the Indian tunas have considerable prospects (NFDB, 2013). Pillai and Satheeshkumar (2013) identify several critical tuna fishery management issues in the Indian Ocean and India's EEZ. These include the lack of reliable stock status information, inadequate data on tuna migration, and the threat posed by illegal, unregulated, and unreported (IUU) fishing activities. By catch is also a significant concern, along with the lack of accurate catch-statistical data for Indian Ocean countries. In the Indian EEZ, specific issues include insufficient trained workforce for tuna longliners and high-sea purse seiners, investor reluctance due to profitability concerns, and the lack of geo-referenced tuna catch data.

Lakshadweep as the sole region of organised tuna fishery in India offers some solutions to few challenges in terms of exploiting the high tuna stock and endeavouring a sustainable fishing practice of targeted pole and line method<sup>4</sup> (Pillai *et al*, 2018). Lakshadweep, rich in tuna potential and reliant on fisheries for livelihoods, struggles due to inadequate harvest technologies, insufficient infrastructure, the lack of processing facilities and export channels. In contrast, the Maldives, the neighbouring island country, effectively utilises their resources by supporting artisanal fishers with carrier vessels, on-shore processing, and cold storage facilities (ICAR, 2014). There is a lack of comprehensive studies on the sustainable management practices and economic potential of tuna fisheries in India's EEZ, particularly in comparison to more organized regions like Lakshadweep and neighbouring countries such as the Maldives. Addressing these multifaceted issues is essential for the sustainable management of tuna fisheries in the Indian Ocean and within India's EEZ. Comprehensive studies and targeted research on tuna fishery dynamics are crucial for developing effective economic gains and ensuring the long-term sustainability of this valuable resource.

Against this backdrop, this paper aims to achieve the following specific objectives:

1. To analyse the trend of tuna fishing and the fishery varietal diversification among tuna fish species in India, with a specific focus on Lakshadweep.
2. To analyse the significance of Lakshadweep in India's tuna fishery

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<sup>4</sup> Other regions might still engage in tuna fishing but possibly lack the same level of organisation, regulation, or sustainable practices that are highlighted in Lakshadweep. This distinction is important for addressing challenges related to sustainable fishing and efficient exploitation of tuna stocks.

## Methodology

In this paper, the Compound Annual Growth Rate (CAGR) is used to calculate the growth and trends of tuna fishing, and the Composite Entropy Index (CEI) is employed to measure the diversification among tuna species in India and Lakshadweep<sup>5</sup>. The assessment and analysis are primarily based on secondary data accessed from the Department of Fisheries India, and Union Territory of Lakshadweep from 1997-2022, referred from various sources, including FAO's FishStatJ Database<sup>6</sup>, Fisheries Department websites<sup>7</sup> and multiple CMFRI reports<sup>8</sup> and research papers (Koya, Abdul Azeez, Rohit, & Abdussamad, 2021; Indian Council of Agricultural Research, n.d. 2024). Since only total tuna landing data for Lakshadweep till 2019 and multi-species landing statistics from 2004 to 2012 are available, the CAGR and CEI calculations were limited to this respective time period for Lakshadweep<sup>9</sup>.

### Compound Annual Growth Rate<sup>10</sup>

In line with the research conducted by Samal *et al* (2017) and Priyadarshini *et al* (2020), this study first focuses on delineating the growth rates of tuna fish landings in India and Lakshadweep through the application of semi-log linear functions. To measure the growth rate, the Log-Linear Model was used by Gujarati, D. N. (2002). Given that the dependent variable ( $Y_t$ ) of total tuna catch at time  $t$  and  $Y_0$ , the initial value of the tuna catches.

$$Y_t = Y_0(1 + r)^t \mu_t(1)$$

where  $r$  is the compound (i.e., over time) rate of growth of  $Y$ . Taking the natural logarithm of (1), we can write

$$\ln Y_t = \ln Y_0 + t \ln(1 + r)$$

Now, letting

$$\beta_0 = \ln Y_0 \text{ and } \beta_1 = \ln(1 + r)$$

We can rewrite the above as

$$\ln Y_t = \beta_0 + \beta_1 t + \mu_t(2)$$

Therefore,

$$r = (\text{Anti log } \beta_1 - 1) \times 100(3)$$

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<sup>5</sup> The use of Compound Annual Growth Rate (CAGR) and Composite Entropy Index (CEI) is appropriate. Since the CAGR provides a clear measure of long-term growth, smoothing out fluctuations to accurately depict trends in tuna fishing. CEI measures diversity and distribution, capturing the complexity and variability within the fishery. Together, these metrics offer a comprehensive view of both growth and diversity, essential for effective fisheries management and policy-making.

<sup>6</sup> Source Note: <https://www.fao.org/fishery/statistics/software/fishstatj>

<sup>7</sup> Source Note: <https://dof.gov.in/state-fisheries-department-websites>

<sup>8</sup> Source Note: [https://www.cmfri.org.in/cmfri\\_annual\\_reports](https://www.cmfri.org.in/cmfri_annual_reports)

<sup>9</sup> The lack of recent tuna landing data for Lakshadweep may be due to resource constraints, logistical challenges, and policy or administrative hurdles.

<sup>10</sup> CAGR is widely used to measure the mean annual growth rate of an investment over a specified period longer than one year, providing a smoothed rate of return that eliminates the effects of volatility. This is particularly useful in assessing the growth trends of tuna fishery over time.

Using the total tuna landings (catches in tonnes) time series data from 1997 to 2022 for India and up to 2019 for Lakshadweep, regression analysis was carried out to find the relevant intercept and coefficient values to calculate the respective CAGRs.

### Composite Entropy Index<sup>11</sup>

Various methods have been proposed to analyse the concentration (specialisation) or diversification of crops, fishes or activities over time and space. Each method possesses its own limitations and strengths when examining these patterns (Shiyani, 1998). In the context of assessing the extent of tuna species diversification in India and Lakshadweep, in this analysis, CEI is used. The CEI is utilised to examine the nature of tuna species diversification significant to the tuna fisheries in Lakshadweep based on the available data from 2004 to 2012, and 1999 to 2022 for the whole of India<sup>12</sup>. Yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*), kawa kawa (*Euthynnus affinis*), frigate tuna (*Auxisthazard*), bigeye tuna (*Thunnus obesus*), bullet tuna (*Auxisrochei*) and longtail tuna (*Thunnus tonggol*) are the prominent tuna species found in Indian marine landings while recorded tuna catches in Lakshadweep's comprises species like yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*), kawa kawa (*Euthynnus affinis*), frigate tuna (*Auxisthazard*), bullet tuna (*Auxisrochei*) and dogtooth tuna (*Gymnosarda unicolor*).

$$C.E.I = -\left[\sum_{i=1}^N p_i \log p_i\right] \times \left\{1 - \left(\frac{1}{N}\right)\right\} \quad (4)$$

where

$N$ -Total number of tuna species

$p_i$ -Average proportion of the  $i^{th}$  tuna landings in respective marine areas.

The third objective of analysing the significance of Lakshadweep involves a comparative discussion on the growth trend of tuna fishing and the fishery varietal diversification in Lakshadweep with the corresponding statistics in India. Lakshadweep's share of total tuna fishery and particularly skipjack tuna landings will be calculated based on data from the latest "Handbook of Fisheries Statistics". Existing research literature will be referred to highlight the tuna potential, successful sustainable practices, and economic utilization of tuna resources in Lakshadweep.

**Note:** Fish Landings, Catches and Production are used synonymously throughout the study

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<sup>11</sup> CEI is valuable for assessing the diversity and distribution of data, offering insights into the complexity and variability within the tuna fishery dataset. By comparing these methods to existing ones, the study can better justify the choice of these metrics and highlight their significance in understanding the economic and ecological dynamics of tuna fisheries in Lakshadweep.

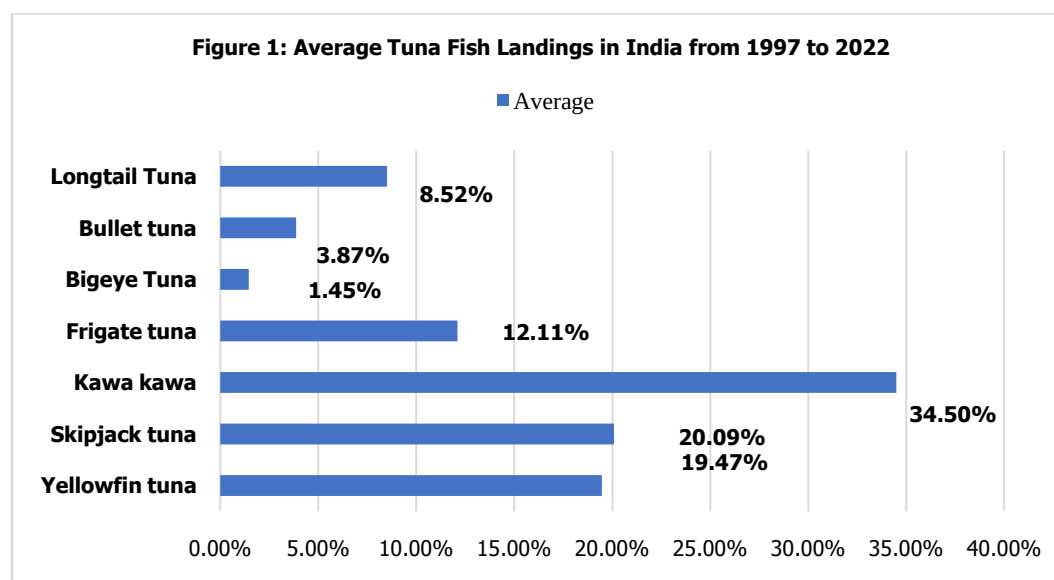
<sup>12</sup> The limitation of using data from 2004–2012 for Lakshadweep's diversification analysis (CEI), while having a longer period (1997–2022) for India, impacts the conclusions of this investigation by potentially skewing the understanding of long-term trends and changes in tuna species diversification in Lakshadweep. This shorter timeframe may not fully capture recent developments, fluctuations, or emerging patterns in the region's tuna fishery. Consequently, the findings might not reflect the current state or future projections accurately, necessitating cautious interpretation. This highlights the importance of continuous and updated data collection to ensure more comprehensive and reliable conclusions.



## Results and Discussion

### Average tuna fish landings in India from 1997 to 2022

As previously discussed, India's tuna fishery has historically been dominated by landings of neritic tuna species. Over the last 25 years, this trend continues, with kawa kawa (little/mackerel tuna) leading the average tuna landings, accounting for 35% of the total from 1997 to 2022.



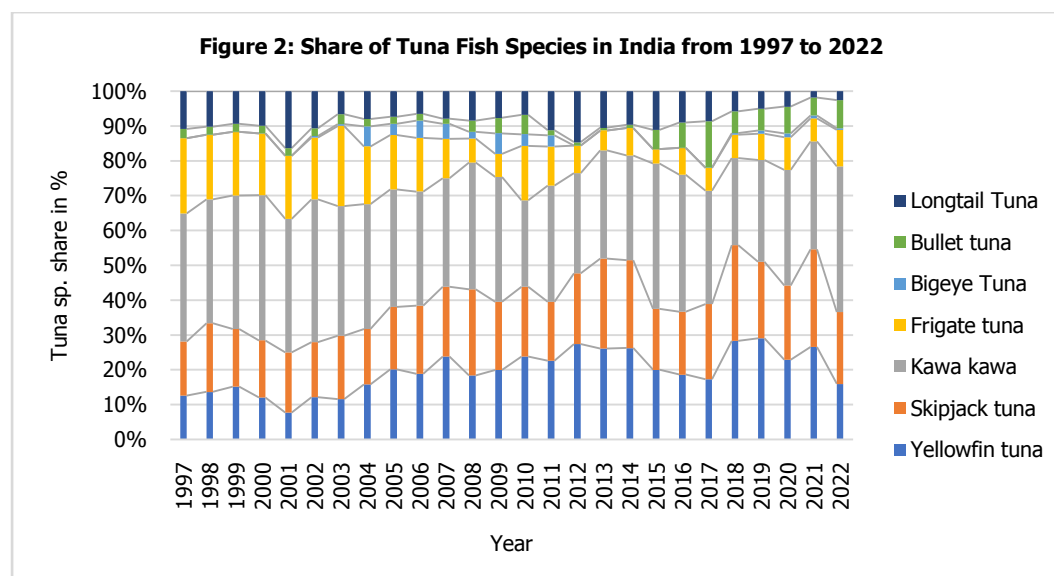
**Source:** Author's calculation based on the data collected from Department of Fisheries, sourced from FishStatJ Database, 2023<sup>13</sup>

However, there has been a noticeable shift towards increased landings of oceanic tuna species during this period, as indicated in Figure 1. skipjack and yellowfin, the two primary oceanic tuna species, follow closely, each contributing approximately 20% (approximately an average of 18000 tons per year) to the total tuna landings in India.

### Share of tuna fish species in India from 1997 to 2022

An analysis of the share of each tuna species in total landings in India from 1997 to 2022 reveals a significant shift towards oceanic tuna species in recent years. Notably, four times in the last decade, the combined catches of oceanic species like skipjack, yellowfin, and bigeye tunas have surpassed 50% of the total, while the neritic tuna share has been largely maintained by kawakawa. This contrasts with the period before 2010, when other neritic species like frigate and longtail tuna also made substantial contributions to the total catch.

<sup>13</sup> <https://www.fao.org/fishery/en/statistics/software/fishstatj>



**Source:** Author's calculation based on the data collected from Department of Fisheries, sourced from FishStatJ Database, 2023<sup>14</sup>

### Growth Trend and Diversification of Tuna Fish Catches in India

The species-wise tuna catches and total tuna landings in India between 1997 and 2022 are given in Appendix 1. The CAGR of all the relevant tuna species for these 25 years is given in the final row along with the CAGR of the total tuna production in India. The CEI is also calculated using equation (4) for each year and provided in the last column of Table 1.

**Table 1: Growth Trend of Tuna Fish Species Landings in India from 1997 to 2022**

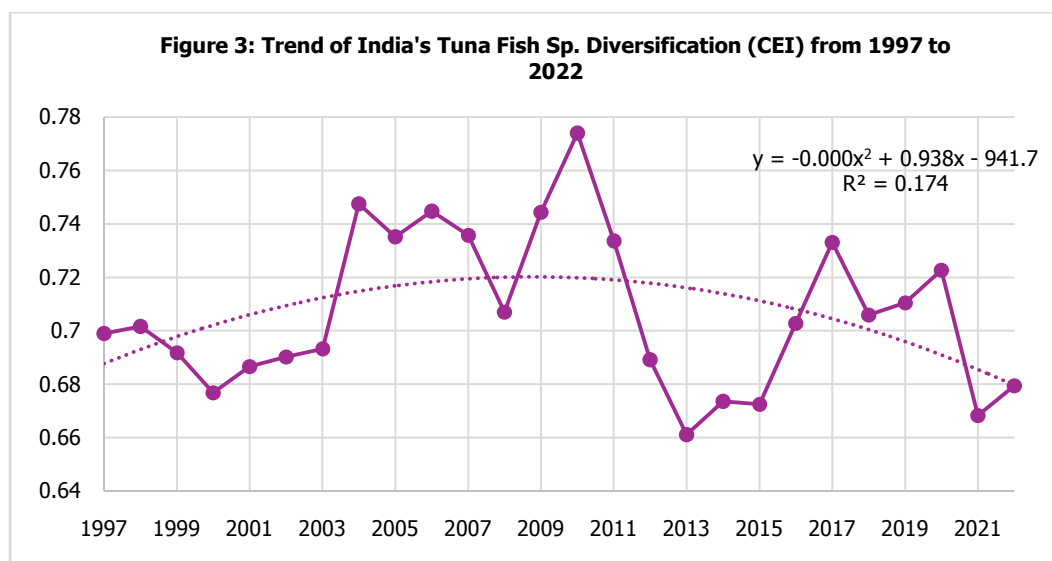
| Particulars | Yellowfin tuna | Skipjack tuna | Kawa kawa | Frigate tuna | Bigeye Tuna         | Bullet tuna | Longtail Tuna       | Total Tuna Landings |
|-------------|----------------|---------------|-----------|--------------|---------------------|-------------|---------------------|---------------------|
| CAGR (in %) | 6.27***        | 4.62***       | 2.37***   | -1.94**      | 21.44 <sup>NS</sup> | 8.19***     | -0.63 <sup>NS</sup> | 3.09***             |

**Note:** \*\*\* indicates 1% significance, \*\* indicates 5% significance and NS for Not significant

**Source:** Author's calculation.

The CAGR is estimated using equations (1) & (2) and calculated as **3.09%** for total tuna catches from 1997 to 2022 in the country with 1% significance. All major tuna species like yellowfin, skipjack, kawakawa and bullet tunas show a positive growth trend aligning to the total tuna catches with only 1% significance. In contrast, frigate and longtail tunas show a negative CAGR, indicating a lesser growth trend over the corresponding years. It has to be noted that frigate tuna's negative CAGR has 5% significance, having a probability value (P. value) of 0.02, while the longtail tuna has no significant CAGR, given its high P. value of 0.60. Bigeye tuna having exceptionally lower number in 1997 to sudden appraisal in landings later (may be due to poor recording), also reveals a high CAGR but with no significance (P. value= 0.19).

<sup>14</sup> <https://www.fao.org/fishery/en/statistics/software/fishstatj>



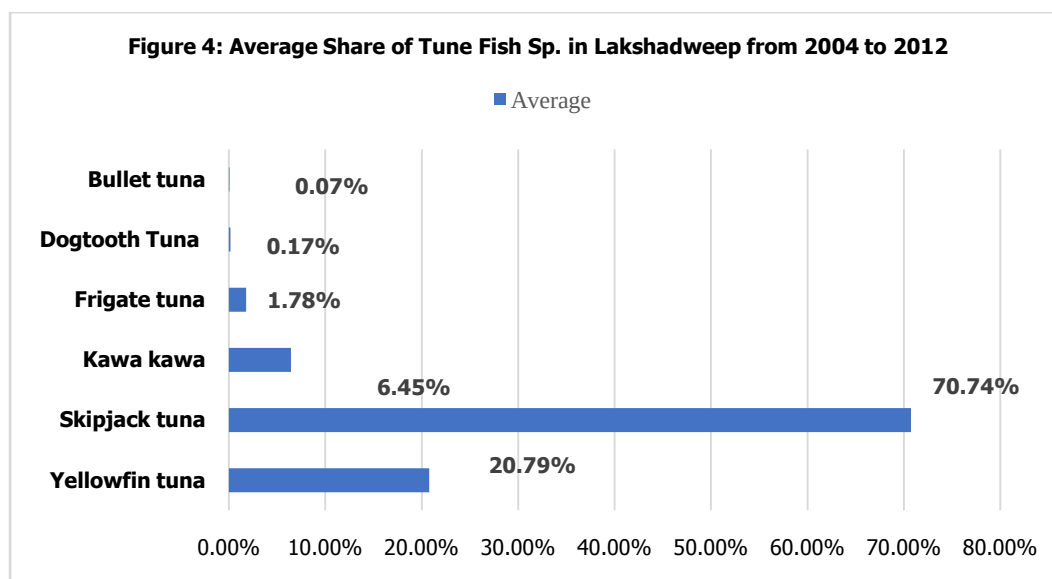
**Source:** Authors' calculation based on the data collected from Department of Fisheries, sourced from FishStatJ Database, 2023<sup>15</sup>

The detailed calculation of tuna fish species diversification (CEI) from 1997 to 2022 is provided in Appendix 2. As evident in Figure 3, the CEI of tuna species in India since 1997 has always been more than 0.65 (lowest in 2013), often reaching as high as 0.77 (in 2010), suggesting a favourable trend of diversification, CEI being closer to 1 than 0. Higher CEI indicates increased diversity in tuna catches and lesser dependence on one or two species. It is good to have an increasing trend of diversification as it enhances resilience against various risks and contributes to sustainable output from tuna fisheries. However, the inverted U-shaped curve (quadratic function) in the graph alarms how the growing diversification started to decline from the midway and fell as low as 0.67 in 2021. The CAGR value being negative for the CEI in this period underlines this concern of decreasing diversification of tuna fish species in the recent years.

### **Average tuna fish species in Lakshadweep from 2004 to 2012**

Lakshadweep tuna fishery is synonymous with the targeted fishing of skipjack tuna. Known as *Mass Choora* in Lakshadweep, the skipjack tuna is selectively fished for making *Massmin*, the dried and processed tuna powder, that forms a major ingredient of most of the food items in the island. Figure 4 shows the average tuna species landings and share of each species across the corresponding period. It reveals the extent to which skipjack tuna dominates Lakshadweep's tuna fishery and how meagre the catches of other species are, except that of yellowfin tuna.

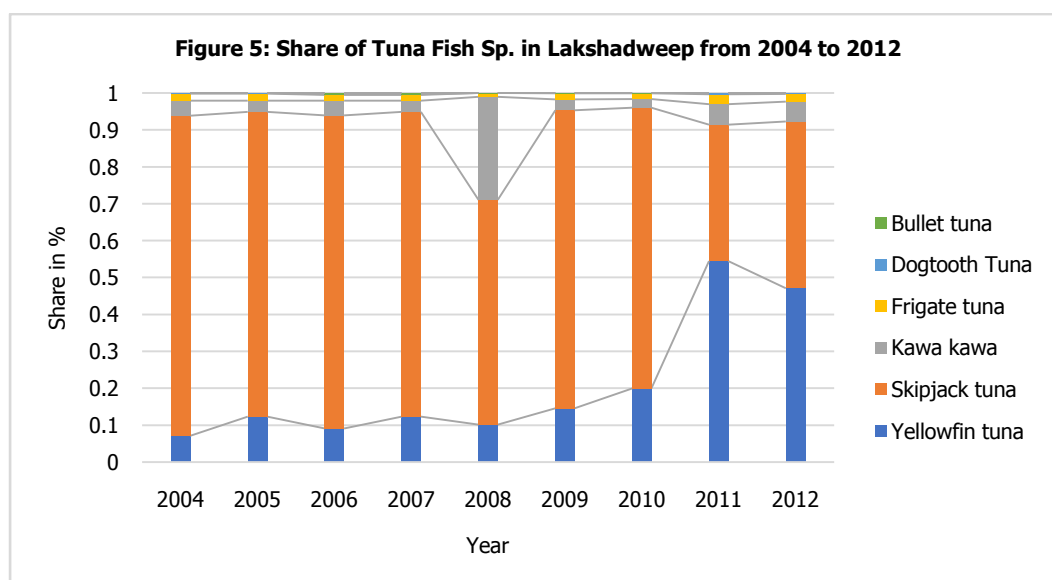
<sup>15</sup> <https://www.fao.org/fishery/en/statistics/software/fishstatj>



**Source:** Authors' calculation based on the data collected from Lakshadweep Fisher's Handbook, ICAR, CMFRI, 2020

### Share of tuna fish species in Lakshadweep from 2004 to 2012

The period between 2004 and 2012 in Lakshadweep's tuna fishing data is important not only to understand the high specialisation of skipjack tuna but also because it shows the rarest occurrence of yellowfin tuna taking over skipjack, as in 2011, while maintaining a strong share even in the next year, as shown in figure 5. This chart also throws light on how negligible the share of neritic tuna landings, including that of kawa kawain Lakshadweep, is compared to those of the Indian mainland.



**Source:** Authors' calculation based on the data collected from Lakshadweep Fisher's Handbook, ICAR, CMFRI, 2020

## Growth Trend and Diversification of Tuna Fish Catches in Lakshadweep

Aligning with the second objective to assess the growth trend of tuna catches in Lakshadweep by calculating CAGR, the required available data from 1997 to 2019 are provided in Appendix 3, and the calculated CAGR result is given below.

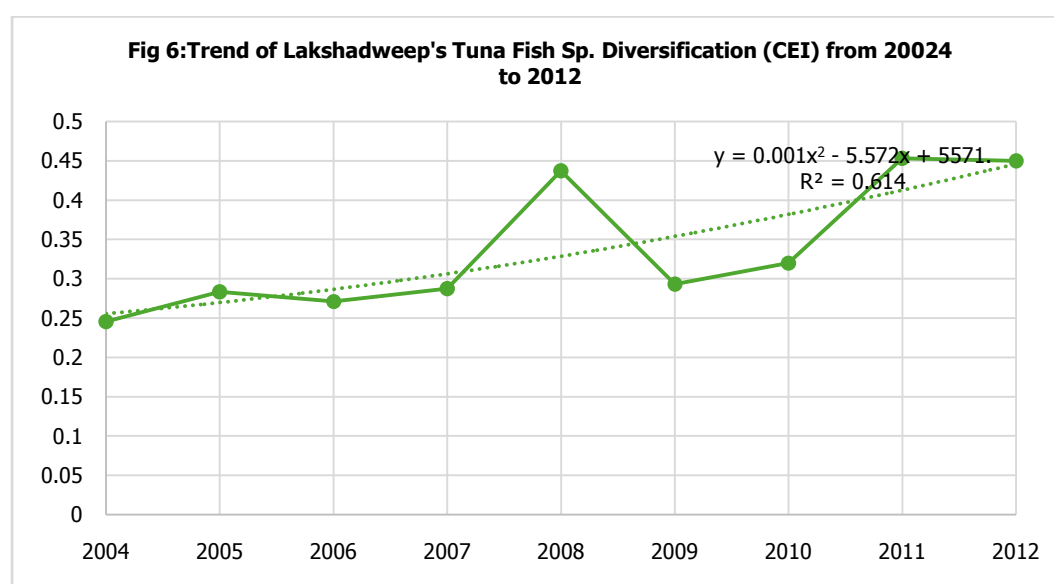
**Table 2: Growth Trend of Tuna Fish Species Landings in Lakshadweep during 1997-2019**

| S.No. | Particulars | Total Tuna Landings in Lakshadweep |
|-------|-------------|------------------------------------|
| 1     | CAGR in %   | 3.80 ***                           |

**Note:** \*\*\* indicates 1% significance

**Source:** Authors' calculation based on the secondary data

The CAGR of tuna catches in Lakshadweep from 1997 to 2019 is 3.80%, implying a positive growth rate. The probability value (P-value) of 0.003 (<0.01) indicates 1% significance. In table in Appendix 4 provides the only available data on species-specific tuna catches and total tuna landings in Lakshadweep, covering the years from 2004 to 2012. The detailed calculation of tuna fish species diversification as the CEI of this period is provided in Appendix 5. The tuna species diversification data calculated using CEI from 2004 to 2012 in Lakshadweep is shown in Figure 6.



**Source:** Authors' calculation based on the secondary data

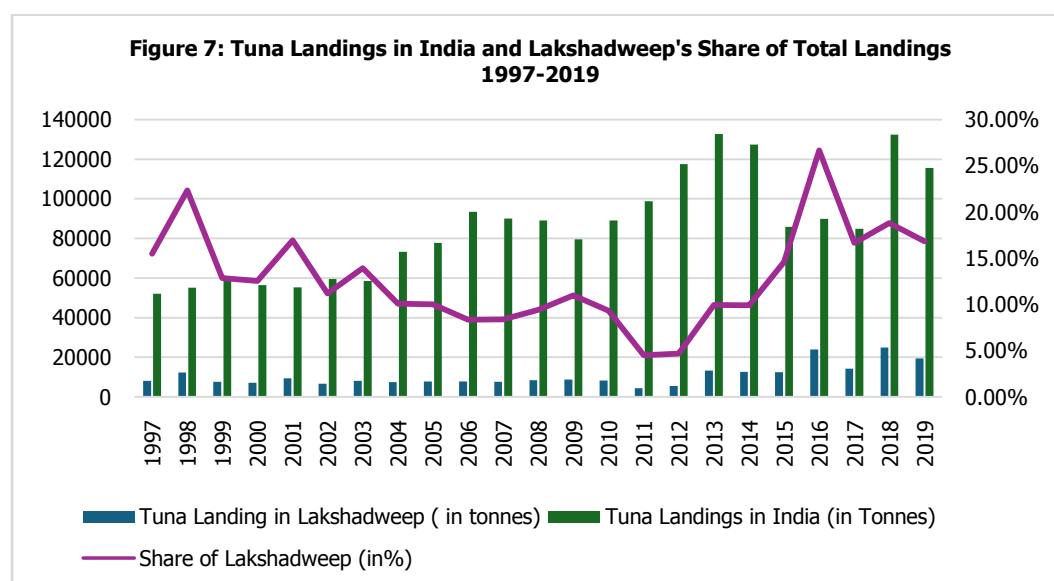
Lakshadweep archipelago is famous for the targeted fishing of the resilient skipjack tuna and is one of the highest contributors of total skipjack tuna landings in India, comprising around 30% in 2022-23 (GOI, 2023). This specialisation in skipjack fishing is the major reason behind the diversification of tuna species always being below 0.5, reaching as low as 0.24 in 2004. Although diversification of fishing practice had been advocated for better resilience of the islands' fisheries sector in view of the species being a highly migratory one whose distribution and movement depends greatly on the oceanic environment and larger oceanic processes, overdependence on skipjack species had been the hallmark

of Lakshadweep's fisheries (Koya *et al*, (2019). However, as seen in Figure 6, from 2009 onwards till 2012-13, the CEI shows a stable increment, especially because of the higher landings of yellowfin tuna. The 7.22% CAGR value for the CEI in these years (see appendix 4) points out the positive trend of diversification in the early years of the last decade.

Koya *et al* (2019) note how a sharp decline in skipjack tuna catch during 2011-13 had turned around the fishermen's attitude in Lakshadweep and how they indigenously developed techniques to harness the yellowfin tuna. Consistent domestic demand for yellowfin tuna generated during this period persuaded scaling up of extant traditional handline fishing for yellowfin tunas with hooked live baits by the rowing and motorised crafts as well as the non-pole and line vessels. Traditionally, this handline fishery was limited to the dusk hours of winter months and conducted mainly by rowing canoes. However, the positive response of yellowfin tuna to chumming in pole-and-line fishing led fishers to experiment with it for handline fishing as well, thereby increasing the tuna species diversity in landings in Lakshadweep, in the early years of the previous decade.

## Significance of Lakshadweep in India's Tuna Fishery

From the discussion so far, it is clear that Lakshadweep holds a prominent space in India's tuna fishery arena. If we compare the growth trends of tuna production, it also underlies this fact. Lakshadweep displays a higher CAGR of 3.80 % against India's 3.09% in the last 20 to 25 years.



**Source:** Authors' calculation based on the secondary data

Figure 7 depicts Lakshadweep's share of total tuna landings in India from 1997 to 2019. It goes as high as 26.6 % in 2016 and maintains an average share of 13% for this corresponding period. However, despite Lakshadweep showing a positive CAGR for its CEI from 2004 to 2012 (see Appendix 4), its diversification value in this period is way too lower than India's tuna fishery varietal diversification in the entire 25 years, implying high level of specialisation. If we check the latest data focusing on skipjack tuna landings, provided in the Handbook of Fisheries Statistics from 2019 to 2023, it is evident

that around 30% of total skipjack tuna catches in India, is contributed by Lakshadweep islands (GOI, 2023).

Skipjack tuna accounts for 57.5% of global tuna production, followed by yellowfin tuna at 27.1% (Abdussamad *et al*, 2012). However, according to a 2014 ICAR report, Lakshadweep's average fishery potential is estimated at approximately 100,000 tons, yet only about 13% of this potential is currently being utilised. This underutilisation is primarily due to the lack of effective research and technological interventions in resource exploitation. The island fishers predominantly rely on traditional pole-and-line fishing, focusing mainly on skipjack tuna. Despite the presence of high-value resources such as large yellowfins, billfishes, carangids, and groupers in significant quantities, these species remain largely untargeted.

Lakshadweep is unique in India as the only region where pole-and-line gear is used, and this acclaimed sustainable fishing method contributed 7.21% to the total tuna and allied resource catches in the country in 2020 (IOTC, 2021). Moreover, Lakshadweep has developed a well-established value chain for tuna products, including smoked and sun-dried tuna loins known as *Masmin*, which is similar to Maldivian fish, as well as packaged tuna cuisines and animal and fish feeds produced in cottage industries.

## **Conclusion and Policy Implication**

With the growing market for high-grade tuna, the Indian tuna fishery holds considerable potential. It is imperative for the Indian government to tap into this economic opportunity while ensuring the sustainability of its tuna stocks.

A significant finding of this study is the overall positive growth trend in Indian tuna fisheries in the last 25 years. The positive growth trend, evidenced by a CAGR of 3.08%, indicates a promising future despite recent dips in production. To address the recent fall out in production, investment in modern infrastructure is crucial. This includes enhancing storage, processing, and export facilities to mitigate post-harvest losses. There should also be strict monitoring on commercial industrial fleet fishing within India's EEZs and the Indian Ocean's proximity zones. Providing training in modern post-harvest handling techniques and sustainable tuna fishing practices can further bolster this sector.

Another major finding is the observed trend towards higher diversification within the Indian tuna fishery, although there has been a recent decline, with CEI dropping to 0.67 in 2021. To counteract this, focus should shift towards targeted fishing of abundant oceanic tunas while avoiding fishing gears that result in significant by catch.

Further analysis revealed a favourable growth trend, specifically in Lakshadweep, with a CAGR of 3.80%. Despite this, Lakshadweep has seen a reduction in total tuna catches in recent years. To sustain and enhance growth, there is a pressing need to develop infrastructure for storage, processing, and export within the region. Encouraging the use of Fish Aggregating Devices (FADs) and continued monitoring of bait fish for pole-and-line method can support sustainable growth.

Another critical finding concerns the low diversification and high specialisation within the tuna fishery in Lakshadweep. The low diversification (CEI always below 0.5) and overdependence on skipjack tuna require immediate attention. Actions should be taken to encourage yellowfin tuna fishing, which

has high estimated potential in Lakshadweep waters. Training in chumming for handline gears and the induction of a new value chain for yellowfin tuna, involving mid-sea collection and transport to mainland markets, can diversify the sector and reduce reliance on a single species. The contrast between Lakshadweep's performance and India's overall diversification trend could be explored more comprehensively, particularly regarding lessons learned and best practices available in those regions. Lakshadweep has shown a favourable growth trend with a CAGR of 3.80%, yet it faces challenges such as low diversification and overdependence on skipjack tuna. In contrast, India's broader tuna fishery has seen higher diversification, although recent declines have been noted. By examining the successful strategies employed in other regions, such as the Maldives' use of pole-and-line fishing and robust infrastructure for processing and export, Lakshadweep can adopt similar practices to enhance its tuna fishery. Specific strategies for promoting species diversification in Lakshadweep while maintaining sustainable practices can be highlighted with suitable success stories and case studies. For instance, encouraging yellowfin tuna fishing, which has high potential in Lakshadweep waters, can reduce reliance on skipjack tuna. Training local fishers in chumming for handline gears and developing a new value chain for yellowfin tuna, involving mid-sea collection and transport to mainland markets, can diversify the sector. Additionally, investing in modern infrastructure for storage, processing, and export, as well as promoting sustainable fishing practices, can ensure long-term growth and sustainability.

The positive growth trend in Indian tuna fisheries and the increased varietal diversification over the past 25 years are encouraging signs. However, significant challenges and concerns persist within the Indian tuna fishery sector. Addressing these issues necessitates a special focus on the Lakshadweep islands, the only region in India with an organized tuna fishery. Lakshadweep has shown a promising growth trend in tuna catches, highlighting the need for diversification in its tuna fishery. The region offers valuable lessons in sustainable fishing practices, particularly through the use of pole-and-line method, and the production of value-added tuna products.

To fully realize the potential of the Indian tuna fishery, it is essential for the government to prioritize investment in storage, processing, and export infrastructure, particularly in Lakshadweep. Policies must promote sustainable fishing practices to prevent the depletion of tuna stocks and protect the ecosystem. Continued research into tuna stock status, migration patterns, and the impact of environmental changes is necessary to inform sustainable management practices. Additionally, supporting and training local fishers in modern post-harvest handling and sustainable practices can enhance economic benefits while preserving traditional methods. Encouraging the development and marketing of value-added tuna products will further increase economic returns and support local livelihoods. By addressing these areas, the Indian government can ensure the sustainable and economically beneficial growth of its tuna fishery, leveraging the unique strengths of regions like Lakshadweep.

### **Specific policy recommendations**

1. **Investment in Infrastructure:** To address the recent decline in tuna production and enhance the growth of the tuna fishery in Lakshadweep, it is crucial to invest in modern infrastructure. This includes developing facilities for storage, processing, and export to mitigate post-harvest losses. By



improving these aspects, the region can better handle and market its tuna, ensuring higher economic returns and reducing wastage.

2. Promotion of Sustainable Fishing Practices: Policies should focus on promoting sustainable fishing practices to prevent the depletion of tuna stocks and protect the ecosystem. This includes encouraging the use of fish aggregating devices (FADs), monitoring bait fish for pole-and-line methods, and training local fishers in modern post-harvest handling techniques. Additionally, diversifying the tuna fishery by encouraging yellowfin tuna fishing can reduce overdependence on skipjack tuna and support long-term sustainability.

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## Appendices

**Appendix 1: Species-wise Tuna Landings (in tons) in India during 1997-2022, CAGR and the CEI**

| Years              | Yellowfin Tuna | Skipjack Tuna | Kawakawa  | Frigate Tuna | Bigeye Tuna         | Bullet Tuna | Longtail Tuna       | Total Tuna Landings | CEI                 |
|--------------------|----------------|---------------|-----------|--------------|---------------------|-------------|---------------------|---------------------|---------------------|
| 1997               | 6,575          | 8,089         | 19,167    | 11,246.93    | 0.0001              | 1,390.07    | 5,659               | 52,127              | 0.699               |
| 1998               | 7,511          | 10,841        | 19,610    | 10,216.31    | 10                  | 1,262.69    | 5,602               | 55,053              | 0.702               |
| 1999               | 8,977          | 9,851         | 22,753    | 10,853.55    | 6                   | 1,341.45    | 5,559               | 59,341              | 0.692               |
| 2000               | 6,769          | 9,280         | 23,516    | 10,002.71    | 3                   | 1,236.29    | 5,603               | 56,410              | 0.677               |
| 2001               | 4,256          | 9,565         | 21,172    | 9,969.78     | 0.0001              | 1,232.22    | 9,040               | 55,235              | 0.687               |
| 2002               | 7,208          | 9,422         | 24,421    | 10,531.37    | 278                 | 1,301.63    | 6,350               | 59,512              | 0.690               |
| 2003               | 6,787          | 10,629        | 21,792    | 13,467       | 304                 | 1,664       | 3,861               | 58,504              | 0.693               |
| 2004               | 11,541         | 11,697        | 26,224    | 12,148.60    | 4,233               | 1,501.40    | 5,870               | 73,215              | 0.747               |
| 2005               | 15,658         | 13,969        | 26,224    | 12,152.91    | 2,509               | 1,551.33    | 5,752               | 77,816              | 0.735               |
| 2006               | 17,579         | 18,373        | 30,606    | 14,395.75    | 4,648               | 1,779.25    | 6,116               | 93,497              | 0.745               |
| 2007               | 21,430         | 18,038        | 28,070    | 10,200.29    | 3,879               | 1,260.71    | 7,154               | 90,032              | 0.736               |
| 2008               | 16,348         | 22,058        | 32,400    | 6,186        | 1,718               | 2,863       | 7,515               | 89,088              | 0.707               |
| 2009               | 15,842         | 15,591        | 28,562    | 5,240        | 4,743               | 3,493       | 6,112               | 79,583              | 0.744               |
| 2010               | 21,214         | 17,804        | 22,098    | 13,912       | 2,989               | 4,910       | 6,092               | 89,019              | 0.774               |
| 2011               | 22,344         | 16,698        | 32,938    | 11,120       | 3,207               | 1,374       | 11,117              | 98,798              | 0.734               |
| 2012               | 32,187.09      | 23,864.78     | 33,839.23 | 9,278.52     | 4.31                | 1,146.47    | 17,237.26           | 117,558             | 0.689               |
| 2013               | 34,617.91      | 34,288.32     | 41,205.53 | 7,689.05     | 0.01                | 950.06      | 13,976.71           | 132,728             | 0.661               |
| 2014               | 33,427.24      | 32,136.10     | 38,321.22 | 10,085.95    | 0.0001              | 1,163.56    | 12,289.71           | 127,424             | 0.674               |
| 2015               | 17,159.39      | 15,054.08     | 35,846    | 3,495        | 3.21                | 4,732       | 9,568               | 85,858              | 0.672               |
| 2016               | 16,722.24      | 16,233.27     | 35,393    | 6,900        | 30                  | 6,505       | 8,090               | 89,874              | 0.703               |
| 2017               | 14,697         | 18,322.1      | 27,680    | 5,499        | 89                  | 11,307      | 7,349               | 84,943              | 0.733               |
| 2018               | 37,488.1       | 36,387.7      | 33,208    | 8,806        | 610.4               | 8,296.8     | 7,678.3             | 132,475             | 0.706               |
| 2019               | 33,553.95      | 25,383.16     | 33,863    | 8,669        | 1,043.64            | 7,242       | 5,852               | 115,607             | 0.710               |
| 2020               | 20,794.73      | 19,385.05     | 30,134    | 8,487        | 1,031.1             | 6,930       | 4,050               | 90,812              | 0.723               |
| 2021               | 24,515.4       | 25,860.87     | 28,628.97 | 6,145.7      | 760.23              | 47,15.22    | 17,07.23            | 92,334              | 0.668               |
| 2022               | 17,248.81      | 22,286.07     | 45,260    | 11,379.9     | 534.88              | 8,731.1     | 2,756               | 108,197             | 0.679               |
| <b>CAGR (in %)</b> | 6.27***        | 4.62***       | 2.37***   | -1.94**      | 21.44 <sup>NS</sup> | 8.19***     | -0.63 <sup>NS</sup> | <b>3.09***</b>      | -0.05 <sup>NS</sup> |

**Note:** \*\*\* indicates 1% significance, \*\* indicates 5% significance and NS for No significance

**Appendix 2: Composite Entropy Index (CEI) of Tuna Species in India from 1997 to 2022**

| Year | $\left[ \sum_{i=1}^N p_i \log_n^{p_i} \right]$ | $\left\{ 1 - \left( \frac{1}{N} \right) \right\}$ | $C.E.I = - \left[ \sum_{i=1}^N p_i \log_n^{p_i} \right] \times \left\{ 1 - \left( \frac{1}{N} \right) \right\}$ |
|------|------------------------------------------------|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| 1997 | -0.81543                                       | 0.857143                                          | 0.698937                                                                                                        |
| 1998 | -0.81848                                       | 0.857143                                          | 0.701552                                                                                                        |
| 1999 | -0.80708                                       | 0.857143                                          | 0.69178                                                                                                         |
| 2000 | -0.78958                                       | 0.857143                                          | 0.676781                                                                                                        |
| 2001 | -0.80106                                       | 0.857143                                          | 0.686624                                                                                                        |
| 2002 | -0.80523                                       | 0.857143                                          | 0.690199                                                                                                        |
| 2003 | -0.80871                                       | 0.857143                                          | 0.693184                                                                                                        |
| 2004 | -0.87202                                       | 0.857143                                          | 0.747444                                                                                                        |
| 2005 | -0.85759                                       | 0.857143                                          | 0.73508                                                                                                         |
| 2006 | -0.86878                                       | 0.857143                                          | 0.744672                                                                                                        |
| 2007 | -0.85839                                       | 0.857143                                          | 0.73576                                                                                                         |
| 2008 | -0.82483                                       | 0.857143                                          | 0.706996                                                                                                        |
| 2009 | -0.86846                                       | 0.857143                                          | 0.744397                                                                                                        |
| 2010 | -0.90289                                       | 0.857143                                          | 0.773905                                                                                                        |
| 2011 | -0.85577                                       | 0.857143                                          | 0.73352                                                                                                         |
| 2012 | -0.80388                                       | 0.857143                                          | 0.68904                                                                                                         |
| 2013 | -0.77122                                       | 0.857143                                          | 0.661046                                                                                                        |
| 2014 | -0.78575                                       | 0.857143                                          | 0.673502                                                                                                        |
| 2015 | -0.78458                                       | 0.857143                                          | 0.672493                                                                                                        |
| 2016 | -0.81994                                       | 0.857143                                          | 0.702805                                                                                                        |
| 2017 | -0.85531                                       | 0.857143                                          | 0.73312                                                                                                         |
| 2018 | -0.82356                                       | 0.857143                                          | 0.705906                                                                                                        |
| 2019 | -0.82886                                       | 0.857143                                          | 0.710455                                                                                                        |
| 2020 | -0.84313                                       | 0.857143                                          | 0.722684                                                                                                        |
| 2021 | -0.77968                                       | 0.857143                                          | 0.668295                                                                                                        |
| 2022 | -0.79267                                       | 0.857143                                          | 0.679433                                                                                                        |

**Appendix 3: Tuna Catches (in tons) in Lakshadweep during 1997-2019 and CAGR**

| Years            | Total Tuna Landings in Lakshadweep |
|------------------|------------------------------------|
| 1997             | 8072                               |
| 1998             | 12299                              |
| 1999             | 7624                               |
| 2000             | 7070                               |
| 2001             | 9343                               |
| 2002             | 6656                               |
| 2003             | 8148                               |
| 2004             | 7364                               |
| 2005             | 7782                               |
| 2006             | 7787                               |
| 2007             | 7551                               |
| 2008             | 8398                               |
| 2009             | 8738                               |
| 2010             | 8274                               |
| 2011             | 4438                               |
| 2012             | 5494                               |
| 2013             | 13225                              |
| 2014             | 12614                              |
| 2015             | 12516                              |
| 2016             | 23959                              |
| 2017             | 14154                              |
| 2018             | 24923                              |
| 2019             | 19444                              |
| <b>CAGR in %</b> | <b>3.80 ***</b>                    |

**Note:** \*\*\* indicates 1% significance

**Appendix 4: Species-wise Tuna Landings (in tons) in Lakshadweep during 2004-2012 and CEI**

| Year | Yellowfin Tuna   | Skipjack Tuna | Kawakawa | Frigate Tuna | Dogtooth Tuna | Bullet Tuna | Total Tuna catches | CEI           |
|------|------------------|---------------|----------|--------------|---------------|-------------|--------------------|---------------|
| 2004 | 523              | 6391          | 295      | 140          | 15            | 0.0001      | 7364               | 0.24541       |
| 2005 | 957              | 6428          | 233      | 148          | 16            | 0.0001      | 7782               | 0.28312       |
| 2006 | 709              | 6603          | 311      | 125          | 16            | 23          | 7787               | 0.2711        |
| 2007 | 929              | 6236          | 227      | 121          | 15            | 23          | 7551               | 0.28715       |
| 2008 | 854              | 5112          | 2343     | 88           | 0.0001        | 1           | 8398               | 0.43701       |
| 2009 | 1272             | 7059          | 259      | 141          | 6             | 1           | 8738               | 0.29293       |
| 2010 | 1650             | 6294          | 192      | 133          | 4             | 1           | 8274               | 0.32003       |
| 2011 | 2419             | 1640          | 245      | 121          | 13            | 0.0001      | 4438               | 0.45293       |
| 2012 | 2588             | 2483          | 294      | 113          | 16            | 0.0001      | 5494               | 0.44979       |
|      | <b>CAGR in %</b> |               |          |              |               |             |                    | <b>7.22**</b> |

**\*\* indicates 5% significance**

**Appendix 5: Composite Entropy Index (CEI) of Tuna Species in Lakshadweep from 2004 to 2012**

| Year | $\left[ \sum_{i=1}^N p_i \log_n^{p_i} \right]$ | $\left\{ 1 - \left( \frac{1}{N} \right) \right\}$ | $C.E.I = - \left[ \sum_{i=1}^N p_i \log_n^{p_i} \right] \times \left\{ 1 - \left( \frac{1}{N} \right) \right\}$ |
|------|------------------------------------------------|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| 2004 | -0.2945                                        | 0.833333                                          | 0.245415                                                                                                        |
| 2005 | -0.33975                                       | 0.833333                                          | 0.283123                                                                                                        |
| 2006 | -0.32532                                       | 0.833333                                          | 0.271104                                                                                                        |
| 2007 | -0.34458                                       | 0.833333                                          | 0.287151                                                                                                        |
| 2008 | -0.52441                                       | 0.833333                                          | 0.437006                                                                                                        |
| 2009 | -0.35151                                       | 0.833333                                          | 0.292929                                                                                                        |
| 2010 | -0.38404                                       | 0.833333                                          | 0.320033                                                                                                        |
| 2011 | -0.54352                                       | 0.833333                                          | 0.452934                                                                                                        |
| 2012 | -0.53975                                       | 0.833333                                          | 0.44979                                                                                                         |

## Recent Working Papers

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