THE UNITED REPUBLIC OF TANZANIA

THE STATE OF TUNA STOCKS IN THE UNITED REPUBLIC OF TANZANIA

Yellowfin, Bigeye & Skipjack Tunas

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CONTRIBUTIONS AND COORDINATION

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FOREWORD

The sustainable management of marine resources is a cornerstone of the United Republic of Tanzania (URT)'s Blue Economy Policy, serving as a critical driver for achieving both economic prosperity and upper middle-income status by 2050. Tuna, as a highly migratory and economically important group of fish species in the tropical Western Indian Ocean (WIO), presents both opportunities and complex management challenges in region. This second annual stock assessment report, focusing on bigeye, yellowfin, and skipjack tuna, demonstrates strong commitments of both mainland Tanzania and Zanzibar governments to harnessing scientific knowledge for the management of these valuable resources. Through the annual fish stock status and assessments, the URT is building the knowledge base necessary for sustainable fisheries management, which is a critical requirement for ensuring (1) long-term food security; (2) sustainable coastal livelihoods; and (3) optimum economic benefits from the marine resources.

Key findings from this year's tuna stock status assessment, that is the biological and exploitation reference points and stock status, offer a critical evidence base for informed decision-making by government agencies, industry, stakeholders, and the coastal communities regarding the exploitation of bigeye, yellowfin and skipjack tuna.

The collaborative efforts of our national research and academic institutions in developing this comprehensive report deserves special recognition. The synergy between the Tanzania Fisheries Research Institute (TAFIRI), the Zanzibar Fisheries and Marine Resources Research Institute (ZAFIRI), the Deep Sea Fishing Authority (DSFA), and the Nelson Mandela African Institution of Science and Technology (NM-AIST) exemplifies the integrated approach required to address the multifaceted nature of fisheries management in the country. As we navigate the path towards realizing the full potential of our blue economy, reports such as this serve as indispensable tools. They empower both Mainland Tanzania and Zanzibar governments to make strategic choices, implement adaptive management measures, and ensure that the exploitation of tuna resources in the URT is both profitable and sustainable. It is with great optimism that we present this report, confident that it will contribute significantly to the ongoing efforts by both mainland Tanzania and Zanzibar governments to build a vibrant, resilient, and equitably beneficial fisheries sector in the URT.

Dr. Ismael Kimirei
Director General

EXECUTIVE SUMMARY

Annual fish stock assessments are essential for monitoring the trends of the tuna fishery by defining the catch, stock status, and sustainable exploitation levels. Supported by the government, the TAFIRI, in partnership with ZAFIRI and DSFA, initiated a continuous program of annual stock assessments for tuna and tuna-like species in 2024. This is a second annual stock assessment report in a series, following the initial assessment report released in 2024. It provides information on the stock status for bigeye, yellowfin, and skipjack tuna in the URT for the year 2025. The report provides an evidence base for sustainable management of these valuable marine resources. Data for the current assessment were drawn from both neritic (coastal) and Exclusive Economic Zone (EEZ) waters, combining information from artisanal and industrial fishing to capture a comprehensive view of the tuna populations in marine waters of the URT, including juvenile and adult stages. The Length-Based Spawning Potential Ratio (LBSPR) model, a method appropriate for data-limited situations, was employed to estimate key biological reference points (including, length at 50% maturity - L_{50}, asymptotic length SSB_0, growth coefficient - K) and exploitation status (including Spawning Potential Ratio - SPR, fishing mortality relative to natural mortality - F/M) for Bigeye, Yellowfin, and Skipjack tuna.

Key findings indicate that the annual yields are 927,723 metric tonnes for yellowfin tuna, 385,950 metric tonnes for bigeye tuna, and 103,289 metric tonnes for skipjack tuna. All species have SPRs below the target reference point of 0.40. Yellowfin tuna is of greatest concern (SPR 0.29), classified as likely overfished. Skipjack and bigeye tuna (both with SPR 0.33) are below optimal levels, approaching a state that could lead to overfishing if current pressures continue or management is not effective. The report details specific biological parameters and exploitation rates, offering insights into the current stocks of bigeye, yellowfin, and skipjack tuna. There is consistent pattern of growth overfishing across all three species, where the length at 50% selectivity (SL_{50}) is significantly lower than the length at 50% maturity (L_{50}). This indicates that a substantial portion of the catch consists of immature fish, particularly acute for yellowfin tuna, undermining the reproductive potential of the stocks.

While this assessment provides reliable scientific information, ongoing challenges related to data comprehensiveness and consistency persist. The findings call for the continued and enhanced data collection, particularly from the EEZ, and regular stock assessments to adapt management strategies to changing environmental conditions and fishing pressures. The findings in this report will be complemented by the results of the ship-based survey (a fisheries-independent method) that is currently scheduled for October 18th to 30th, 2025.

This report provides an essential scientific basis for the Deep Sea Fishing Authority (DSFA), which is mandated with overseeing deep-sea fisheries management in the URT, and other relevant entities to make informed policy and management decisions. The recommendations derived from these findings aim to ensure the long-term sustainability of tuna fishery in the URT, supporting national development goals and the realization of the blue economy.

ACKNOWLEDGEMENT

This work was generously funded by the government of the URT through European Union Budget Support under the Blue Economy component. This funding for annual tuna stock assessments underscores the commitment of both the mainland Tanzania and Zanzibar governments to implementing their blue economy policies and achieving their respective national development visions for 2050. This second annual stock assessment report is a result of collaborative efforts among four key government institutions: the TAFIRI, the ZAFIRI, the DSFA, and the NM-AIST.

TAFIRI, mandated with overseeing fisheries and aquaculture research in mainland Tanzania, is entrusted with leading these efforts and providing crucial data and technical expertise. ZAFIRI, mandated for fisheries and marine resources research in Zanzibar, is recognized for its supportive initiatives and technical contributions. The DSFA, which is mandated to oversee fisheries management in the Exclusive Economic Zone (EEZ), is commended for its invaluable technical input and unwavering support in providing the necessary data. Finally, special recognition is extended to NM-AIST for their significant technical contributions to the report, particularly through their technical capacity in data processing, analysis, and modeling, which generated key findings on biological and exploitation reference points and stock status.

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ABBREVIATION

DSFA — Deep Sea Fishing Authority

EEZ — Exclusive Economic Zone

K — Growth Coefficient

LBSPR — Length-Based Spawning Potential Ratio

L50 — Length at 50% Maturity

L95 — Length at 95% Maturity

Lin — Asymptotic Length

MK — Ratio of Natural Mortality to Growth Coefficient

NM-AIST — Nelson Mandela African Institution of Science and Technology

NOAA — National Oceanic and Atmospheric Administration

SL50 — Selection Length at 50%

SL95 — Selection Length at 95%

SPR — Spawning Potential Ratio

SSB — Spawning Stock Biomass

SSB0 — Unfished Spawning Stock Biomass

t50 — Time at 50% Maturity

t95 — Time at 95% Maturity

TAFIRI — Tanzania Fisheries Research Institute

URT — United Republic of Tanzania

Yield — The total weight of fish harvestable

YPR — Yield Per Recruit

Z — Total Mortality Rate

ZAFIRI — Zanzibar Fisheries and Marine Resources Research Institute

1. INTRODUCTION

Tuna fishery is a cornerstone of Tanzania's blue economy, but a lack of scientific data impedes its sustainable management. This report addresses this by providing updated 2024 stock assessments for bigeye and yellowfin tuna and the first-ever assessment for skipjack, offering crucial evidence to guide policy and ensure long-term sustainability.

Photo Credit: Mwita Mangora

1.1. BACKGROUND

The fisheries sector is identified as a strategic priority in Tanzania's Vision 2050 (URT) and Zanzibar's Development Vision 2050 (RGoZ, 2050). It is recognized for its enormous potential to drive economic growth and support the United Republic of Tanzania's (URT) goal of achieving upper-middle-income status by 2050. This sector contributes to food security and socio-economic development by providing employment to over 6 million people, generating TZS 56.07 billion in revenue (Mainland Tanzania), and supplying 30% of the nation's animal protein (MBEF, 2025). Furthermore, it contributes to foreign exchange earnings, thereby contributing to the nation's overall prosperity (URT, 2022).

The URT's territory is approximately 36% water, comprising 61,500 km² of freshwater bodies, 64,000 km² of coastal waters, and an extensive 223,000 km² Exclusive Economic Zone (EEZ). These waters sustain a fisheries sector dominated by artisanal fishing, which contributes 95% of national production, while industrial fishing accounts for just 5% (URT, 2022, Fisheries Master Plan). Notably, despite marine waters covering ~30% of URT's territory, marine fisheries contribute less than 15% of total annual catches, with freshwater systems producing over 85% (URT, 2022). This disparity underscores the underdevelopment of marine fisheries and inefficient utilization of their economic potential. To address this, both Mainland Tanzania and Zanzibar are implementing blue economy policies to formalize the sector as a key driver of employment and poverty reduction (URT, 2024, 2022).

Bigeye, yellowfin, and skipjack tuna rank among the most economically valuable marine resources in URT waters, harvested by domestic and distant-water fleets (Igulu and al., 2013). Their high global demand commands premium prices, making them critical for revenue generation (Guillotreau and al., 2017). However, sustainable management remains hindered by knowledge gaps, particularly regarding total annual catches, stock status, and biological and exploitation reference points (TAFIRI, 2024). The absence of such information not only impedes effective management of the tuna fishery but also elevates investment risks, discouraging local participation in this fishery. To address this gap, TAFIRI, in collaboration with ZAFIRI and DSFA, launched an annual stock assessment programme in 2024 targeting tuna and tuna-like species in URT marine waters.

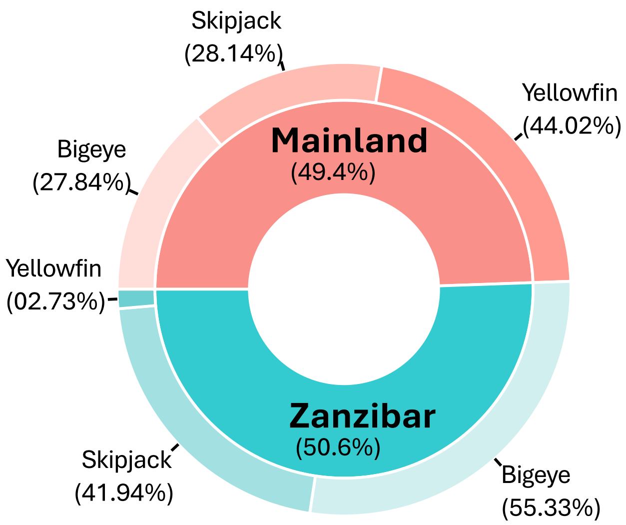

Figure 1.1: Nested frequencies of sampled tuna and tuna like species by locations and species

The first annual Stock Assessment Report (2024) established important information on the available stocks, and biological and exploitation reference points of bigeye and yellowfin tuna in URT waters in the year 2023, derived using data-poor methods. Key findings revealed substantial maximum sustainable yields (1.03 million metric tonnes for bigeye; 530,640 metric tonnes for yellowfin), indicating significant economic potential. However, a critical sustainability concern emerged: most harvested bigeye and yellowfin were caught before reaching maturity (Figure 1.1). While this assessment marks progress, annual updates are essential to track stock fluctuations influenced by productivity, fishing pressure, and migratory patterns (Marsac, 2017). Additionally, assessments must expand to include other commercially important, yet unassessed, species. The current assessment estimates biological and exploitation reference points as well as current stock of bigeye and yellowfin tuna for the year 2024. It also provides for the first-time stock for skipjack tuna, which was covered in the previous report.

Photo Credit: Baraka Kuguru

1.2. TUNA FISHERIES

Tuna fisheries in the URT are composed of two distinct categories: artisanal and industrial. The artisanal fishery operates mainly within territorial waters (<200 m depth), targeting species like frigate tuna (*Auxis thazard*), yellowfin tuna (Thunnus albacares), skipjack tuna (*Katsuwonus pelamis*), and bigeye tuna (*Thunnus obesus*) using a variety of gears. As shown in Table 1.1, there is considerable overlap in the gear used. Handlines and longlines are used to catch bigeye, yellowfin and skipjack tuna, while ring nets and shark nets are also used for yellowfin and skipjack. Bigeye tuna is notably not caught with ring nets or shark nets in this fishery.

Table 1.1: Fishing gears used by tuna species

Tuna	Fishing gears
Bigeye	Ringnet, Handline, Longline, Other gears
Skipjack	Ringnet, Handline
Yellowfin	Handline, Ringnet, Longline

The monthly catches of tuna in artisanal fisheries have bimodal patterns with two distinct peaks. The first peak occurs in February/March during the northeast (NE) monsoon season, while the second peak is observed in June-July during the southeast (SE) monsoon season (Figure 1.2). Conversely, skipjack catches seasonal peaks are unclear because are typically caught throughout the year.

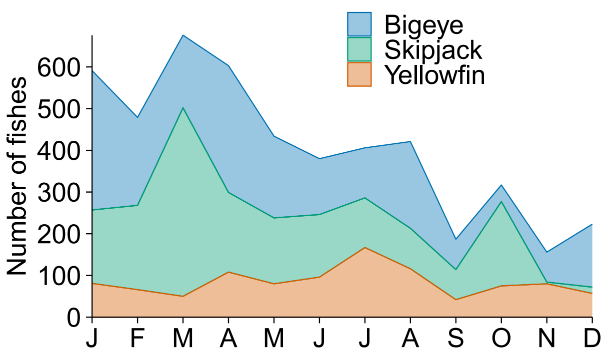

Figure 1.2: Area plot of monthly frequencies of selected tuna species

On the other hand, the industrial tuna fisheries operate primarily within the EEZ by distant water fishing nations' fleets. The two most widely used fishing gears in this category are larges-cale longlines and purse seines. Purse seines operate throughout the year, while longlines are predominantly used during the northeast monsoon, from October to March. The spatial distribution of fishing intensity, combining both longline and purse seine effort, within the EEZ waters of the URT is illustrated in Figure 1.3. This figure delineates distinct zones: hotspot1 areas characterized by high level of fishing effort. Essentially, these are areas with significantly high fishing effort clustered together (High-High); coldspots are areas characterized by low fishing effort. These represent statistically significant clusters of minimal fishing activity (Low-Low); and regions where fishing intensity does not show a statistically significant spatial pattern.

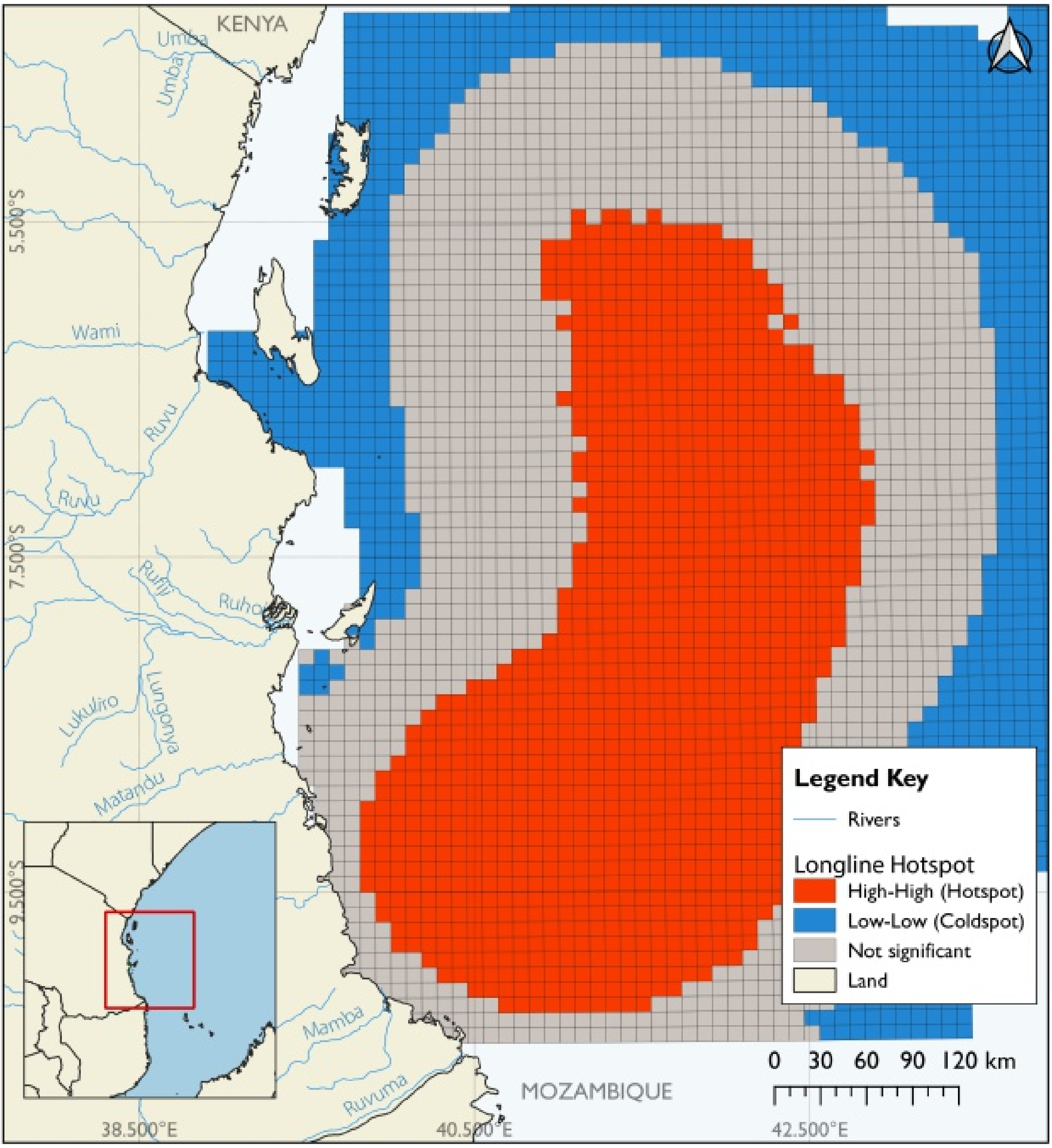

Figure 1.3: Fishing intensity from industrial tuna fishing in the EEZ water of the URT.

1.3. GOVERNANCE

The governance of marine fisheries in the URT is structured according to its unique political union between mainland Tanzania and Zanzibar. Management responsibilities are divided based on maritime zones. The territorial waters, extending 12 nautical miles from the coast, are managed separately: the Ministry of Livestock and Fisheries oversees the mainland's waters, while the Ministry of Blue Economy and Fisheries manages Zanzibar's waters. Beyond the territorial sea, the expansive Exclusive Economic Zone (EEZ), which covers approximately 223,000 km^2, falls under the jurisdiction of a single union body, the Deep Sea Fishing Authority (DSFA). The DSFA is responsible for the management of deep-sea fisheries, including policy formulation, implementation, monitoring, and ensuring compliance with the Deep Sea Fisheries Management and Development Act (URT, 2020a)

1.4. OBJECTIVES

The primary goal of this study is to provide a scientific basis for the sustainable management of key tuna species in URT. The specific objectives are:

1. To estimate key biological and exploitation reference points (e.g., size at maturity, growth rates, mortality) for yellowfin, bigeye, and skipjack tuna.
2. To assess the current stock status for each species using the Length-Based Spawning Potential Ratio (LBSPR) model.

Photo Credit: Baraka Kuguru

1.5. RATIONALE

The fisheries sector is a cornerstone of the realization of the blue economy in the URT, supporting food security, employment, and income, particularly in coastal communities. The sector is predominantly artisanal, sustaining a large workforce engaged in fishing, processing, and trade across both mainland Tanzania and Zanzibar (URT, 2020b). Within this sector, tuna fishery is of immense economic and ecological importance. Species such as yellowfin, bigeye, and skipjack are not only high-value commercial targets that generate significant revenue through catch and licensing fees, but they are also key predators within the marine ecosystem.

However, the sustainable management of yellowfin, bigeye, and skipjack is hampered by a critical lack of scientific data on their stock status and biological and exploitation reference points within marine waters of the URT. This data gap limits the ability of management bodies, particularly the DSFA, to implement effective, evidence-based management strategies for sustainable exploitation and to accurately guide investment in these resources. Without understanding of the stock status of yellowfin, bigeye, and skipjack, the nation faces risks of overfishing, potential loss of revenue, and long-term harm to marine biodiversity. This study was undertaken to fill this knowledge gap by providing the biological and exploitation reference points as well as the stock status of yellowfin, bigeye, and skipjack in the URT to support sustainable fisheries development, enhance national planning, and improve investment decisions for these vital tuna resources.

2. METHODS AND APPROACHES

This chapter details the methodology for the 2024 tuna stock assessment in Tanzanian marine waters. It covers the geographical scope, data collection from artisanal and industrial fisheries, and key analytical assumptions. The core of the analysis involves processing combined length-frequency data and applying the Length-Based Spawning Potential Ratio (LBSPR) model to estimate stock status (SPR) and exploitation levels (F/M) for Bigeye, Yellowfin, and Skipjack tuna.

2.1. GEOGRAPHICAL SCOPE

This assessment covers the marine waters of the URT, a coastal nation situated between latitudes 1° and 11°48'S and longitudes 38°23' and 45°14'E (Figure 2.1). The URT's maritime jurisdiction includes a 1,424 km coastline, territorial waters covering 64,000 km², and an extensive EEZ of approximately 223,000 km², which constitutes the primary study area.

The country's oceanography is dominated by a reversing monsoon system, which dictates local environmental conditions. The northeast (NE) monsoon (October-March) is typically associated with calmer seas and warm surface waters, while the southeast (SE) monsoon (May-September) brings stronger winds and cooler waters (Richmond, 1995). These seasons influence the strength of the northward-flowing East African Coastal Current (EACC) and drive key oceanographic processes (Semba et al., 2019), such as seasonal upwelling in the Pemba Channel, which impacts fisheries productivity (Halo et al., 2020; Kyewalyanga et al., 2020).

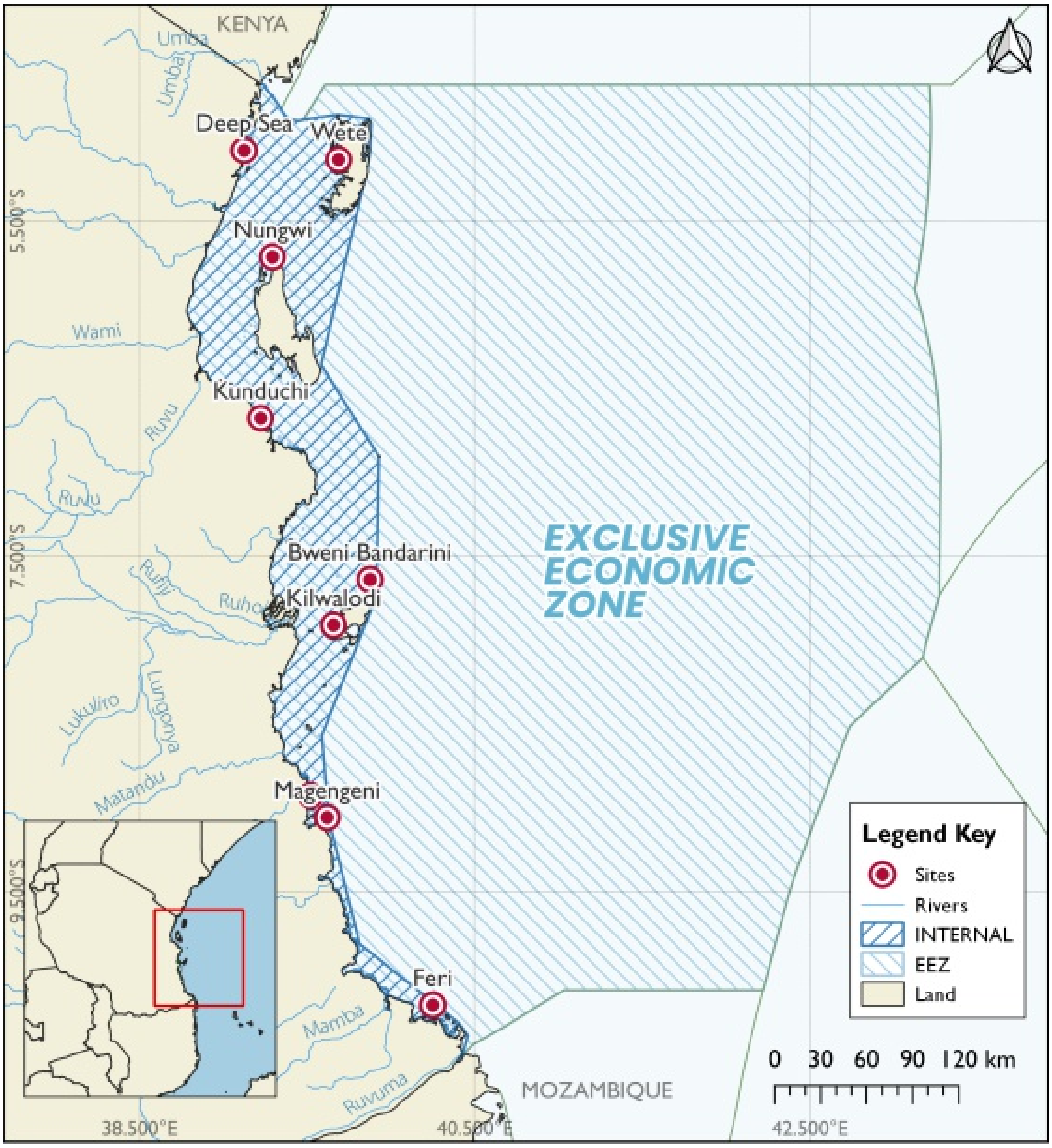

Figure 2.1: The internal and exclusive economic zones of the URT. An inset map locates Tanzania with neighbouring countries and the Indian Ocean.

2.2. ASSUMPTIONS

This assessment relies on several key assumptions, which are standard for length-based stock assessment models:

1. Unit Stock: The populations of bigeye, yellowfin, and skipjack tuna within the URT's marine waters are treated as single, self-contained stocks for this assessment.
2. Representative Sampling: The length-frequency data collected from the artisanal and industrial fisheries are assumed to be representative of the true size distribution of the exploited portion of each stock. To correct for known gear selectivity biases (e.g., industrial longlines catching larger fish), data from both fisheries were integrated to represent the full population structure.
3. Equilibrium State: The fishery and the underlying population are assumed to be in a state of equilibrium. This implies that recruitment, growth, and mortality rates have been relatively constant over the period represented by the length-frequency data, a key requirement for the LBSPR model.
4. Closed Population: The stocks are considered demographically closed, with negligible immigration or emigration during the assessment period.

Photo Credit: Baraka Kuguru

2.3. POPULATION STRUCTURE

This study focuses on the population structure of three key tuna species: bigeye tuna (Thunnus obesus), yellowfin tuna (*Thunnus albacares*), and skipjack tuna (*Katsuwonus pelamis*). These species are widely distributed across the Indian Ocean (Lee et al., 2005). Tuna are highly migratory species whose movements are influenced by ocean currents, prey availability, and spawning behaviour. They are widely distributed in tropical and subtropical seas around the world. The most commercially important tuna species found in tropical waters include yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), and skipjack tuna (*Katsuwonus pelamis*). Tuna species exhibit a wide range of biological characteristics, including size at maturity, maximum length, and age, which are important for understanding biological characteristics and exploitation status, crucial for sustainable management. Table 2.1 summarizes key biological and exploitation reference points for these species.

Table 2.1: Biological and exploitation reference points for selected tuna species in the Western Indian Ocean.

Parameter	Bigeye	Yellowfin	Skipjack
L_{inf} (cm)	210	190	90
K (year-1)	0.18	0.35	0.80
L_{50} (cm)	105	100	42
L_{95} (cm)	130	125	50
M/K Ratio	1.9	1.7	1.1

2.4.1.Bigeye Tuna

Bigeye tuna (*Thunnus obesus*) are found throughout the tropical and subtropical waters of the Indian Ocean. They are a relatively long-lived species, with slower growth rates compared to yellowfin or skipjack. Spawning occurs year-round in tropical waters, with peaks often associated with warmer sea surface temperatures. Larvae and juveniles are found in surface waters, while adults typically inhabit deeper, cooler waters during the day and may move to shallower depths at night to feed. The Indian Ocean Tuna Commission (IOTC) considers the Indian Ocean bigeye tuna as a single stock for assessment purposes. Bigeye tuna mature at an average length of 112.5 cm, reach a maximum total length of 250 cm, are commonly around 180 cm (Table 2.1), and can weigh up to 210 kg with a lifespan of up to 11 years (Collette & Nauen, 1983).

2.4.2.Yellowfin Tuna

Yellowfin tuna (*Thunnus albacares*) are widely distributed across the tropical and subtropical Indian Ocean. They are a fast-growing species, reaching maturity relatively quickly. Spawning is also widespread and occurs throughout the year in warm tropical waters, often with seasonal peaks. Yellowfin tuna are highly migratory, and their stock structure in the Indian Ocean is generally considered as a single unit for management by IOTC. Yellowfin tuna reach sexual maturity at an average length of 103.3 cm and can grow up to 239 cm (Table 2.1) and weigh up to 200 kg, living up to 9 years (Collette & Nauen, 1983).

2.4.3.Skipjack Tuna

Skipjack tuna (*Katsuwonus pelamis*) are the most abundant and widely distributed of the principal market tuna species in the Indian Ocean. They are a fast-growing, early-maturing, and short-lived species. Spawning occurs year-round in equatorial waters, with larval and juvenile stages found predominantly in warm surface waters. Skipjack are highly opportunistic feeders and form large schools, often associated with floating objects or other marine life. The IOTC assesses skipjack tuna in the Indian Ocean as a single stock, which mature at a much smaller size, averaging 41.3 cm, grow up to 110 cm (Table 2.1), weigh up to 34.5 kg, and may live as long as 12 years (Collete, 1983).

2.4. LENGTH AND WEIGHT DATA

The study used neritic (coastal waters) and EEZ data. Data from the neritic zone were sourced from both the TAFIRI and the DSFA. This dataset is crucial, as it typically includes a mix of juvenile and sub-adult tuna, which are often caught by artisanal fishers. Data from the EEZ were primarily sourced from the DSFA. This information is generally collected through mandatory logbooks submitted by licensed industrial fishing vessels operating within the EEZ, supplemented by data from observer programs when available. The EEZ data used in this study typically covers the period from October 2023 to December 2024. These two datasets (neritic and EEZ) were combined in the study. This approach was adopted because the EEZ data predominantly consist of adult individuals, while the neritic dataset includes younger fish. Combining them creates a more comprehensive population structure, containing both juvenile and adult life stages, which is essential for robust stock assessment.

2.4.4.Sampling Sites

The contextual information for each sampling event was recorded. This included the date of fishing, the date the data were entered, the specific name of the landing site (as detailed in Table 2.2), and, when reliably provided by the fishers, the general fishing ground or area where the catch was made.

2.4.5.Fishing Grounds

The data were collected from various landing sites, including Deep Sea, Feri, Jimbiza, Kunduchi and Magengeni in Mainland, as well as Nungwi, and Wete in Zanzibar (Table 2.3). It's interesting to note that “Chundo, and Milangoni Kaskazini” are ishing ground accessed by fishers from both “Deep Sea” and “Wete” landing sites. Similarly, “Lukila” is accessed from both “Jimbiza” and “Magengeni”.

Table 2.2: Landing sites for Neritic data sampling Coordinates (decimal degrees)

			Coordinates (decimal degrees)	
Area	Village	Landing site	Longitude	Latitude
Zanzibar	Wete	Wete	39.050	-5.080
Zanzibar	Nungwi	Nungwi	42.870	-7.000
Mainland	Halmashauri	Deep Sea	39.300	-4.870
Mainland	Jimbiza	Jimbiza	39.520	-8.928
Mainland	Shangani East	Feri	40.250	-10.180
Mainland	Other	Other	40.000	-5.660
Mainland	Kunduchi Pwani	Kunduchi	35.440	-6.660
Mainland	Bweni	Bweni Bandarini	42.560	-6.760
Mainland	Magengeni	Magengeni	39.620	-9.060
Mainland	Tumbuju	Kilwalodi	39.658	-7.911

Table 2.3: Fishing grounds by landing sites.

Landing sites	Fishing ground
Bweni Bandarini	Kanga
Deep Sea	Mataani, Chundo Milangoni Kaskazini, Mwamba Nyama, Wamba, Nyuli, Kijambani
Feri	Bohari, Vyulu 2, Majomvi, kivale, Vyulu, Msanga Mkuu Shimoni
Jimbiza	Lukila, Kivulugo, Lwanje, Songo, Mawalani, Chamba cha Sudi, Chamba cha ndoana
Kilwalodi	Boyani shungumbili
Kunduchi	Karage, Karage kubwa, Kobela 2, Kipwani, Kobela, Pungume, Mkokoni 2, Pungume 3
Magengeni	Lukila
Nungwi	Milango ya Pangani, Milango ya Mwera, Kipwani
Wete	Kijambani, Gando Chokaani, Kundeni Chini, Chundo Milangni Kaskazini, Kashani chini, Jambani, Funzi, Mnarani Mnjee, Misali chini, Mkondoni, Fundo, Mnarani, Gando, Funguni, Fungu Yasini, Deep Sea, Fungu, Kijamba Pemba

2.4.6.Sampling Months

Table 2.4 summarizes the monthly frequencies of the data share of landings for each tuna species over a one-year cycle. Total tuna data records were highest in March (14.8%) and January (14.3%), with April (13.5%) also showing a high record. There's a general decline from May through September, with the lowest records observed in November (1.9%), December (2.6%), and September (3.7%).

2.4: Monthly frequencies in percentage for selected tuna species in the neritic waters sampled in 2024

	Bigeye	Skipjack	Yellowfin
Jan	19.0%	10.7%	12.0%
Feb	9.3%	8.1%	5.1%
Mar	9.4%	26.1%	8.6%
Apr	17.9%	11.3%	9.8%
May	13.3%	9.7%	6.1%
Jun	4.5%	6.8%	7.0%
Jul	7.7%	5.9%	14.6%
Aug	9.1%	3.0%	12.5%
Sept	1.8%	5.3%	4.4%
Oct	3.8%	11.8%	10.8%
Nov	1.6%	0.0%	4.8%
Dec	2.6%	1.2%	4.4%

2.4.7. Fishing Gears

Data from the neritic zone were primarily collected from the catches of artisanal fishers. Sampling was opportunistic, targeting active landing sites during peak fishing seasons to capture a representative sample of the landed catch. Enumerators recorded data from various gear types commonly employed by the artisanal fleet. These included, but were not limited to, surface gillnets (both drift and set), handlines (often deployed from small, motorized or non-motorized vessels), and occasionally ring nets or small purse seines where prevalent. The specific gear type used for each sampled catch was recorded to allow for potential gear-specific analyses of catch composition and size selectivity.

2.4.8.Species Identification

Landed fish including tuna were identified to species level by trained enumerators at the landing sites. Local names provided by fishers were recorded and subsequently cross-referenced with established English common names and scientific names (e.g., yellowfin tuna, skipjack tuna, bigeye tuna) using standardized taxonomic guides and internal reference lists.

2.4.9.Morphometric Measurements

Key morphometric measurements taken for each sampled individual include total length, fork length and weight. Fork Length (FL) was measured as the straight-line distance from the tip of the snout (upper jaw) to the fork of the caudal (tail) fin, recorded to the nearest centimeter (cm) using a calibrated measuring board or tape. Total Length (TL), from the tip of the snout to the tip of the longest lobe of the caudal fin, was also recorded to the nearest centimeter (cm) when available and appropriate for the species. The total body weight (WT) of each fish was measured, typically to the nearest gram (g) for smaller individuals or to the nearest 0.1 kilogram (kg) for larger tuna, using electronic balances. All weight data were subsequently standardized to kilograms (kg) according to IOTC1.

2.5. DATA PROCESSING AND ANALYSIS

2.5.1.Tidying Data

The length and weight data collected from both neritic and EEZ were assessed for quality and consistency. The process involved several key procedures, including checking numeric errors and verifying species identification. Then, the length data with missing weight information were fitted using Equation 1.1.

$$W = aL^b \tag{1.1}$$

Where W is weight, L is length, and a and b are parameters estimated by fitting a linear regression to log-transformed data. The corrected data were then aggregated into size classes to prepare Length Frequency Distributions (LFDs) for each species over the sampling period for subsequent stock assessment analyses.

2.5.2.Partitioning of Juveniles and Adults

Then the LFDs was used to classify individual fish into juvenile and adult stages based on established length-at-maturity (L_{50}) information for each target tuna species. Individuals with a recorded fork length (FL) less than the species-specific L_{50} were categorized as juveniles, while those individuals with a fork length greater than or equal to L_{50} were classified as adults. The resulting classification was used to estimate biological and exploitation reference points, which serve as input in the LBSPR model.

2.5.3.Stock Estimation

The stock of bigeye, yellowfin, and skipjack tuna was estimated using the Length-Based Spawning Potential Ratio (LBSPR) model Hordyk (2021). This approach was chosen for its robustness and suitability in data-poor fisheries, where comprehensive age-structured data are often unavailable. A fundamental assumption of the LBSPR model is that the fishery is in equilibrium, that the observed length composition data reflect a stable state of exploitation. The specific input parameters for the LBSPR model include the asymptotic length (L_{inf}), the von Bertalanffy growth coefficient (K), the natural mortality to growth rate ratio (M/K), and the lengths at which 50% (L_{50}) and 95% (L_{95}) of individuals are mature.

These parameters were estimated using the methods described in Appendix C and additional parameters sourced from peer-reviewed literature relevant to tuna stocks in the Western Indian Ocean. The LBSPR model then fits these parameters and simulates length compositions to the empirical length frequency data and estimates several key fishery reference points. The primary outputs are the Spawning Potential Ratio (SPR) and the relative fishing mortality (F/M). The SPR is used as a key indicator of stock health, representing the proportion of the unfished spawning stock biomass that currently exists under the prevailing fishing pressure. An SPR value below 0.4 indicates a depleted or overfished stock. The F/M ratio provides an index of fishing intensity relative to natural mortality.

3. YELLOWFIN TUNA

This chapter provides information on stock of yellowfin Tuna in the marine waters of the URT, as estimated by the LBSPR model. It covers key aspects of juvenile and adult individuals, biological and exploitation reference points, and the current stock status.

3.1. LENGTH FREQUENCY

Analysis of the length composition of yellowfin tuna catches in 2024 reveals clear seasonal shifts in the population's size structure. The sampled population, with fork lengths ranging from approximately 42 cm to 150 cm, showed a distinct progression of size groups, or cohorts, throughout the year (Figure 3.1). Catches in the first half of the year were characterized by larger individuals (90-114 cm). A significant recruitment event was observed in August, marked by a strong pulse of smaller fish centered around 66 cm. This cohort demonstrated clear growth, becoming the dominant size class at 78-90 cm by November. Tracking this modal progression is essential for understanding the recruitment patterns and growth dynamics of yellowfin tuna within marine waters of URT.

3.2. JUVENILE AND ADULT

The best fit measured length and weight of yellowfin tuna resulted in the clear separation of sample individuals into juvenile and adult (Figure 3.2 a), an important parameter for estimating the length at first maturity (L50). The study estimated L50 of yellowfin tuna at 92.3 cm, with more than 84% of the yellowfin individuals correlated well in model fit (Figure 3.2 b). The R2 value of 0.84 signifies a strong goodness-of-fit for the logistic model. This means that approximately 84% of the variation in maturity status (juvenile vs. adult, See Table 3.1) can be explained by the fork length of the yellowfin tuna. Although the estimate L50 of 91.2 cm in this study is lower than the median length of 103.3 cm reported in fishBase, it is within the maturity range of 78 and 158 cm (FishBase, 2023a).

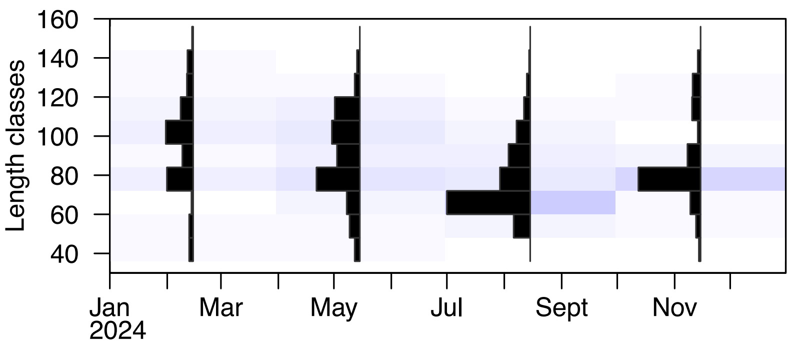

Figure 3.1: Length frequency of yellowfin tuna over twelve months of 2024.

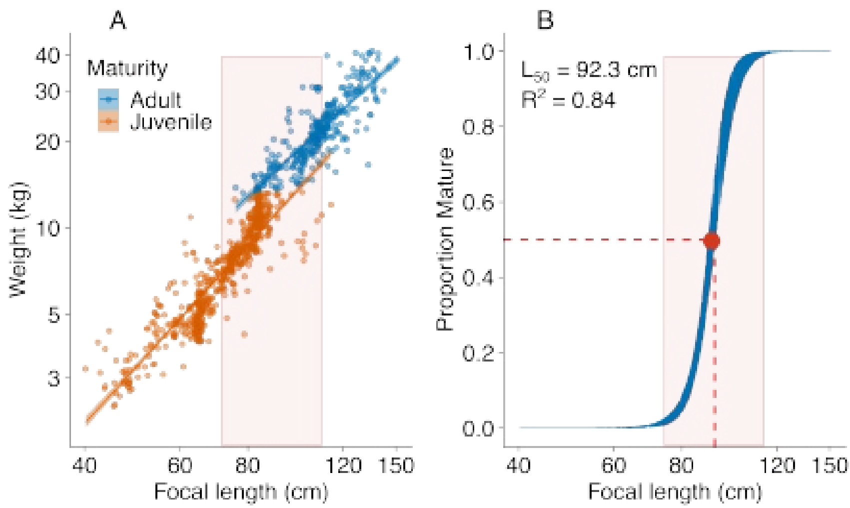

Figure 3.2: Length and weight information with a) juvenile and adults and b) maturity ogive for yellowfin tuna.

Table 3.1: Yellowfin tuna parameters derived from the logistic models.

	Ogive Parameters			
Model	A[1]	B[2]	L_{50}	R^2
Original	-23.07	0.25	92.39	0.84
Bootstrap (Median)	-23.28	0.25	92.36	-

[1] A for Intercept of the logistic curve.
[2] B for slope of the logistic curve.

3.3. BIOLOGICAL AND EXPLOITATION REFERENCE POINTS

Table 3.2 summarizes the biological and exploitation reference points of yellowfin tuna. The L50 value of 91.8 indicates that, on average, yellowfin tuna reaches 50% sexual maturity at a fork length of 92.3 cm. This is a key biological reference point used to assess the reproductive capacity of the stock and can inform management measures such as minimum size limits. The estimated asymptotic length (L_{inf}) for yellowfin tuna is 161.28 cm, with a relatively low growth coefficient (K) of 0.10 year^{-1} (Table 3.2). This suggests that yellowfin tuna grow to a large size but approach this maximum size more slowly compared to species like skipjack. The natural mortality to growth coefficient ratio (M/K) was estimated at 1.43. Given K = 0.10 year^{-1}, the natural mortality rate (M) can be inferred as approximately 0.143 year-1 (M = 1.43 × 0.10). The total mortality rate (Z) was estimated at 0.27 year^{-1}.

Table 3.2: Estimated biological and exploitation reference points for yellowfin tuna.

Parameter	Value	Description
Biological		
L_{inf} (cm)	161.3	Asymptotic length, theoretical maximum length fish can reach.
K (year-1)	0.1	Von Bertalanffy growth coefficient
M/K Ratio	1.4	Ratio of natural mortality (M) to the growth coefficient (K).
L_{50} (cm)	92.3	Length at which 50% of the fish are sexually mature.
L_{95} (cm)	103.4	Length at which 95% of the fish are sexually mature.
Z (year-1)	0.3	Total mortality rate (Z = F + M).
t_{50} (years)	4.6	Age at which 50% of the fish are sexually mature.
Exploitation		
t_{95} (years)	6.2	Age at which 95% of the fish are sexually mature.
SL_{50} (cm)	59.5	Length at which 50% of the fish are vulnerable to the fishing gear.
SL_{95} (cm)	74.2	Length at which 95% of the fish are vulnerable to the fishing gear.
F/M Ratio	0.8	Ratio of fishing mortality to natural mortality

3.3.1.Growth and Mortality

The estimated asymptotic length (L_{inf}) for yellowfin tuna is 161.28 cm, with a relatively low growth coefficient (K) of 0.10 $year^{-1}$ (Table 3.2). This suggests that yellowfin tuna grow to a large size but approach this maximum size more slowly compared to species like skipjack. The natural mortality to growth coefficient ratio (M/K) was estimated at 1.43. Given K = 0.10 year-1, the natural mortality rate (M) can be inferred as approximately 0.143 $year^{-1}$ (M = 1.43 × 0.10). The total mortality rate (Z) was estimated at 0.27 $year^{-1}$.

3.3.2.Maturity and Selectivity

Yellowfin tuna are estimated to reach L_{50} at a fork length of 92.29 cm (corresponding to an age, t_{50}, of 4.61 years) and 95% L_{95} at 103.36 cm (age t_{95} of 6.16 years). The fishing gear selectivity indicates that 50% of individuals are selected (SL_{50}) at 59.52 cm, and 95% are selected (SL_{95}) at 74.20 cm. This is a critical finding, as SL_{50} is substantially lower than L_{50}, indicating that a large proportion of the yellowfin tuna catch consists of immature individuals. This practice can significantly impair the stock's reproductive capacity.

3.5. FISHING, SPAWNING, YIELD AND BIOMASS

Key metrics derived from the LBSPR model, which are crucial for determining the sustainability of current fishing levels include the Spawning Potential Ratio, fishing pressure, and estimates of yield and biomass. presented in Table 3.3.

3.5.1.Fishing Pressure

The ratio of fishing mortality to natural mortality (F/M) is 0.80. This value suggests that fishing mortality is somewhat less than natural mortality. While an F/M ratio below 1.0 is generally preferred, its interpretation must be combined with other indicators like SPR.

3.5.2.Spawning Potential Ratio (SPR)

The SPR is estimated at 0.29. This indicates that the current spawning stock biomass is only 29% of what it would be in an unfished state. This SPR value is below the commonly used limit reference point of 0.40 (40%) and also below the more critical threshold of 0.30 (30%), which often triggers strong management action. An SPR of 0.29 suggests that the yellowfin tuna stock is likely overfished and at a high risk of recruitment impairment, necessitating immediate and stringent restrictions on fishing effort.

Table 3.3: Estimated stock metrics for Yellowfin Tuna.

Parameter	Value	Description
SPR	0.29	Spawning Potential Ratio
Yield (kg)	927,723,024	Estimated total annual yield from the fishery.
YPR (kg)	130,246	Yield Per Recruit, expected yield from an average recruit.
SSB (kg)	799,846,689	Current Spawning Stock Biomass.

3.4. YIELD AND BIOMASS

The estimated total annual yield from the fishery is very high (Figure 3.3), at approximately 927,723 metric tonnes (assuming the unit is kg). The Yield Per Recruit (YPR) is 130,246.10 kg/recruit. The current SSB is estimated at 799,846,689.27 kg. The unfished spawning stock biomass (SSB_0) of 381,530.20 kg appears inconsistent with the SSB and SPR values (as SPR = SSB/SSB_0; 799,846,689.27 / 381,530.20 would yield an SPR far greater than 1). If SPR is 0.29, then SSB_0 should be approximately SSB/0.29 = 2,758,092,032 kg. This discrepancy in the provided SSB_0 should be noted, and the SPR value itself is the more direct indicator from the LBSPR model for stock status.

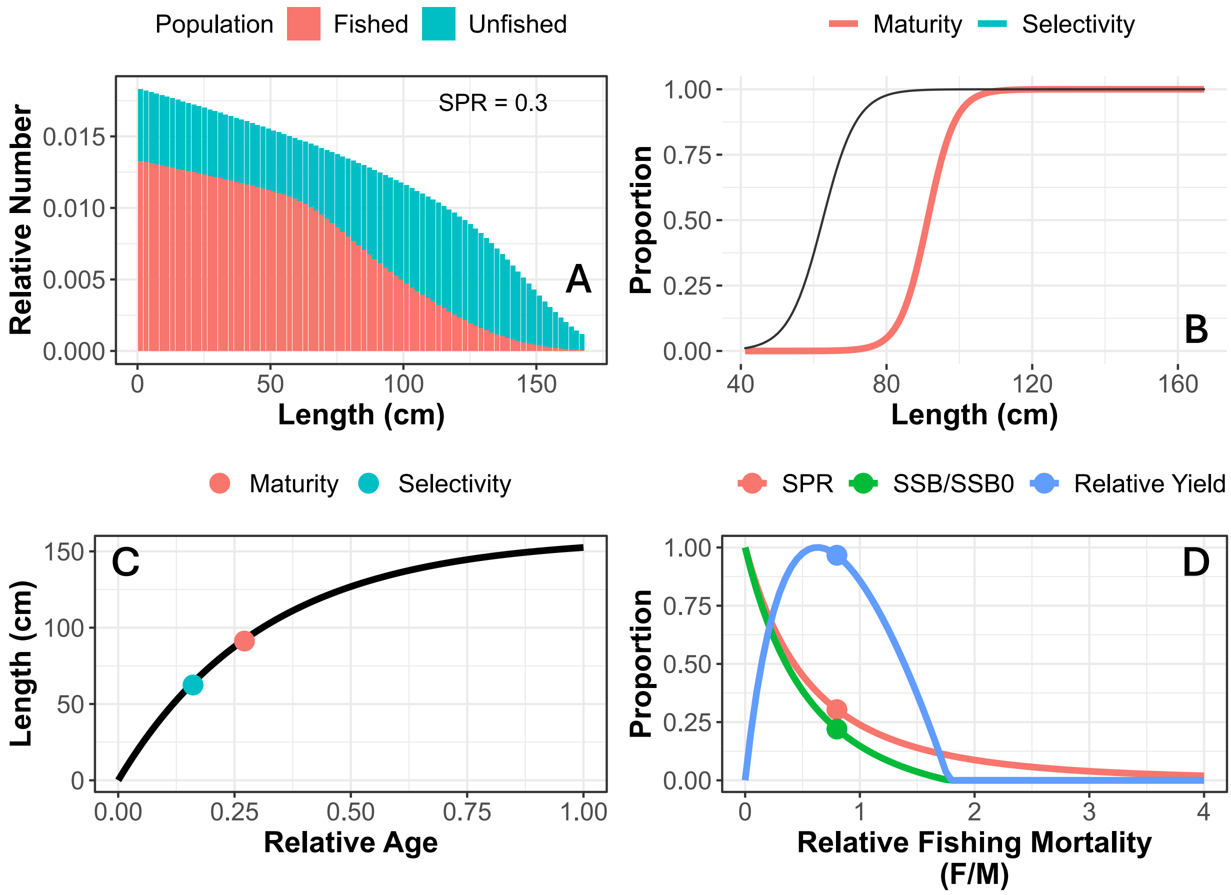

Figure 3.3: LB-SPR model outputs for yellowfin tuna. (A) length that 50% of individuals are matured and selected (B) relative number of fished and unfished fishes in the stock

4. BIGEYE TUNA

This chapter provides information on stock characteristics of bigeye tuna in the marine waters of the URT, as estimated by the LBSPR model. It covers key aspects of juvenile and adult individuals, biological and exploitation reference points, and the current stock status.

4.1. LENGTH FREQUENCY

Analysis of the length composition of bigeye tuna catches in 2024 reveals clear seasonal shifts in the population's size structure. The sampled population, with fork lengths ranging from 50 cm to 158 cm, showed a distinct progression of size groups, or cohorts, throughout the year (Figure 4.1). Catches in the first half of the year were characterized by a mix of sizes, with a strong presence of larger individuals around 78-86 cm. A significant recruitment event was observed in August, marked by a strong pulse of smaller fish centered around 62-66 cm. This cohort demonstrated clear growth, becoming the dominant size class in the 74-82 cm range by November. This temporal progression of modes provides valuable insights for understanding the recruitment patterns, growth rates, and the overall dynamics of the bigeye tuna within the marine waters of the URT.

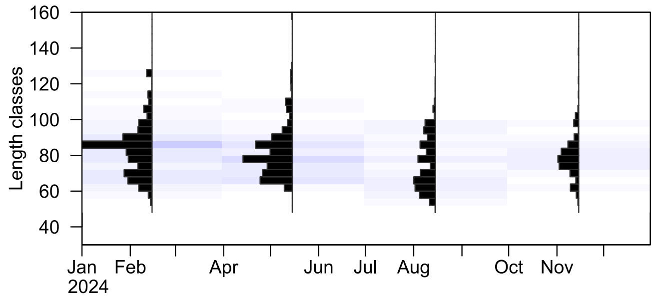

Figure 4.1: Length frequency of bigeye over twelve months for the year 2024

4.3. JUVENILE AND ADULT

The best fit measured length and weight of bigeye tuna resulted in the clear separation of sample individuals into juvenile and adult (Figure 4.2 a), an important parameter for estimating the L_{50}. The study estimated L_{50} of bigeye tuna at 82.5 cm. The R1value of 0.51 signifies a weak goodness-of-fit for the logistic model, as about 50% of the bigeye individuals correlated well in model fit (Figure 4.2 b). This means that only 51% of the variation in maturity status (juvenile vs. adult, See Table 4.1) can be explained by the fork length of the bigeye Tuna. The estimated L_{50} of 82.1 cm is lower than the median length of 125.5 cm reported in fishBase, and even lower than the range of maturity, which vary between 100 and 125 cm (FishBase, 2023b).

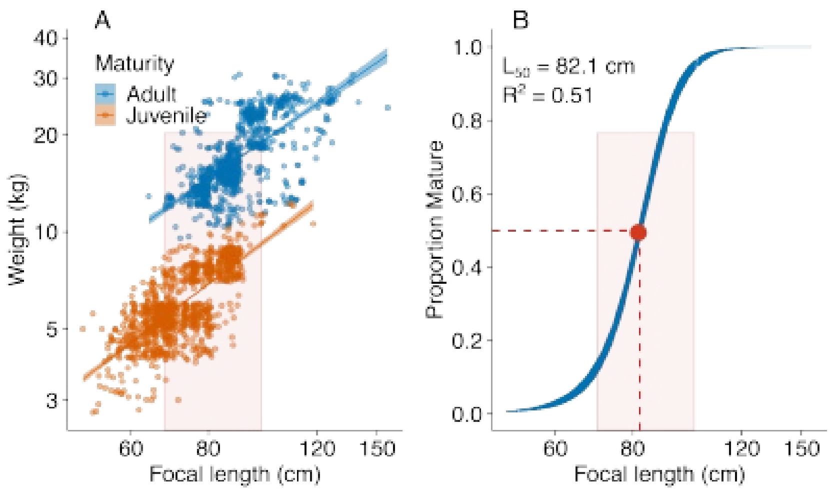

Figure 4.2: Length and weight information with a) juvenile and adults and b) maturity ogive for bigeye tuna.

Table 4.1: Bigeye tuna parameters derived from the logistic models.

	Ogive Parameters			
Model	A[1]	B[2]	L_{50}	R^2
Original	-13.36	0.16	82.15	0.51
Bootstrap (Median)	-13.40	0.16	82.12	-

[1]A for Intercept of the logistic curve.
[2]B for slope of the logistic curve.

4.2. BIOLOGICAL AND EXPLOITATION REFERENCE POINTS

Table 4.2 summarizes the biological and exploitation reference points for Bigeye Tuna. The length at 50% maturity (L50) is 81.95 cm, indicating that, on average, Bigeye Tuna reach sexual maturity at this fork length. This is a key biological reference point used to assess the stock's reproductive capacity. The estimated asymptotic length (Linf) is 96.98 cm, with a growth coefficient (K) of 0.46 year^{-1}). This indicates a species that reaches a moderate maximum size with a relatively fast growth rate. The natural mortality to growth coefficient ratio (M/K) was estimated at 1.12. Given K = 0.46 year^{-1}, the natural mortality rate (M) can be inferred as approximately 0.515 year^{-1} (M = 1.12 $ \times$ 0.46). The total mortality rate (Z) was estimated at 0.65 year^{-1}.

Table 4.2: Estimated biological and exploitation reference points for bigeye tuna.

Parameter	Value	Description
Biological		
L_{inf} (cm)	97.0	Asymptotic length, theoretical maximum length fish can reach.
K (year-1)	0.5	Von Bertalanffy growth coefficient
M/K Ratio	1.1	Ratio of natural mortality (M) to the growth coefficient (K).
L_{50} (cm)	82.0	Length at which 50% of the fish are sexually mature.
L_{95} (cm)	99.5	Length at which 95% of the fish are sexually mature.
t_{50} (years)	2.3	Age at which 50% of the fish are sexually mature.
t_{95} (years)	2.7	Age at which 95% of the fish are sexually mature.
Exploitation		
Z (year-1)	0.6	Total mortality rate (Z = F + M).
SL_{50} (cm)	62.7	Length at which 50% of the fish are vulnerable to the fishing gear.
SL_{95} (cm)	69.1	Length at which 95% of the fish are vulnerable to the fishing gear.
F/M Ratio	0.8	Ratio of fishing mortality (F) to natural mortality (M)

4.3.1.4.3.1 Growth and Mortality

The estimated asymptotic length (L_{inf}) for bigeye tuna is 96.98 cm, with a growth coefficient (K) of 0.46 year^{-1}. This indicates a species that reaches a moderate maximum size with a relatively fast growth rate towards that size. The natural mortality to growth coefficient ratio (M/K) was estimated at 1.12. Given K = 0.46 year^{-1}, the natural mortality rate (M) can be inferred as approximately 0.515 year-1 (M = 1.12 * 0.46). The total mortality rate (Z) was estimated at 0.65 year^{-1}.

4.3.2.4.3.2 Maturity and Selectivity

Bigeye tuna are estimated to reach L_{50} at a fork length of 81.95 cm (corresponding to an age, t_{50}, of 2.26 years) and L_{95} at 99.46 cm (age t_{95} of 2.71 years). The fishing gear selectivity indicates that 50% of individuals are selected (SL_{50}) at 62.67 cm, and 95% are selected (SL_{95}) at 69.11 cm. This is an important finding, as SL_{50} is considerably lower than L_{50}, implying that a substantial portion of the bigeye tuna catch consists of immature individuals. This pattern of exploitation can negatively impact the stock's reproductive potential.

4.5. FISHING, SPAWNING, YIELD AND BIOMASS

Key metrics derived from the LBSPR model, which are crucial for determining the sustainability of current fishing levels include the Spawning Potential Ratio, fishing pressure, and estimates of yield and biomass. presented in Table 4.3.

4.5.1.Fishing Pressure

The ratio of fishing mortality to natural mortality (F/M) is 0.80. This value suggests that fishing mortality is somewhat less than natural mortality. While an F/M ratio below 1.0 is generally preferred, its interpretation must be combined with other indicators like SPR.

4.5.2.Spawning Potential Ratio (SPR)

The SPR for bigeye tuna is estimated at 0.33. This means that the current spawning stock biomass is approximately 33% of what it would be in an unfished state. An SPR of 0.40 (40%) is often used as a limit reference point, below which the stock is considered overexploited and is at increased risk of impaired recruitment. An SPR of 0.30 is often considered a threshold where management action is strongly recommended. With an SPR of 0.33, the Bigeye Tuna stock is below the common target of 40% but slightly above the 30% threshold, suggesting that the stock is likely being exploited at a level that warrants careful monitoring and potentially precautionary management measures to prevent further decline.

Table 4.3: Estimated stock metrics for bigeye Tuna.

Parameter	Value	Description
SPR	0.33	Spawning Potential Ratio
Yield (kg)	385,950,127	Estimated total annual yield from the fishery.
YPR (kg)	51,395	Yield Per Recruit, expected yield from an average recruit.
SSB (kg)	186,897,622	Current Spawning Stock Biomass.

4.4. YIELD AND BIOMASS

The estimated total annual yield from the fishery is substantial, at approximately 385,950 metric tonnes (assuming the unit is kg). The Yield Per Recruit (YPR) is 51,394.52 kg/recruit. The current SSB is estimated at 186,897,621.79 kg. Similar to the assessments for other tuna species, the provided unfished spawning stock biomass (SSB_0) of 76,539.68 kg appears inconsistent with the SSB and SPR values (as SPR = SSB/SSB_0; 186,897,621.79 / 76,539.68 would yield an SPR far greater than 1). If SPR is 0.33, then SSB_0 should be approximately SSB/0.33 = 566,356,429.67 kg. This discrepancy in the provided SSB_0 should be noted, and the SPR value itself is the more direct indicator from the LBSPR model for stock status.

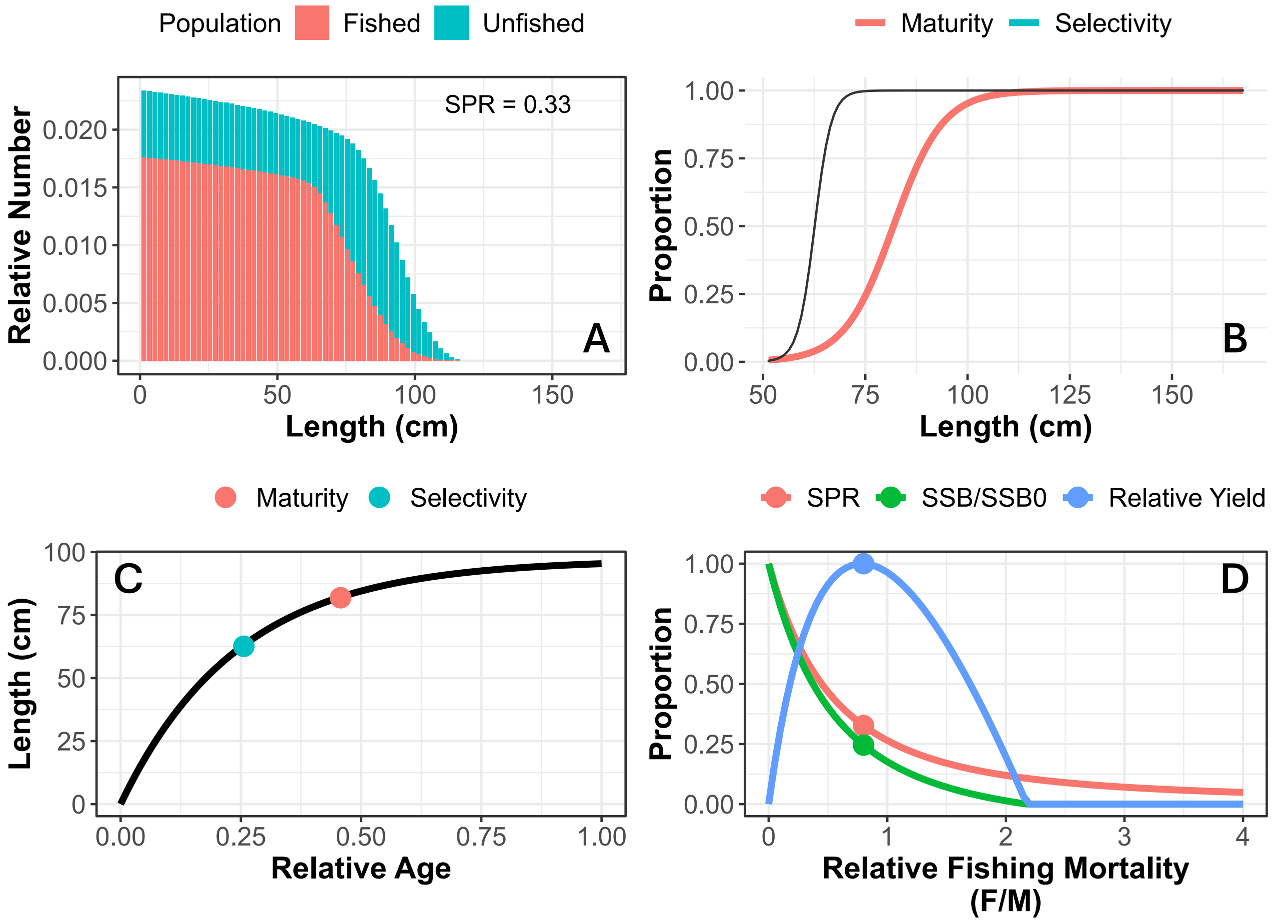

Figure 4.3: LB-SPR model outputs for bigeye tuna. (A) length that 50% of individuals are matured and selected (B) relative number of fished and unfished fishes in the stock

5. SKIPJACK TUNA

This chapter provides information on stock of skipjack tuna in the marine waters of the URT, as estimated by the LBSPR model. It covers key aspects of juvenile and adult individuals, biological and exploitation reference points, and the current stock status.

5.1. LENGTH FREQUENCY

Analysis of the length composition of skipjack tuna catches in 2024 reveals clear seasonal shifts in the population's size structure. The sampled population, with fork lengths ranging from 41 cm to 79 cm, showed a distinct progression of size groups, or cohorts, throughout the year (Figure 5.1). Catches early in the year were characterized by a wide range of sizes. By August, the catch shifted towards smaller fish (51-55 cm), suggesting a recruitment pulse. This cohort demonstrated clear growth, as the catch in November was dominated by larger individuals in the 67-69 cm range. This temporal shift strongly suggests the growth of one or more cohorts over the year, providing critical data for estimating growth parameters and understanding the

5.2. JUVENILE AND ADULT

The best fit measured length and weight of skipjack tuna resulted in the clear separation of sample individuals into juvenile and adult (Figure 5.2 a), an important parameter for estimating the L_{50}. The study estimated L_{50} of skipjack tuna of around 61.2 cm. The R1 value of 0.76 signifies a good goodness-of-fit for the logistic model, as about 76% of the skipjack individuals correlated well in model fit (Figure 5.2 b). This means that more than 76% of the variation in maturity status (juvenile vs. adult, See Table 5.1) can be explained by the fork length. Although the estimate L_{50} of 61.2 cm in this study is higher than the median length of 41.3 cm reported in fishBase, it is below the maximum length of 110 cm (FishBase, 2023c).

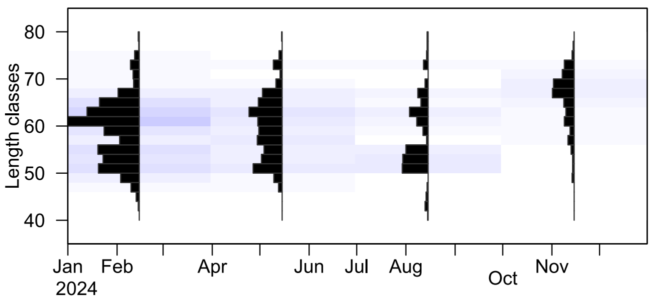

Figure 5.1: Length frequency of skipjack tuna over twelve months for the year 2024.

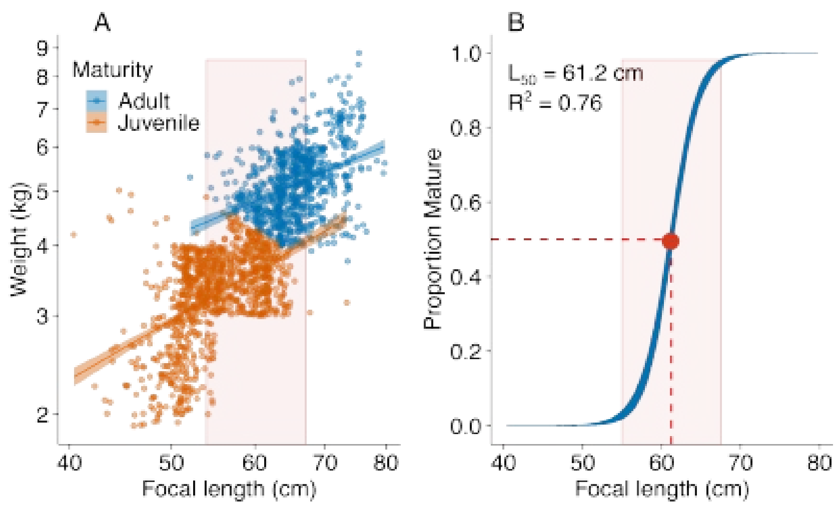

Figure 5.2: Length and weight information with a) Juvenile and adults and b) Maturity ogive for skipjack tuna.

Table 5.1: Skipjack tuna parameters derived from the logistic models

	Ogive Parameters			
Model	A[1]	B[2]	L_{50}	R^2
Original	-33.52	0.55	61.24	0.76
Bootstrap (Median)	-33.61	0.56	61.23	-

[1]A for Intercept of the logistic curve.

[2]B for slope of the logistic curve.

5.3. BIOLOGICAL AND EXPLOITATION REFERENCE POINTS

Table 5.2. summarizes the key biological and exploitation reference points for Skipjack Tuna. The length at 50% maturity (L_{50}) is 59.85 cm, which is a key biological reference point for assessing the stock's reproductive capacity. The estimated asymptotic length (L_{inf}) is 70.48 cm, with a high growth coefficient (K) of 0.44 $year^{-1}$, indicating that Skipjack is a relatively fast-growing species that reaches its maximum size quickly. The natural mortality to growth coefficient ratio (M/K) was estimated at 1.26. Given K = 0.44 $year^{-1}$, the natural mortality rate (M) can be inferred as approximately 0.55 $year^{-1}$ (M = 1.26 * 0.44). The total mortality rate (Z) was estimated at 0.57 $year^{-1}$.

Table 5.2: Estimated biological and exploitation reference points for skipjack tuna.

Parameter	Value	Description
Biological		
L_{inf} (cm)	70.5	Asymptotic length, theoretical maximum length fish can reach.
K (year-1)	0.4	Von Bertalanffy growth coefficient
M/K Ratio	1.3	Ratio of natural mortality (M) to the growth coefficient (K).
L_{50} (cm)	59.9	Length at which 50% of the fish are sexually mature.
L_{95} (cm)	64.3	Length at which 95% of the fish are sexually mature.
t_{50} (years)	2.8	Age at which 50% of the fish are sexually mature.
t_{95} (years)	3.4	Age at which 95% of the fish are sexually mature.
Exploitation		
Z (year-1)	0.6	Total mortality rate (Z = F + M).
SL_{50} (cm)	50.2	Length at which 50% of the fish are vulnerable to the fishing gear.
SL_{95} (cm)	54.4	Length at which 95% of the fish are vulnerable to the fishing gear.
F/M Ratio	0.8	Ratio of fishing mortality (F) to natural mortality (M)

5.3.1.Growth and Mortality

The estimated asymptotic length (L_{inf}) for skipjack tuna is 70.48 cm, with a growth coefficient (K) of 0.44 $year^{-1}$. This suggests a relatively fast-growing species that reaches its maximum size quickly. The natural mortality to growth coefficient ratio (M/K) was estimated at 1.26. Given K = 0.44 $year^{-1}$, the natural mortality rate (M) can be inferred as approximately 0.55 $year^{-1}$ (M = 1.26 * 0.44). The total mortality rate (Z) was estimated at 0.57 $year^{-1}$.

5.3.2.Maturity and Selectivity

Skipjack tuna are estimated to reach L_{50} at a fork length of 59.85 cm (corresponding to an age, t_{50}, of 2.84 years) and L_{95} at 64.26 cm (age t_{95} of 3.36 years). The fishing gear selectivity indicates that 50% of individuals are selected (SL_{50}) at 50.24 cm, and 95% are selected (SL_{95}) at 54.39 cm. This implies that a significant portion of the catch occurs before the fish reach 50% maturity, as SL_{50} is considerably lower than L_{50}.

5.5. FISHING, SPAWNING, YIELD AND BIOMASS

Key metrics derived from the LBSPR model, which are crucial for determining the sustainability of current fishing levels include the Spawning Potential Ratio, fishing pressure, and estimates of yield and biomass. presented in Table 5.3.

5.5.1.Fishing Pressure

The ratio of fishing mortality to natural mortality (F/M) is 0.80. This value suggests that fishing mortality is slightly less than natural mortality. An F/M ratio around 1.0 is often considered a target for optimal exploitation for many species, while values significantly above 1.0 can indicate overfishing.

5.5.2.Spawning Potential Ratio (SPR)

The SPR for skipjack tuna is estimated at 0.33. This means that the current spawning stock biomass is approximately 33% of what it would be in an unfished state. The SPR is below 0.40 (40%), which is often used as a limit reference point, below which the stock is considered overfished and is at increased risk of impaired recruitment. With an SPR of 0.33, the skipjack tuna stock is below the common target of 40% but slightly above the 30% threshold, suggesting that the stock is likely being exploited at a level that warrants careful monitoring and potentially precautionary management measures to prevent further decline.

Table 3.3: Estimated stock metrics for Yellowfin Tuna.

Parameter	Value	Description
SPR	0.33	Spawning Potential Ratio
Yield (kg)	103,288,858	Estimated total annual yield from the fishery.
YPR (kg)	13,725	Yield Per Recruit, expected yield from an average recruit.
SSB (kg)	50,251,534	Current Spawning Stock Biomass.

5.4. YIELD AND BIOMASS

The estimated total annual yield from the fishery is substantial, at approximately 103,289 metric tonnes (assuming the unit is kg). The YPR is 13,725.03 kg/recruit. The current SSB is estimated at 50,251,533.84 kg. The provided unfished spawning stock biomass (SSB_O) of 20,446.38 kg appears inconsistent with the SSB and SPR values (as SPR = SSB/SSB_0; 50,251,533.84 / 20,446.38 would yield an SPR far greater than 1, which is not possible). When SPR is 0.33, then SSB_0 should be approximately SSB/0.33 = 152,277,375 kg. This discrepancy in the provided SSB_0 should be noted, and the SPR value itself is the more direct indicator from the LBSPR model for stock status.

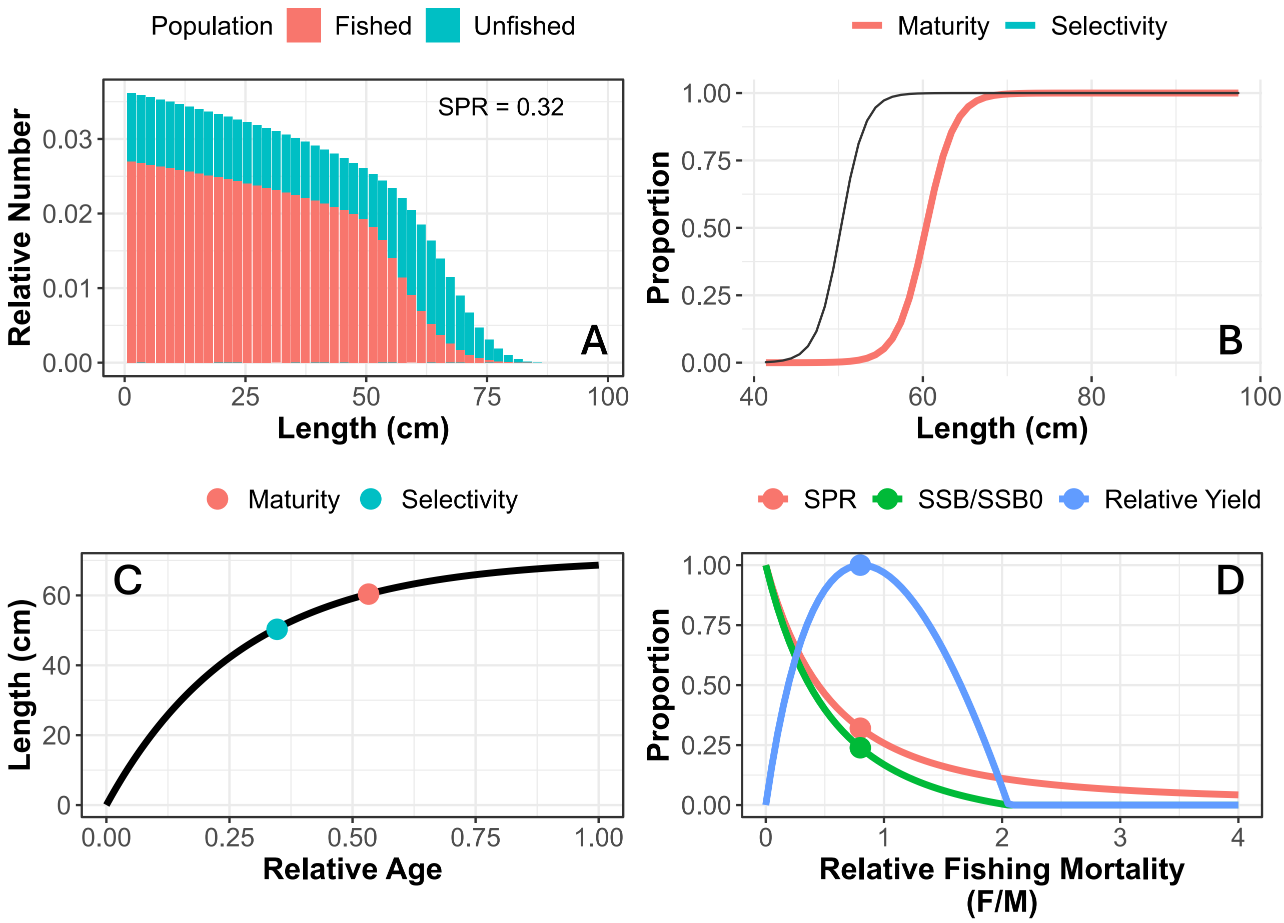

Figure 5.3: LB-SPR model outputs for skipjack tuna. (A) length that 50% of individuals are matured and selected (B) relative number of fished and unfished fishes in the stock

6. FINDINGS AND MANAGEMENT IMPLICATIONS

This chapter summarizes key findings and its management implications of tuna species caught in the marine waters of the URT. Referencing the first annual stock assessment TAFIRI (2024) report, which focused on yellowfin and bigeye tuna, the current stock assessment expands the scope to include skipjack tuna and uses the BSPR model with 2024 length and weight data from both neritic and industrial fisheries. While the TAFIRI (2024) report provided initial insights into the stock status of yellowfin and bigeye, this report offers a more comprehensive and current stock, allowing for a direct comparison of trends and status changes for yellowfin and bigeye tuna and establishing baseline stock data for skipjack tuna.

6.1. KEY FINDINGS

This report provides an updated and expanded analysis of tuna stocks in URT waters, building upon the TAFIRI (2024) annual stock assessment report. A consistent finding across stock assessment of yellowfin, bigeye and skipjack tuna assessed in the current study is that all species have SPR values below the commonly accepted target reference point of 0.40 (40% of unfished spawning biomass). This universally low SPR indicates that the current fishing pressure is significantly reducing the reproductive capacity of all assessed tuna stocks. A key improvement over the TAFIRI (2024) report is that the current assessment features more robust estimates for biological and exploitation parameters, stock status, and the underlying drivers of observed trends. This enhancement is the direct result of incorporating new data generated from spatially distributed landing sites across the nation.

6.1.1.Yellowfin Tuna

The current assessment estimates the yellowfin tuna SPR at 0.29 (29%). Because this is well below the 0.40 target threshold, the stock is considered overfished and facing a risk of recruitment impairment. This contrasts with the TAFIRI (2024) report's more dire SPR estimate of 0.13 (13%), though both reports identify the stock as viable. Other key differences in estimated parameters include:

- **Maturity (L_{50}):** The current study estimates L_{50} at 92.29 cm, significantly lower than TAFIRI (2024)'s 114.24 cm. This suggests that yellowfin tuna mature at a smaller size than previously estimated.
- **Selectivity (SL_{50}):** A critical finding in the current study is an SL_{50} of 59.52 cm, which is markedly lower than TAFIRI (2024)'s 87.51 cm. This indicates that a much larger proportion of immature yellowfin tuna are being caught in the current fishery, exacerbating the impact on the stock's reproductive capacity.
- **Growth(K):** The current study estimates a lower growth coefficient (K = 0.10 year^{-1}) compared to TAFIRI (2024)'s 0.28 year^{-1}. While the asymptotic length (Linf) is similar (current: 161.28 cm; TAFIRI: 156.21 cm), a slower growth rate implies fish take longer to reach maturity and vulnerable sizes.
- **Total Mortality (Z):** The current study estimates Z at 0.27 year^{-1}, lower than TAFIRI (2024)'s 0.35 year^{-1}.

6.1.2. Bigeye Tuna

For bigeye tuna, the current assessment estimates an SPR of 0.33 (33%). Because this is well below the 0.40 target threshold, the stock is considered to be at a high risk of overfishing and potential recruitment impairment. This finding represents a substantial improvement in the estimated stock status compared to the TAFIRI (2024) report, which estimated an SPR of 0.14 (14%). Notable differences in parameters include:

- **Maturity(L_{50}):** The current study estimates L_{50} at 81.95 cm, lower than TAFIRI (2024)'s 100.72 cm.
- **Selectivity (SL_{50}):** The current study's SL_{50} is 62.67 cm, which is lower than TAFIRI (2024)'s 72.32 cm, indicating a continued issue with the capture of immature individuals, though the difference is less pronounced than for Yellowfin.
- **Growth(K):** TAFIRI (2024) reported a higher growth coefficient (K = 0.42 year^{-1}) for Bigeye Tuna.
- Total Mortality(Z): TAFIRI (2024) estimated a higher total mortality rate (Z = 0.51 year^{-1}).

6.1.3.Skipjack Tuna

TAFIRI (2024) did not include an assessment for skipjack tuna, making this current assessment a new baseline. The estimated SPR for skipjack tuna is 0.33 (33%). Since this value is well below the 0.40 target threshold, the stock is considered to be at a high risk of overfishing and potential recruitment impairment. A significant concern, however, is that the length at 50% selectivity (SL_{50} = 50.24 cm) is considerably lower than the length at 50% maturity (L_{50} = 59.85 cm), indicating that a substantial portion of the catch consists of immature fish.

6.1.4.General Observations and Data Consistency

Across all individual species assessed in the current study, it was noted that the provided SSB values in the summary tables appeared inconsistent with the estimated current SSB and SPR values. This inconsistency was also present in the TAFIRI (2024) report provided SSB0 values. The SPR, derived directly from the LBSPR model, was therefore considered the more robust indicator of stock status for this assessment, as it is a ratio that is less sensitive to absolute biomass estimation errors. The consistent finding that SL_{50} is significantly lower than L_{50} for all three species in the current study is a major red flag that needs management attention.

6.2. MANAGEMENT IMPLICATIONS

The findings collectively point to a situation where the tuna fishery in URT waters is exerting considerable pressure on the assessed stocks, particularly impacting their reproductive potential due to the prevalent capture of immature fish.

Stock Health: Considering that the SPR values for bigeye, yellowfin, and skipjack tuna are all below 0.40, the stocks of these three species are considered to be at a high risk of overfishing and potential recruitment impairment.

Exploitation Patterns: A major red flag for sustainability is the consistent finding that harvested individuals across all three species (bigeye, yellowfin, and skipjack tuna) are being caught at sizes smaller than L_{50} (the size at which 50% of the population reaches maturity).50 50 (most acutely for Yellowfin) is. This issue appears more pronounced in the current assessment's SL_{50} estimates compared to TAFIRI (2024) for yellowfin and bigeye.

In conclusion, while URTs tuna resources hold significant economic potential, this assessment indicates that current exploitation levels and patterns pose risks to their long-term sustainability. A shift towards more precautionary and ecosystem-based management approaches, with a strong focus on protecting juvenile fish and improving gear selectivity, is necessary to ensure the health of these valuable stocks for future generations and to support the goals of the blue economy.

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