Spatial Dynamics of Yellowfin Tuna (*Thunnus albacares*) in the Indian EEZ (1990–2020): Center of Gravity (CoG) and Hotspot Analysis

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Introduction

Yellowfin Tuna (YFT) is a premier pelagic species in the Indian Ocean, vital for both commercial fisheries and regional food security.

The Problem: Climate-driven changes in oceanographic conditions impact the distribution and accessibility of tuna stocks within the Indian Exclusive Economic Zone (EEZ).

Objective: To quantify decadal shifts in the centre of gravity (CoG) and identify persistent abundance hotspots using 31 years of longline survey data.

Materials & Methods

Data Source: Longline survey data from the Fishery Survey of India (1990–2020), covering the Indian EEZ.

Modeling: Generalized additive models (GAMs) were used to predict abundance (hooking rates) as a function of environmental predictors.

Spatial Metrics:

- **CoG:** calculated as the abundance-weighted mean spatial position
- **Hotspot Analysis:** defined as grid cells within the top 10% of predicted abundance values

Covariates: Analysis integrated **Sea surface temperature (SST), chlorophyll-a, salinity,** and the **Indian Ocean Dipole (IOD).**

Results and Discussion

Centre of Gravity (CoG) Shifts

Mean Position: The population core averaged at **14.8˚N** and **81.1˚E** *(Figs. 1 – 2)*

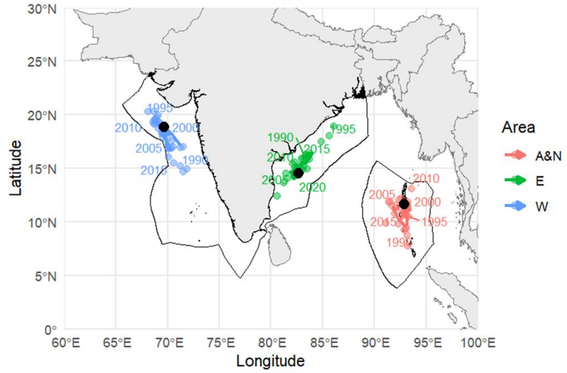

Figure 1. Annual CoG movement trajectories

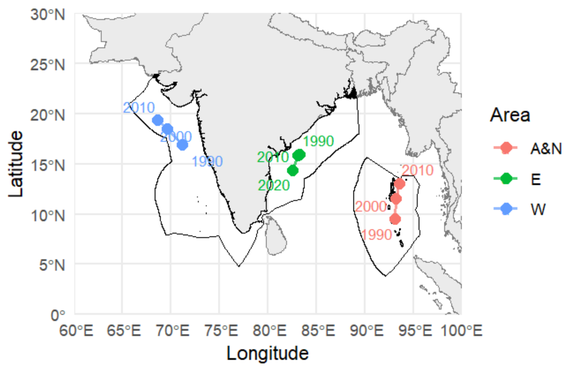

Figure 2. Decadal CoG shifts

Latitudinal trend: A significant **northward shift** was observed from 1990 to the late 2000s.

Longitudinal trend: A notable **westward displacement** occurred during the early 2000s.

Regional Variation: The Bay of Bengal showed the highest variability, whereas the Arabian Sea and Andaman regions remained geographically stable.

Results and Discussion (continued)

Hotspot Identification

Seasonality: The **Southwest (SW) Monsoon** exhibited the highest abundance (0.768 ± 0.586 SD), with hotspots intensifying in the eastern and northwestern sectors *(Fig. 3).*

Environmental Drivers

Thermal Window: Optimal abundance was linked to SSTs between **24–26˚C**.

Productivity: Higher chlorophyll-a concentrations and **lower salinity (associated with frontal zones)** were positively correlated with hotspot formation.

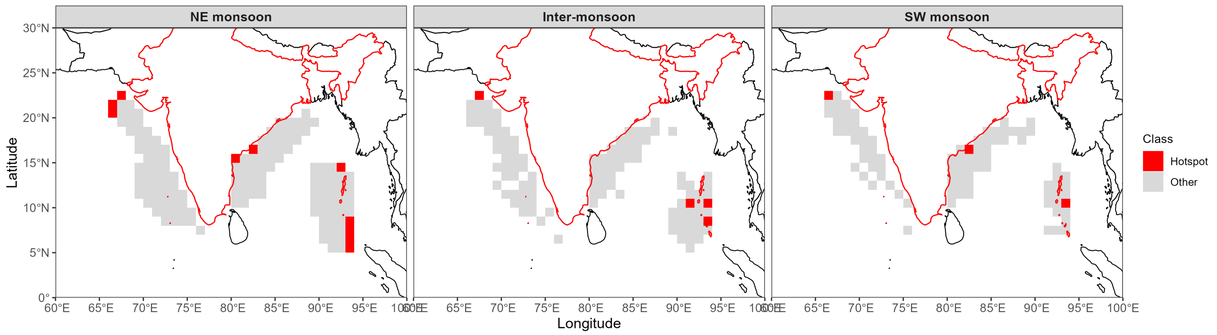

Figure 3. Seasonal Hotspots during 1990-2020.

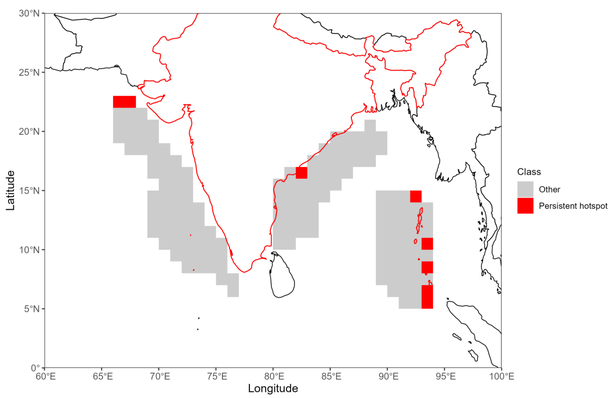

Figure 4. Persistent Hotspots during 1990-2020

Primary Zones: Three permanent hotspots were identified: the **Andaman Sea** (92–94˚E), the **Northwestern Arabian Sea** (66–68˚E), and the **central-eastern Bay of Bengal** (82–83˚E).

Conclusion

The YFT population in the Indian EEZ has undergone **significant spatial reorganization** over the past three decades, characterized by a general northward and westward shift.

The Andaman Sea remains the most critical and stable habitat for YFT throughout the year.

These spatial insights are essential for adaptive fisheries management and for developing **climate-resilient harvesting strategies** in the Indian Ocean.

References & Acknowledgements

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