Trend analysis of tropical tuna production in Sri Lanka.

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Abstract

Tropical tuna in Sri Lanka is one of the important sources of income for the country. Hence, it is necessary to monitor the trend of the production to ensure continuous and sustainable utilization of the resources. In this study, the production trend analysis was performed for the three tropical tuna species, yellowfin tuna (*Thunnus albacares* (YFT)), big eye tuna (*Thunnus obesus* (BET)), and skip jack tuna (*Katsuwonus pelamis* (SKJ), using the data obtained from the IOTC database from the years 2000 to 2023. The total Sri Lankan tropical tuna production contribution for total production in the Indian Ocean was 8.5%(YFT), 2.9% (BET) and 10.7% (SKJ). The production trends of the three tropical species were analyzed using the Man-Kendal trend test and Sen's innovative trend analysis. There, local production was divided into two categories: production originated from the exclusive economic zone (EEZ) and beyond the exclusive economic zone (BEEZ). The yellow fin tuna production shows a significant positive trend in EEZ (tau=0.319, p<0.05) while an insignificant positive trend (tau=0.091, p>0.05) for BEEZ. The Big Eye tuna production shows a significant positive trend in both regions (tau=0.304 for EEZ and tau=0.636 for BEEZ, p<0.05). The production of skip jack tuna follows an insignificant positive trend in EEZ (tau=0.217, p>0.05) while an insignificant negative trend (tau= - 0.127, p>0.05) in BEEZ. Also, the analysis was conducted for total Sri Lankan production and production in the Indian Ocean region for three tropical species. An insignificant increase trend was obtained for yellowfin tuna production in Sri Lanka (tau=0.116, p>0.05) and the Indian Ocean region (tau=0.181, p>0.05). In contrast, big-eye tuna shows a significant positive trend in Sri Lanka (tau=0.761, p<0.05) and while significant negative trend in the Indian Ocean region (tau= -0.529, p<0.05). The skip jack tuna production in Sri Lanka follows a significant negative trend (tau=-0.471, p<0.05) while a positive production trend is in the Indian Ocean region (tau= 0.326, p<0.05). The results revealed that the recent management options introduced by the Sri Lankan government as well as the Indian Ocean Tuna Commission have made an impact on tropical tuna production. Further, management measures will help to manage tropical tuna production while ensuring the livelihood of the stake holders.

Introduction

One of the coastal nations in the Indian Ocean, Sri Lanka, has engaged in tuna fishing since ancient times (Dayaratne,& Maldeniya,1995; Miyake,2005) Even though the country consists of different tuna species, the three tropical tuna species, namely yellowfin tuna (*Thunnus albacares* (YFT)), big eye tuna (*Thunnus obesus* (BET)), and skip jack tuna (*Katsuwonus pelamis* (SKJ)), own a great place in the fishery industry due to the high demand in the seafood market (Kawamoto,2022) and local consumption. On the other hand, fish production has been increasing to fulfil the continous high demand, especially since the 2000.

The Sri Lankan marine capture fishery production exhibits several fluctuations after 2000 (Hettiarachchi & Samarawickrama,2014). Specially the technological development caused a gradual increase in production in the initial phase. Hence, identifying the production trend from 2000 to the present will help to imply the actual direction of tropical fish production in Sri Lanka.

Several researchers have identified the Man- Kendal(MK) test (Kendall,1950) and innovative Sens slope(Şen,2012) for finding the fisheries production trend (Dhunganaa et al.,2022; Kale,2020; Saifuddin et al.,2022). Our study can be introduced as the pioneering research work that applies the MK test and Sens' slope method to find the fish production trend of tropical tuna in Sri Lanka.

Methodology

The production data of skip jack tuna, yellowfin, and big eye tuna from 2000 to 2023 were obtained from the IOTC database. Each species' total production was calculated for Sri Lanka and the Indian Ocean region. The production data of the Sri Lankan exclusive economic zone and beyond exclusive economic zone were obtained considering the particular fishing gears operated in the respective areas. The Gill net, coastal longline, coastal ring net, hand line and beach seine harvests were taken into account for the exclusive economic zone (EEZ). The catch data of Offshore gillnet, long line and ring net were considered as the fish production comes from high seas or beyond the exclusive economic zone (BEEZ). The production trend analysis was performed using the Man-Kendal trend test and Innovative Sens's slope. Data were analysis through the R statistical software (V4.1.3; R Core Team 2022)

Results

The total production of the three tropical tuna species, yellowfin tuna (YFT), big eye tuna (BET), and skip jack tuna (SKJ), from Sri Lanka was 2,166,621 MT for the period from 2000 to 2023, which is 8.9% of the total tropical tuna production of the Indian Ocean region. Further, it represents 8.5% of yellowfin tuna (YFT), 2.9% of big eye tuna (BET) and 10.7% of skip jack tuna (SKJ) from a total production of the particular species of the Indian Ocean.
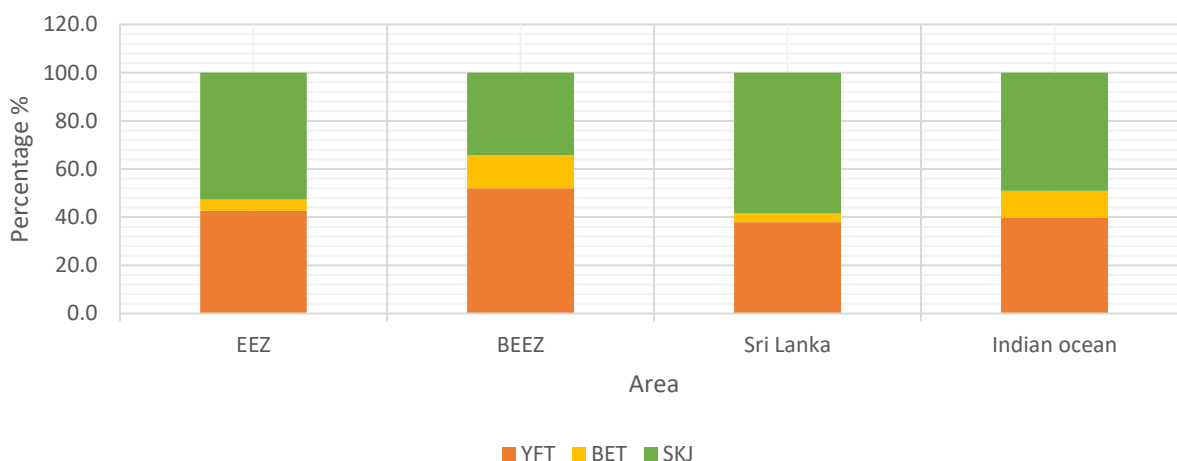

Fig. 1) Percentage of production of tropical tuna species (YFT- yellowfin tuna, BET-Big eye tuna, SKJ- Skip jack tuna) in Sri Lankan EEZ, High sea, Sri Lanka and India ocean from 2000 to 2023.

Skip jack tuna (SKJ) (52.6%) from the EEZ represented the highest percentage fish production, while YFT production (52%) dominated the high-sea tropical tuna production. SKJ dominates the total tropical tuna production by owning a value of 58.5%. The BET production was the lowest in both regions and the whole country. The Indian oceanic region follows the same percentage composition.

The production trend analysis of the EEZ shows a significant positive trend in both YFT and BET production. Even though SKJ production shows a positive trend, it does not show a significant manner. The trend line shows a sudden increment in the tropical tuna production of Sri Lankan exclusive economic zone after 2013. However, more or less, the tropical tuna species followed the same production pattern in EEZ. The Sen's slope values were estimated as 708.51, 53.51 and 714.7 for YFT, BET and SKJ production in the EEZ (Fig.2).
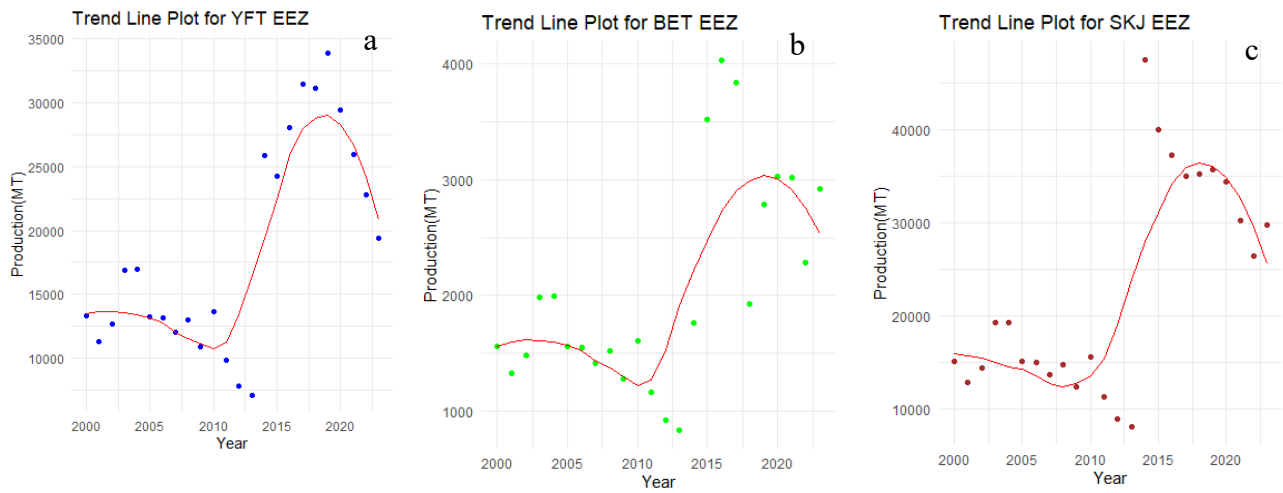
Fig. 2) Production trend of a) yellowfin tuna b)big eye tuna and c) skip jack tuna in exclusive economic zone of Sri Lanka

Only BET production shows a significant positive trend in high-sea tropical tuna production, while YFT production shows an insignificant positive value. Conspicuously, the SKJ production shows an insignificant negative trend. The Sen's slope values of the three species were 59.79, 188.86 and -141.7 for YFT, BET and SKJ, respectively (Fig.3).
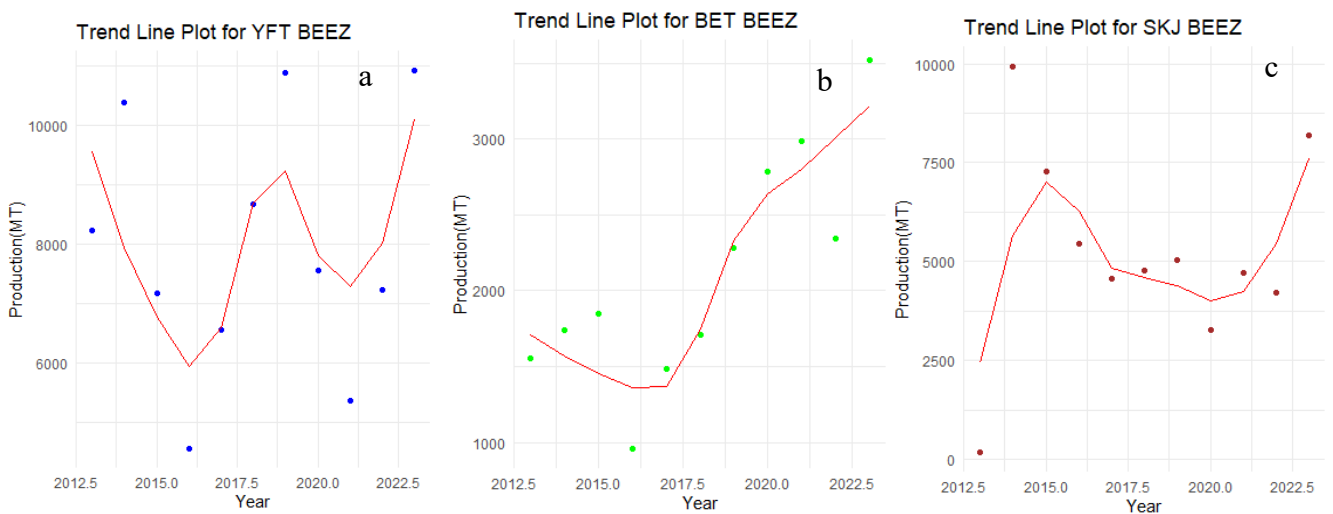

Fig. 3) Production trend of a) yellowfin tuna b) big eye tuna and c) skip jack tuna in beyond exclusive economic zone of Sri Lanka

Considering the total tropical tuna production for Sri Lanka, YFT shows an insignificant positive trend. The BET production shows a significant positive trend, while SKJ shows a significant negative production trend. The Sen's slope values for the Sri Lankan tropical tuna production were 129.35, 207.31 and – 1090.12 for YFT, BET and SKJ, respectively(Fig.4).
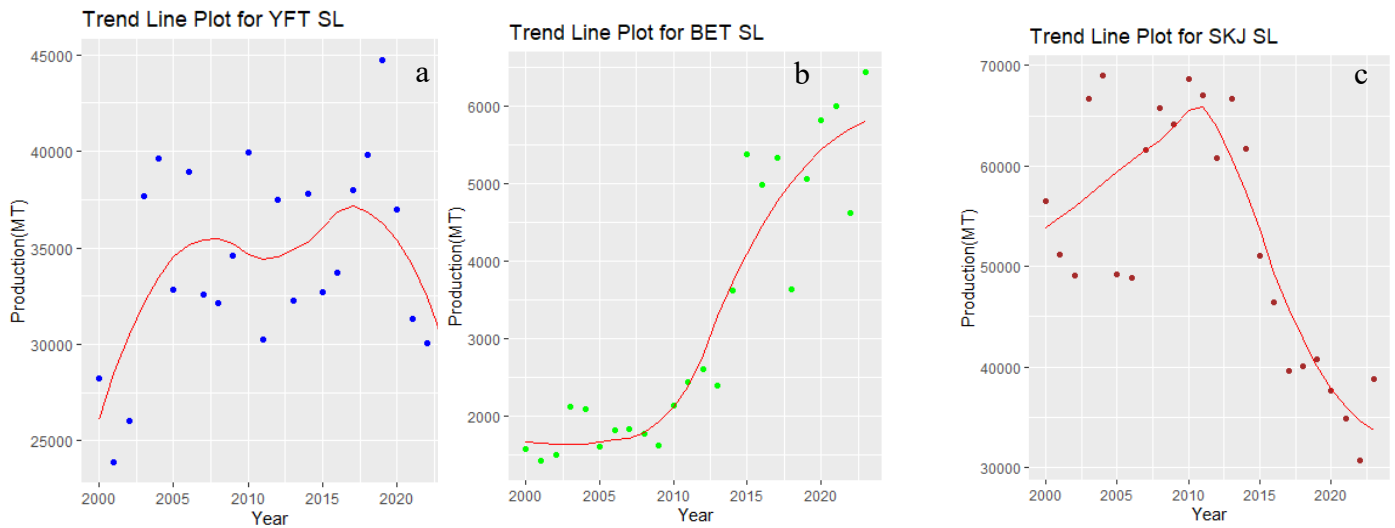

Fig. 4) Production trend of a) yellowfin tuna b) big eye tuna and c) skip jack tuna in Sri Lanka

When moving to the total tropical tuna production of the Indian oceanic region, both YFT and SKJ show a positive production trend, but only the SKJ shows a significant increase trend. The BET production implies a significant negative trend with -2620.42 Sen's slope value. The Sen's slope values for YFT production were 3135.79 and -2620.42 for BET production (Fig. 5).
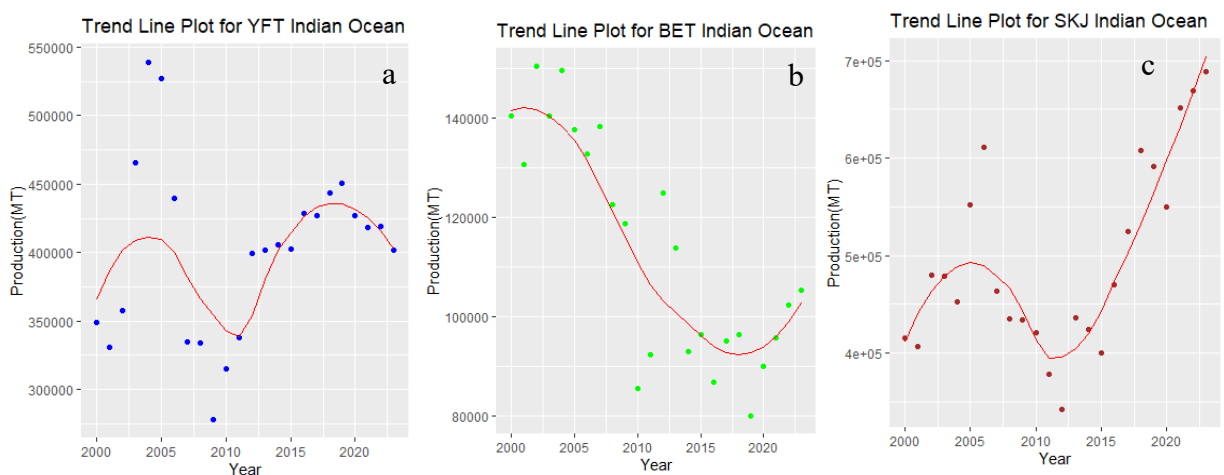

Fig. 5) Production trend of a) yellowfin tuna b) big eye tuna and c) skip jack tuna in the Indian oceanic region.

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Table.1. Values of trend analysis of tropical tuna production in different regions

AREA	ANALYSIS	YFT	BET	SKJ
EEZ	Kendal tau value	0.319	0.304	0.217
	P value	0.031	0.040	0.143
	Sens slope	708.51	53.51	714.7
	Trend	↑	↑	↑
BEEZ	Kendal tau value	0.0909	0.636	-0.127
	P value	0.756	0.008	0.640
	Sens slope	59.79	188.86	-141.7
	Trend	↑	↑	↓
SRI LANKA	Kendal tau value	0.116	0.761	-0.471
	P value	0.442	0.000	0.001
	Sens slope	129.35	207.31	-1099.12
	Trend	↑	↑	↓
INDIAN OCEAN	Kendal tau value	0.181	-0.529	0.326
	P value	0.224	0.000	0.027
	Sens slope	3135.79	-2620.42	7800.925
	Trend	↑	↓	↑

↑ significant positive trend   ↑ insignificant positive trend

↓ significant negative trend   ↓ insignificant negative trend

Discussion

The tropical tuna production of Sri Lanka is vital as it contributes to the national economic growth through the export market. Hence, the production trend analysis of the three tropical tuna species, yellowfin tuna (*Thunnus albacares* (YFT)), big eye tuna (*Thunnus obesus* (BET)), and skip jack tuna (*Katsuwonus pelamis*(SKJ), gives an insightful message on fishery resource management. Our research findings reveal that the three species show different production trends related to the fishing areas even though their percentage contributions are in the same pattern.

The yellowfin tuna, one of the prominent tuna species in the world, shows a growing production trend in Sri Lanka and the Indian Oceanic region. Due to the high demand for the YFT in the food trade, this growing trend has occurred and continued. As the YFT in the Indian Ocean is in a dire state (Heidrich et al.,2023), all IOTC member country needs to focus more on the

management of the resource, not only by applying the legislation but also by monitoring the resources in a collaborative manner. Even though Sri Lanka shows a significant positive trend, the magnitude of the trend is low. Also, the recent IOTC resolution has made a noticeable reduction in the YFT production in the country, which implies a downward trend line starting from 2018. However, Sri Lanka needs to focus more on managing the YFT resources from its economic zone to ensure the fishermen's livelihood, as many local fishers depend on YFT production.

Moreover, our research findings show significant positive trends in BET production in both exclusive economic zone and high seas. The BET forecasting program can have a positive influence on production. On the other hand, introducing YFT catch limitations can positively affect BET production in Sri Lanka. As YFT is declining, the BET can be moved to the shallow water column in the oceanic habitat (Humphries et al.,2024; Pecoraro et al.,2017) , which can be a reason for higher production around Sri Lanka. However, overall BET production in the Indian Ocean has declined due to the piracy activities in the western Indian Ocean (Pillai and Satheeshkumar, 2012).

In Sri Lanka, the SKJ tuna production trend has dramatically declined, while Indian Ocean SKJ production has a conspicuous growing trend. The main reason for the SKJ reduction in Sri Lanka can be the introduction of the limitations for gill net operations. However, we emphasize the necessity of finding stock status and the distribution of the SKJ in the Indian Ocean to make concrete decisions on tropical tuna management in the region.

The Sri Lankan government has introduced several regulations in accordance with IOTC resolutions to manage the tuna resources including reducing the number of new license issues for the IMUL boats and also, they are prohibiting the new license issuing for the ring nets and promoted long lines instead.

Further, the three species' production variabilities can be bound with other environmental factors, such as ocean pollution and deviation of migration patterns due to climate change (Dueri, 2017; Wei et al. and An Lee, 2013).

Through this study, we wish to emphasize the further tropical tuna fishery management in Sri Lanka and the Indian Ocean region by taking management strategies and policies and encouraging collaborative research while ensuring the livelihood of the fisher's population.

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