ORIGINAL RESEARCH

Stock status of *Tylosurus imperialis* in the İskenderun Bay at the northeastern Mediterranean based on data-limited assessment methods

Cemal Turan*

Atlas University, Faculty of Engineering and Natural Sciences, Department of Molecular Biology and Genetics, İstanbul, Türkiye.
ORCID *Cemal Turan* https://orcid.org/0000-0001-9584-0261

ABSTRACT. This study evaluated the stock status of *Tylosurus imperialis* in İskenderun Bay (northeastern Mediterranean Sea) using monthly length-frequency data collected between April and November 2022. Growth parameters were estimated using the Electronic Length Frequency Analysis (ELEFAN) approach implemented in the TropFishR framework. The von Bertalanffy Growth Function parameters were estimated as L_∞ = 127 cm, k = 0.56 year^{-1}, and t_0 = -0.60 year^{-1}, with a growth performance index (Φ′) of 3.95. Gear selectivity analysis estimated a length at first capture (L_{50}) of 76 cm, corresponding to approximately 1.64 years of age. Length-based cohort analysis indicated considerable variation in fishing mortality among size classes, with the highest exploitation observed around 83 cm. Estimated total mortality (Z = 1.81 year^{-1}) and natural mortality (M = 0.54 year^{-1}) yielded a fishing mortality of F = 1.27 year^{-1} and an exploitation rate of E = 0.69. Although fishing mortality was below the estimated $F_{0.1}$ reference point, the exploitation rate exceeded the precautionary threshold ($E_{0.5}$ = 0.55). Yield-per-recruit analysis suggested an optimal length at first capture close to the current estimate (76 cm) and indicated limited potential yield gains under increased fishing effort. While the results suggest that the stock may be experiencing relatively high exploitation pressure, these findings should be interpreted with caution given the data-limited nature of the assessment. Nevertheless, the study provides the first stock assessment information for *T. imperialis* in the northeastern Mediterranean and offers a basis for future monitoring and management efforts.

Key words: Stock assessment, virtual population analyses, biological reference points.

Estado de las poblaciones de *Tylosurus imperialis* en la Bahía de İskenderun, en el noreste del Mediterráneo, basado en métodos de evaluación con datos limitados

RESUMEN. Este estudio evaluó el estado de las poblaciones de *Tylosurus imperialis* en la Bahía de İskenderun (noreste del Mar Mediterráneo) utilizando datos mensuales de frecuencia de longitud recopilados entre abril y noviembre de 2022. Los parámetros de crecimiento se estimaron utilizando el enfoque de Análisis Electrónico de Frecuencia de Longitud (ELEFAN) implementado en el marco TropFishR. Los parámetros de la función de crecimiento de von Bertalanffy se estimaron como L_∞ = 127 cm, k = 0,56 año^{-1} y t_0 = -0,60 año^{-1}, con un índice de rendimiento de crecimiento (Φ′) de 3,95. El análisis de selectividad de artes de pesca estimó una longitud en la primera captura (L_{50}) de 76 cm, correspondiente a aproximadamente 1,64 años de edad. El análisis de cohortes basado en la longitud indicó una variación considerable en la mortalidad por pesca entre las clases de tamaño, con la mayor explotación observada alrededor de los 83 cm. La mortalidad total estimada (Z = 1,81 año^{-1}) y la mortalidad natural (M = 0,54 año^{-1}) arrojaron una mortalidad por pesca de F = 1,27 año^{-1} y una tasa de explotación de E = 0,69. Aunque la mortalidad por pesca fue inferior al punto de referencia estimado $F_{0.1}$, la tasa de explotación superó el umbral de precaución ($E_{0.5}$ = 0,55). El análisis de rendimiento por recluta sugirió una longitud óptima en la primera captura cercana a la estimación actual

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*Correspondence:
cemal.turan@yahoo.com

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(76 cm) e indicó ganancias potenciales limitadas en el rendimiento bajo un mayor esfuerzo pesquero. Si bien los resultados sugieren que la población puede estar experimentando una presión de explotación relativamente alta, estos hallazgos deben interpretarse con cautela dada la naturaleza limitada de los datos de la evaluación. No obstante, el estudio proporciona la primera información de evaluación de la población de *T. imperialis* en el Mediterráneo nororiental y ofrece una base para futuros esfuerzos de monitoreo y gestión.

Palabras clave: Evaluación de poblaciones, análisis de poblaciones virtuales, puntos de referencia biológicos.

INTRODUCTION

Sustainable fisheries management relies on accurate stock assessments; however, many fisheries worldwide, particularly in the Mediterranean Sea, are characterized by limited data availability. In such data-poor contexts, conventional age-structured stock assessment models are often not applicable, necessitating the use of alternative approaches based on length-frequency data (Pauly and Morgan 1987; Hilborn and Walters 2013; Turan 2021). Length-based methods, such as the Electronic Length Frequency Analysis (ELEFAN), have therefore become widely used tools for assessing stock dynamics and exploitation status in data-limited fisheries (Pauly and David 1981; Sparre and Venema 1999; Froese et al. 2017).

The Mediterranean Sea hosts a diverse assemblage of small pelagic and coastal predatory species that support artisanal and small-scale fisheries. However, many of these fisheries are considered data-limited and subject to increasing exploitation pressure (Colloca et al. 2013; FAO 2023). Among these, garfish species (Belonidae) represent an ecologically and economically important group (Turan et al. 2025a), yet their population dynamics remain poorly understood, particularly in the eastern Mediterranean.

Tylosurus imperialis is a pelagic predatory species distributed in tropical and subtropical waters, including the Mediterranean Sea (Collette 2003). In Turkish waters, it co-occurs with other garfish species such as *Belone belone* and *B. svetovidovi*, which are often collectively reported in fisheries statistics (Turan et al. 2024; Uyan et al. 2025; Yaglioglu et al. 2025). This taxonomic aggregation complicates species-specific stock assessments and may mask differences in growth, mortality, and exploitation patterns among species (FAO 2023; Ergüden et al. 2025). Recent trends indicate fluctuations and an overall decline in garfish landings in Türkiye and across the Mediterranean, raising concerns about stock sustainability (FAO 2023). Despite this, the lack of species-specific biological and fisheries data continues to limit the development of effective management strategies (Ergüden et al. 2025). In particular, the absence of minimum landing size regulations and the reliance on aggregated catch data highlight critical gaps in current fisheries management frameworks.

Length–frequency-based approaches provide a practical solution for evaluating stock status under such data-limited conditions. These methods allow for the estimation of key population parameters, including growth, mortality, and exploitation rates, using routinely collected catch data (Sparre and Venema 1999; Mildenberger et al. 2017). Recent advances in computational tools, such as the TropFishR package, have enhanced the implementation and reproducibility of length-based assessment methods by providing standardized analytical workflows and facilitating uncertainty exploration; however, they do not eliminate the inherent assumptions and limitations associated with length-frequency-based stock assessments (Mildenberger et al. 2017).

The present study aimed to assess the stock status of *T. imperialis* in İskenderun Bay (northeastern Mediterranean) using monthly length-frequency data and length-based analytical methods. Specifically, the present study estimates growth parameters, mortality rates, selectivity patterns, and biological reference points to evaluate the current exploitation status of the stock. The findings are expected to contribute to the development of species-specific management strategies and support sustainable fisheries management in the region.

MATERIALS AND METHODS

Sampling and data collection

Specimens of *T. imperialis* were collected monthly from commercial trawl catches in İskenderun Bay (northeastern Mediterranean Sea, Türkiye) between April 2022 and November 2022. Fish were randomly sampled onboard immediately after capture to obtain length-frequency data representative of the catch composition. Because samples were derived from commercial fishing operations, the resulting length distributions reflect the component of the population vulnerable to the fishing gear rather than the entire population.

Each individual was measured for total length (TL, cm) to the nearest 0.1 cm using a measuring board and weighed to the nearest gram (g) using an electronic balance. A total of 146 individuals were collected during the study period. Monthly sample sizes are presented in Table 1.

Length-frequency analysis and growth estimation

Length-frequency catch data (LFCD) were analyzed using the Electronic Length Frequency Analysis (ELEFAN) routine implemented in the TropFishR package (version 1.6.2) in R (Mildenberger et al. 2017; Taylor and Mildenberger 2017). Growth parameters of the von Bertalanffy Growth Function (VBGF) were estimated using the genetic algorithm optimization procedure (ELEFAN_GA), which searches for the parameter combination that maximizes the goodness-of-fit between observed length-frequency distributions and predicted growth trajectories. The ELEFAN growth-fitting procedure identified multiple modal progressions across the monthly length-frequency distributions, allowing cohort trajectories to be tracked throughout the sampling period. The fitted growth curves showed a general correspondence with modal features observed in the length-frequency data (Figure 1), allowing the estimation of growth parameters. However, some overlap among adjacent size classes was evident, and cohort progression should therefore be interpreted with appropriate caution given the limited sample size and sampling duration. Growth parameters and related metrics were further explored using the FSA (Fisheries Stock Assessment) package in R (Ogle et al. 2020). The growth performance index (Φ') was calculated to facilitate comparison with other studies.

Selectivity and size at capture

Gear selectivity was estimated using the trawl-type selectivity ogive model implemented in TropFishR (Taylor and Mildenberger 2017). Selectivity was derived from the ascending limb of the length-converted catch curve and modelled using a logistic ogive describing the probability of capture as a function of relative age and corresponding fish length. The model assumes that retention probabil-

Table 1. Monthly distribution of collected *Tylosurus imperialis* from the İskenderun Bay.

	April	May	June	July	August	September	October	November
N	15	22	14	18	24	20	16	18

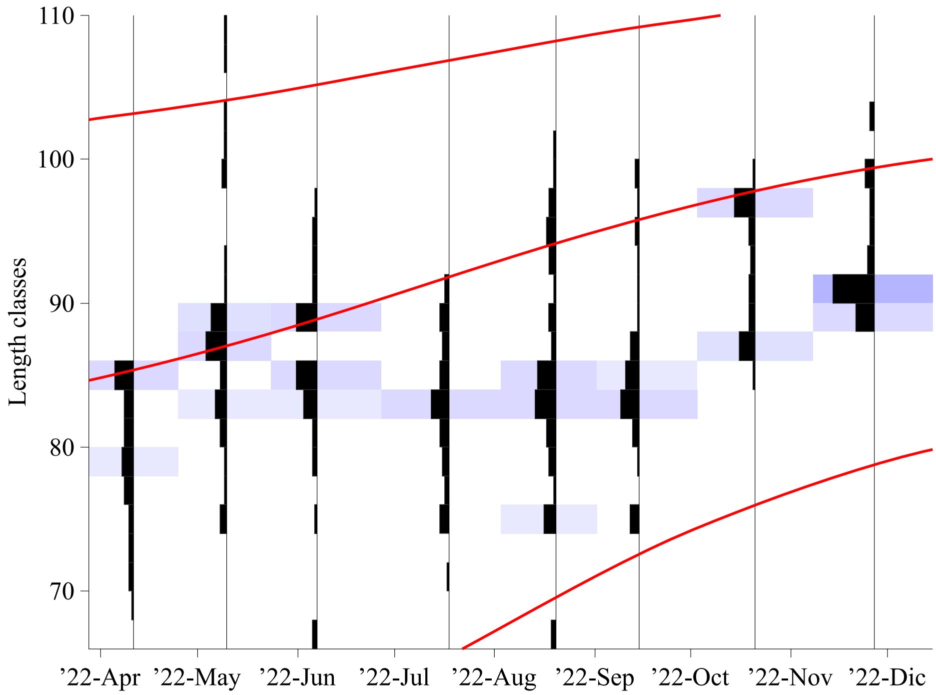

Figure 1. Monthly length-frequency distributions of *Tylosurus imperialis* sampled from İskenderun Bay, with the fitted von Bertalanffy Growth Function (VBGF) curve (red line) overlaid. The fitted growth curve is shown in relation to the observed length-frequency distributions and modal features identified during the ELEFAN analysis. Given the limited sample size and the fishery-dependent nature of the dataset, cohort progression should be interpreted with caution.

ity increases progressively with fish size until full recruitment to the fishery is achieved. The lengths corresponding to 25%, 50%, 75%, and 95% retention probabilities (L_{25}, L_{50}, L_{75}, and L_{95}) were estimated from the fitted selectivity curve. The procedure assumes that selectivity is primarily size-dependent and remains constant throughout the sampling period. The size at maturity was estimated using the sizeMat package in R, which fits logistic models to length-based maturity data to derive maturity ogives.

Mortality and exploitation rates

Natural mortality (M) was estimated using the growth-based empirical equation proposed by Then et al. (2015), which relates natural mortality to the von Bertalanffy growth parameters (L_∞ and K). Fishing mortality (F) and exploitation rate (E) were subsequently calculated as $F = Z - M$ and $E = F/Z$, respectively (Gulland 1985; Hoggarth et al. 2006).

Cohort analysis and yield prediction

Length-based Virtual Population Analysis (VPA) was conducted following the procedures described by Sparre and Venema (1999) and Lassen and Medley (2001) to estimate fishing mortality across length classes. The analysis reconstructs population abundance sequentially from catch-at-length data using estimates of growth, natural mortality, and gear selectivity. Fishing mortality for the terminal length class was initialized using the fishing mortality estimate derived from the length-converted catch curve, and population abundance in preceding length classes was reconstructed iteratively. The analysis assumes constant growth, natural mortality, and selectivity during the assessment period and that the observed length-frequency distributions adequately represent the exploited component of the stock. The outputs from the VPA, including estimates of stock abundance, biomass, and fishing mortality by length class, were subsequently used as input parameters in the Thompson and Bell (1934) yield prediction model. This model was applied to evaluate the effects of alternative fishing mortality and length-at-first-capture scenarios on yield and biomass and to estimate biological reference points, including proxies of maximum sustainable yield (MSY). Changes in fishing effort were simulated by varying fishing mortality, whereas selectivity scenarios were evaluated by modifying the length at first capture (Lc) through the trawl-ogive selectivity model (Thompson and Bell 1934; Pauly and Morgan 1987; Schnute 1987).

RESULTS

Length-frequency distribution and growth parameters

Monthly length-frequency data of *T. imperialis* collected from the coastal waters of İskenderun Bay were analyzed to assess stock status under data-limited conditions. The analysis was conducted using the Electronic Length Frequency Analysis (ELEFAN) approach implemented in the TropFishR package.

The von Bertalanffy Growth Function (VBGF) parameters estimated for *T. imperialis* were L_∞ = 127 cm, k = 0.56 year^{-1}, and t_0 = -0.60 year^{-1}, with a growth performance index (Φ′) of 3.95. The fitted growth curve showed a general correspondence with modal features observed in the monthly length-frequency distributions (Figure 1), allowing the estimation of growth parameters. However, cohort progression was not consistently distinct throughout the sampling period, and the resulting growth estimates should therefore be interpreted with appropriate caution.

Gear selectivity and size at first capture

Gear selectivity analysis indicated that the length at first capture (L_{50}) was 76 cm TL, corresponding to an age of approximately 1.64 years (Figure 2). The lengths at which 75% and 95% of individuals are retained by the gear were estimated as L_{75} = 78 cm (1.71 years) and L_{95} = 81.2 cm (1.83 years), respectively (Figure 2).

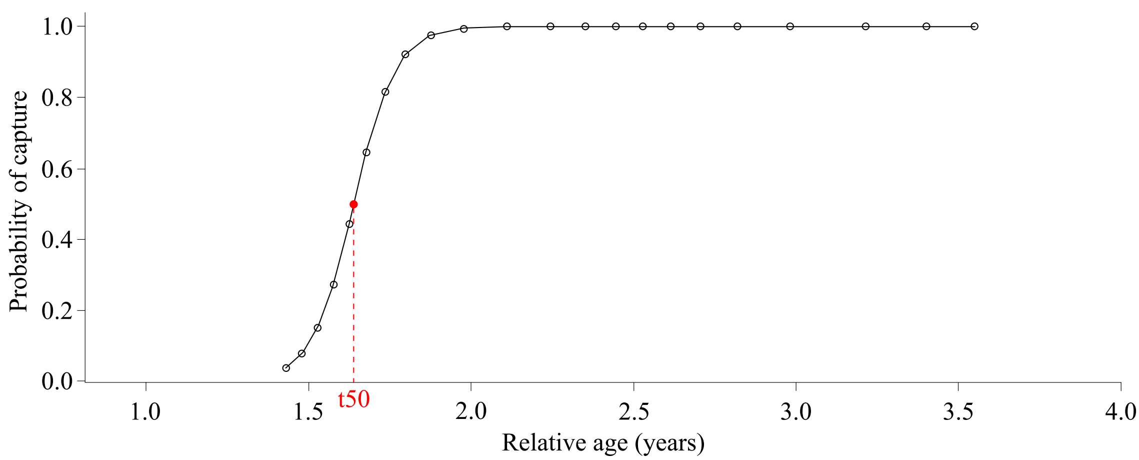

Figure 2. Selectivity give for *Tylosurus imperialis* showing the probability of capture as a function of total length (TL). The estimated lengths at 50%, 75%, and 95% retention (L_{50}, L_{75}, and L_{95}) are indicated, corresponding to 76 cm, 78 cm, and 81.2 cm TL, respectively. These values reflect the size-dependent selectivity pattern of the fishing gear.

Cohort structure and fishing mortality patterns

Length-based cohort analysis revealed marked variability in fishing mortality across size classes (Figure 3). Fishing mortality (F) ranged from 0.037 $year^{-1}$ at 69 cm to a maximum of 5.51 $year^{-1}$ at 99 cm. The highest catch intensity was observed at the 83 cm size class, whereas the lowest catch was recorded at 105 cm, indicating strong size-dependent fishing pressure (Figure 3).

Mortality, exploitation rates and yield analysis

The estimated instantaneous total mortality (Z) and natural mortality (M) were 1.81 $year^{-1}$ and 0.54 $year^{-1}$, respectively. Biological reference points derived from yield-per-recruit analysis were estimated as FMSY = 3.54, $F_{0.1}$ = 1.72, and $F_{0.5}$ = 0.99, with corresponding exploitation rates EMSY = 1.96 and $E_{0.5}$ = 0.55 (Figure 4). The current fishing mortality (F_{cur} = 1.27) and exploitation rate (E_{cur} = 0.69) remained below the $F_{0.1}$ and Fmax reference points but exceeded the precautionary exploitation reference point ($E_{0.5}$) (Figure 4). These results indicated relatively elevated exploitation levels within the assumptions of the yield-per-recruit framework.

Yield-per-recruit analysis indicated that the optimal length at first capture (Lc) was approximately 76 cm TL (Figure 4). The isopleth diagram demonstrated that increasing fishing mortality under the current selectivity regime would not substantially improve yield, with predicted gains limited to an increase from approximately 600 g to a maximum of 700 g (Figure 4). These results indicate that projected yield gains under higher fishing mortality scenarios are limited within the assumptions of the model, suggesting that further increases in fishing effort would provide only marginal increases in yield (Figure 4).

DISCUSSION

Growth dynamics and model performance

Sustainable fisheries management depends on robust stock assessments. However, a substantial

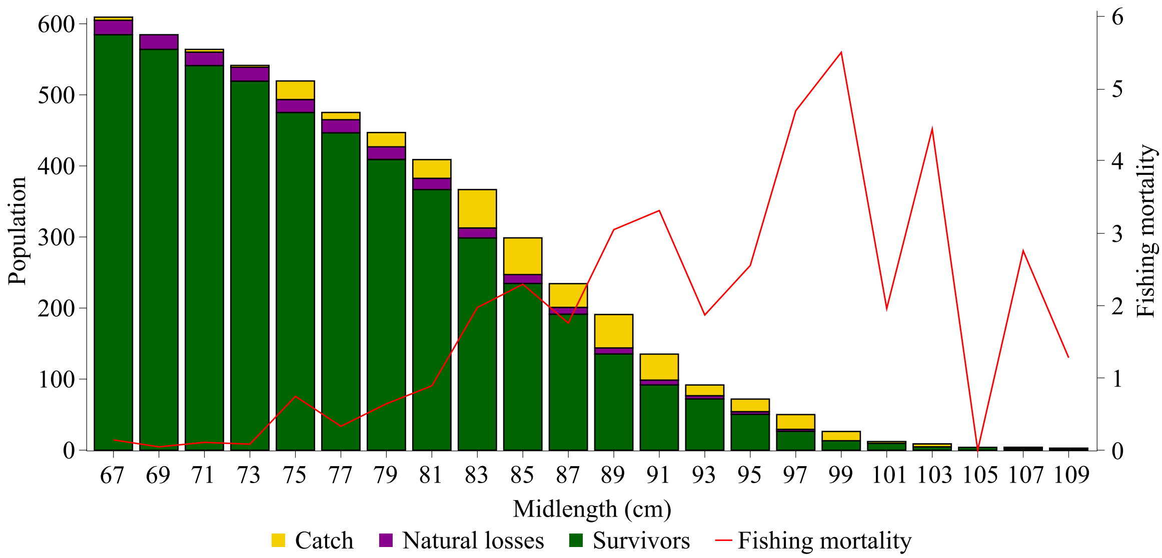

Figure 3. Length-based cohort analysis of *Tylosurus imperialis* illustrating fishing mortality (F, right y-axis) and catch distribution across length classes (x-axis). The analysis highlights strong size-dependent variation in fishing pressure, with peak exploitation occurring around intermediate size classes.

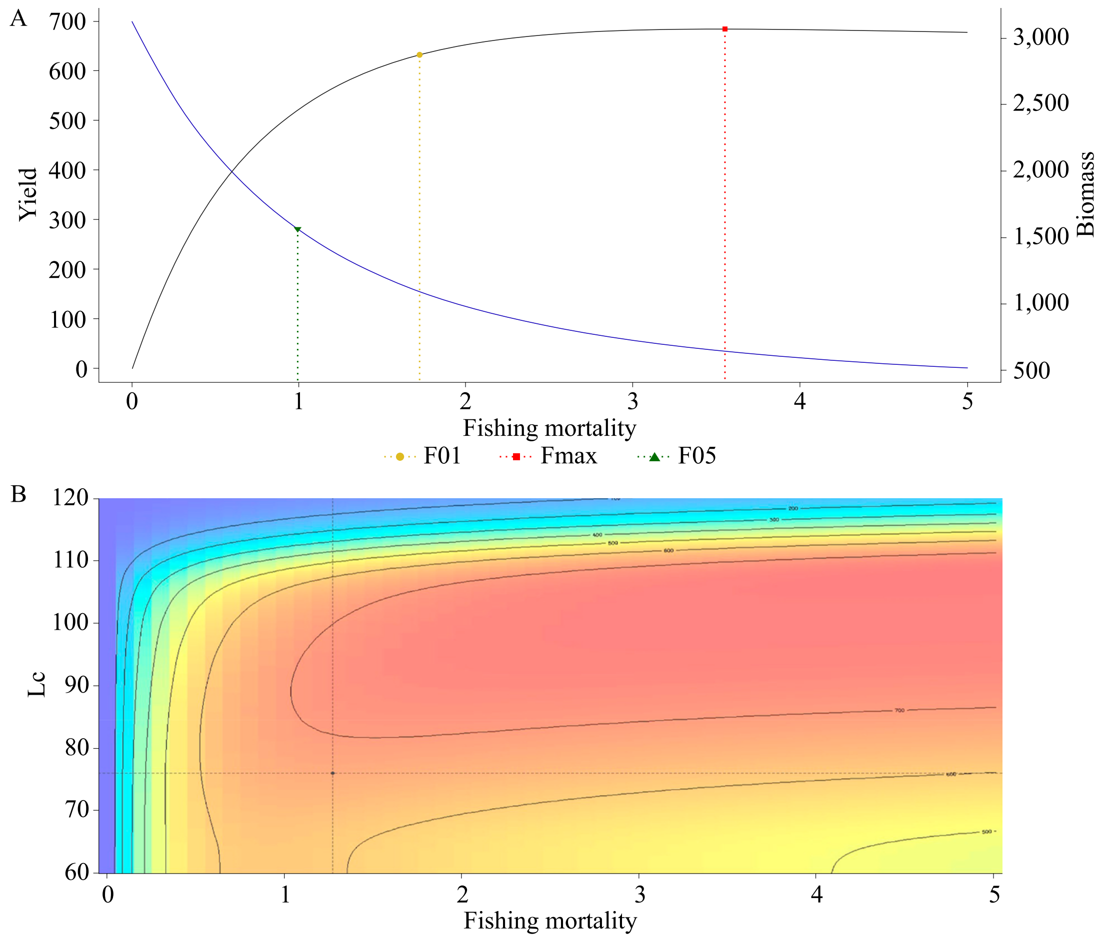

Figure 4. Yield-per-recruit (Y/R) and biomass-per-recruit (B/R) analysis for *Tylosurus imperialis*. A) Relative yield- and biomass-per-recruit curves as a function of fishing mortality (F). B) Yield isopleth diagram showing the combined effects of F and length at first capture (L_c) on yield. The position of current exploitation (F_{cur}, L_c) is indicated, relative to the predicted yield surface.

proportion of global fisheries, particularly in the Mediterranean Sea, are characterized by limited data availability. Under such data-poor conditions, conventional age-structured assessment models are often impractical, necessitating the adoption of alternative approaches based on length-frequency data (Pauly and Morgan 1987; Hilborn and Walters 2013; Turan 2022). Consequently, length-based methods such as the Electronic Length Frequency Analysis (ELEFAN) have become widely applied tools for estimating population dynamics and exploitation status in data-limited fisheries (Pauly and David 1981; Sparre and Venema 1998; Froese et al. 2018; Turan 2022). More recently, open-source analytical frameworks such as TropFishR have improved the reproducibility, transparency, and accessibility of length-based analyses, although they do not eliminate uncertainties associated with sampling design, selectivity, recruitment variability, or model assumptions (Mildenberger et al. 2017; Taylor and Mildenberger 2017).

Results of the present study provide new insights into the population dynamics of *T. imperialis* in İskenderun Bay based on length-frequency data.

The estimated growth parameters indicate relatively rapid growth compared to other Mediterranean belonids, which may reflect species-specific life-history traits or local environmental conditions. The fitted growth curve showed a general correspondence with modal features observed in the length-frequency distributions (Figure 1), allowing the estimation of growth parameters using the ELEFAN framework. However, cohort progression was not consistently distinct throughout the sampling period, and the resulting growth estimates should therefore be interpreted with caution. Furthermore, because the analysis was based on fishery-dependent samples obtained from commercial trawl catches, observed length distributions represent the exploited component of the population rather than the entire population. Consequently, gear selectivity and incomplete representation of certain size classes may have influenced the estimated growth parameters.

The relatively limited sample size available for this study (n = 146) should be considered when interpreting results. Length-based methods such as ELEFAN rely on the identification of modal progression patterns within length-frequency distributions, and their performance may be influenced by sample size, cohort representation, and recruitment variability (Isaac 1990; Schwamborn 2018). Although monthly sampling allowed the detection of distinct size classes and provided sufficient information to estimate growth and mortality parameters, the limited number of observations may contribute to uncertainty in parameter estimates. Consequently, results should be regarded as preliminary indicators of stock status and would benefit from validation through larger sample sizes and longer-term monitoring programs.

Gear selectivity and implications for size structure

Gear selectivity analysis demonstrated that fishing activity primarily targets intermediate size classes. The Mediterranean Sea supports a highly diverse assemblage of coastal and pelagic species that underpin artisanal and small-scale fisheries, yet many of these stocks remain data-limited and increasingly exploited (Colloca et al. 2013; FAO 2023). Within this context, garfish species (Belonidae) constitute an ecologically important group of epipelagic predators, although their population dynamics remain poorly resolved, particularly in the eastern Mediterranean.

The fitted growth curve showed a general correspondence with modal features observed in the length-frequency distributions, allowing the estimation of growth parameters using the ELEFAN framework (Pauly and David 1981; Taylor and Mildenberger 2017). However, cohort progression was not consistently distinct throughout the sampling period, and the resulting growth estimates should therefore be interpreted with caution. Furthermore, because the analysis was based on fishery-dependent samples obtained from commercial trawl catches, the observed length distributions represent the exploited component of the population rather than the entire population. Consequently, gear selectivity and incomplete representation of certain size classes may have influenced the estimated growth parameters (Isaac 1990; Schwamborn 2018).

Mortality, exploitation and stock status

Tylosurus imperialis is a pelagic predator distributed across tropical and subtropical waters, including the Mediterranean Sea (Collette 2003). In Turkish waters, it co-occurs with other belonid species such as *B. belone* and *B. svetovidovi*, which are often reported collectively in fisheries statistics (Turan et al. 2025a, 2025b; TÜİK 2025). This aggregation complicates species-specific assessments and may obscure differences in mortality and exploitation patterns (FAO 2023; Froese and Pauly 2025).

The estimated mortality and exploitation rates suggest that *T. imperialis* may be experiencing relatively high fishing pressure. However, these indicators are derived from growth parameters, catch-curve analyses, and empirical estimates of natural mortality, each of which is associated with uncertainty in data-limited assessments (Hordyk et al. 2015; Froese et al. 2018). Consequently, the magnitude of fishing pressure and exploitation should be interpreted with caution, particularly given the data-limited nature of the assessment, the fishery-dependent sampling design, and the absence of a formal sensitivity analysis.

Although fishing mortality (F_{cur}) remained below $F_{0.1}$, the estimated exploitation rate ($E_{cur} = 0.69$) exceeded the precautionary reference level ($E_{0.5}$). This result suggests relatively elevated exploitation levels under the assumptions of the yield-per-recruit framework and may indicate increased fishing pressure on the stock. However, because the present study did not estimate stock biomass, spawning stock biomass, recruitment dynamics, or spawning potential ratio, these results should not be interpreted as direct evidence of stock depletion or overexploitation status. This pattern aligns with broader regional trends, where Mediterranean stocks frequently exhibit elevated exploitation rates despite moderate fishing mortality (Colloca et al. 2013; FAO 2023). Furthermore, length-based cohort analysis revealed strong size-dependent fishing mortality, with peak exploitation occurring at intermediate sizes, highlighting uneven fishing pressure across the population.

An additional source of uncertainty arises from the estimation of natural mortality (M), which was derived using the empirical equation of Then et al. (2015). Because fishing mortality (F) and exploitation rate (E) are calculated directly from M, uncertainty in natural mortality estimates may propagate through subsequent stock assessment outputs and influence the inferred exploitation status of the stock. Although a formal sensitivity analysis was beyond the scope of the present study, future assessments would benefit from evaluating alternative natural mortality estimators and quantifying the sensitivity of stock status indicators to variation in M (Hordyk et al. 2015; Then et al. 2015).

Yield optimization and management implications

Yield-per-recruit analysis indicated that projected yield increased only marginally under higher fishing mortality scenarios, suggesting limited additional yield gains within the assumptions of the model. However, yield-per-recruit analyses evaluate relative changes in yield under alternative fishing mortality and selectivity scenarios and do not directly estimate stock biomass, recruitment dynamics, reproductive potential, or overall stock status. Therefore, these results should be interpreted as indicators of potential yield responses rather than direct evidence of optimal exploitation. Similar limitations and sources of uncertainty have been highlighted in contemporary data-limited stock assessment studies (Carruthers et al. 2014; Hordyk et al. 2015; Froese et al. 2018). From a management perspective, the available evidence suggests that further increases in fishing effort may provide limited yield benefits under the assumptions of the present assessment framework, while potentially increasing fishing pressure on the stock. However, these conclusions should be interpreted in light of the uncertainties associated with growth estimation, mortality parameters, selectivity assumptions, and the fishery-dependent nature of the dataset. Consequently, a precautionary management approach is warranted. Potential measures may include maintaining or reducing fishing effort, improving gear selectivity through mesh-size modifications, implementing size-based regulations, and aligning the length at first capture with size at maturity to enhance reproductive output and support long-term sustainability.

Data limitations and future directions

Several limitations of the present study should be acknowledged. The assessment was based on length-frequency data collected over a relatively short sampling period and derived exclusively from commercial catches, representing the exploited component of the population rather than its entire size structure. Consequently, the observed length distributions may be influenced by gear selectivity and differential availability of fish to the fishing gear. In addition, ELEFAN-derived growth estimates depend on the identification of modal progression patterns in length-frequency distributions, which may be affected by recruitment variability, cohort overlap, and sample size limitations. Uncertainty associated with growth parameters, natural mortality estimates, selectivity patterns, and biological reference points may further propagate through subsequent analyses, including mortality estimation, virtual population analysis, and yield-per-recruit modelling. Therefore, the exploitation indicators presented here should be interpreted as preliminary estimates within a data-limited assessment framework rather than definitive measures of stock status. Nevertheless, in the absence of age-structured datasets and long-term monitoring programs, length-based approaches provide valuable baseline information and represent a practical tool for supporting fisheries assessment and management in the northeastern Mediterranean. Despite providing valuable insights, this study is subject to several limitations inherent to data-limited fisheries. The reliance on length-frequency data, while practical, may introduce uncertainties related to recruitment variability and sampling representativeness. Additionally, the aggregation of belonid species in fisheries statistics remains a critical constraint for species-specific assessments (Turan et al. 2025a)

Future research should focus on improving species-level data collection, incorporating fishery-independent survey data, and integrating complementary assessment approaches such as length-based spawning potential ratio (LB-SPR), LBB, and other contemporary data-limited methods (Hordyk et al. 2015; Prince et al. 2015; Froese et al. 2018). Strengthening long-term monitoring programs and regional data-sharing initiatives will be essential for reducing uncertainty and improving future assessments of Mediterranean belonid stocks. In conclusion, this study provides the first length-based assessment of *T. imperialis* in İskenderun Bay under data-limited conditions. The analyses generated preliminary estimates of growth, selectivity, mortality, and yield-per-recruit characteristics that contribute to the limited biological and fisheries information currently available for this species in the Mediterranean. The estimated exploitation indicators suggest that fishing pressure may be relatively elevated; however, these findings should be interpreted cautiously given the uncertainties associated with growth estimation, mortality parameters, selectivity assumptions, and the fishery-dependent nature of the dataset. The yield-per-recruit analysis indicated limited projected yield gains under increased fishing mortality scenarios, suggesting that further increases in fishing effort may provide little additional benefit within the assumptions of the model. Consequently, precautionary management measures, including improvements in gear selectivity and consideration of species-specific size regulations, may contribute to sustainable exploitation. More comprehensive assessments incorporating larger sample sizes, longer time series, fishery-independent surveys, and contemporary data-limited assessment approaches (e.g. LBSPR, LBB, CMSY, and SPiCT) would help reduce uncertainty and improve future evaluations of stock status. Despite these limitations, length-based methods remain valuable tools for generating baseline fisheries information in data-limited Mediterranean ecosystems.

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Conflict of interest

There is no conflict of interest.

Artificial intelligence uses declaration

In manuscript preparation, AI-based tools (ChatGPT) were used solely for grammar correction and text fluency improvement. The prompts used were generic requests for improve grammar or enhance readability and interpretation.

Author contributions

Cemal Turan: conceptualization; process; research; materials; formal analysis; software; verification; data curation; composing the first draft; composing the review, and editing.

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