BOLETIM DO INSTITUTO DE PESCA
Scientific Article

Stock assessment of endemic tarek (*Alburnus tarichi* Güldenstädt, 1814) for the data-poor fishery from Lake Van (Türkiye)

Ferhat Demirol[1], Mehmet Cilbiz[2]*

[1]Fisheries Research Institute – Elazığ, Türkiye.
[2]Isparta University of Applied Sciences – Faculty of Eğirdir Fisheries – Department of Fishing and Processing Technology – Isparta, Türkiye.
*Corresponding author: mehmetcilbiz@isparta.edu.tr

ABSTRACT

Alburnus tarichi accounts for about 30% of the annual inland water catch in Turkiye, which is about 33 thousand tonnes. Lake Van is the world's largest alkaline lake and Turkiye's largest lake, at 3,602 km^2. Due to the unavailability of detailed data for the data-rich models, the stock of *A. tarichi* was assessed by the catch-based maximum sustainable yield (CMSY) model, based on catch data from years 1967 to 2021. The values with their confidence intervals were computed for the Lake Van tarek stock by the CMSY model and are showed as follows: MSY = 12.3 (10.8–14.2) ton^{*1,000}, k = 92.4 (66.5–129) ton^{*1,000}, r = 0.536 (0.377–0.76)·year^{-1}, B_{2021} = 48.0 (29.4–55.1) ton^{*1,000}, B_{MSY} = 46.2 (33.2–64.3) ton^{*1,000}, F_{2021} = 0.202 (0.180–0.338)·year^{-1}, F_{MSY} = 0.268 (0.189–0.380)·year^{-1}, F_{2021}/F_{MSY} = 0.772 (0.672–1.260), and B_{2021}/B_{MSY} = 1.04 (0.636–1.190). This study revealed that the stock of *A. tarichi* was subjected to significant and continuously increasing fishing pressure from the early unexploited years (1967–1996) and eventually became overfished in subsequent years (1997–2010). After the prohibition of summer fishing in 1997, which significantly reduced recruitment, the stock began to enter a recovery period in the early 2000s. As a result, the stock of *A. tarichi* has reached a sustainable level currently and has been assessed as a healthy stock based on the CMSY outputs.

Keywords: CMSY method; Small-scale fisheries; Lake Van; sustainability; Fisheries management.

Avaliação das unidades populacionais do tártaro endémico (*Alburnus tarichi* Güldenstädt, 1814) para a pescaria com poucos dados do lago Van (Türkiye)

RESUMO

O Alburnus tarichi representa cerca de 30% da captura anual em águas interiores na Turquia, que é de cerca de 33 mil toneladas. O lago Van é o maior lago alcalino do mundo e o maior lago da Turquia, com 3.602 km2. Devido à indisponibilidade de dados pormenorizados para os modelos ricos em dados, a unidade populacional de *A. tarichi* foi avaliada pelo modelo de rendimento máximo sustentável baseado nas capturas (CMSY), com base nos dados de captura dos anos 1967 a 2021. Os valores e os seus intervalos de confiança foram calculados para a unidade populacional do lago Van tarek pelo modelo CMSY e são apresentados do seguinte modo MSY = 12,3 (10,8-14,2) ton$^{*1.000,}$ k = 92,4 (66,5-129) ton$^{*1.000}$, r = 0,536 (0,377-0,76)·ano^{-1}, B_{2021} = 48,0 (29,4-55,1) ton$^{*1.000}$, B^{MSY} = 46,2 (33,2-64,3) ton^{*1,000}, F_{2021} = 0,202 (0,180-0,338)·ano^{-1}, F_{MSY} = 0,268 (0,189-0,380)·ano^{-1}, F_{2021}/F_{MSY} = 0,772 (0,672-1,260), e B_{2021}/B_{MSY} = 1,04 (0,636-1,190). Este estudo revelou que a unidade populacional de A. tarichi foi sujeita a uma pressão de pesca significativa e continuamente crescente desde os primeiros anos de inexploração (1967-1996) e acabou por ser objeto de sobrepesca nos anos seguintes (1997-2010). Após a proibição da pesca estival em 1997, que reduziu significativamente o recrutamento, a unidade populacional começou a entrar num período de recuperação no início da década de 2000. Consequentemente, a unidade populacional de A. tarichi atingiu atualmente um nível sustentável e foi avaliada como uma unidade populacional saudável com base nos resultados do CMSY.

Palavras-chave: Método CMSY; Pesca de pequena escala; Lago Van; Sustentabilidade; Gestão das pescas.

Received: November 13, 2023 | **Approved:** April 12, 2024
Section editor: Raniere Garcez Costa Sousa

INTRODUCTION

It is known from written historical records that tarek, the only species that can adapt to the salty and soda waters of Lake Van, has been fishing for about one thousand years (Şen et al., 2015). There are five populations of tarek endemic to the Lake Van basin, which is a closed basin, and the largest of these populations is the Van Lake population (Demirol, 2022). However, this species is at risk in a closed basin and may suffer adverse impacts from environmental situation or human intervention. The tarek was placed on the red list in year 1996 by the International Union for Conservation of Nature due to its close status as a species of concern with a declining population trend (Freyhof, 2014; Şen et al., 2015).

In general, fishermen of Lake Van use two different methods to catch tarek, with seasonal variations. The first of these methods is a traditional approach that has been used since ancient times and involves fishing in rivers or downstream during the breeding migration. Although this method is now completely prohibited by fishing regulations, in practice it is not finished. The second method is commercial fishing during the fishing season, between July 15 and April 15 (Demirol & Yüksel, 2022).

Sarı (2001) reported in a study conducted between 1994 and 1997 in Lake Van that the total annual catch was 12,880 tons on average, and 92% of this was done by traditional methods applied during the breeding period. This method is based on the principle of fishing with a beach seine net for collected fish in downstream for breeding migration. With the prohibition of this method in 1997, the rate of fish caught using this method in the total amount of fish has been decreasing over the years. This rate, which was 92% in 1997, decreased to 60% in 2006 (Sarı, 2008) and to approximately 15–20% in 2021 (Demirol, 2022).

Türkiye's inland fisheries catch data has been collected since the 1950s. The collection of catch data of tarek started in 1967. Tarek has accounted for around 30% of the catch in Turkiye's inland fisheries in recent years. As it can be seen in Fig. 1, the increasing or decreasing tarek fisheries have a significant impact on Turkiye's inland fisheries. Sustainable management of the tarek stock in Lake Van, which is the source of almost all tarek fishing, is imperative for the sustainability of inland fish supply not only for the region, but also for the whole of Türkiye. Stock assessment studies can be a good reference to know that the permanency of generations of tarek, which has an extremely important cultural value for the civilizations that existed on the shores of Lake Van, as well as its commercial value, are also safe.

There are two stock assessment studies on the tarek of Lake Van so far. These two studies were carried out by Sarı (2001) between the years 1994 and 1996 and by Demirol (2022) between the years 2017 and 2021. Except for the annual catch, no data has been collected for stock assessment outside these time periods.

We have the detailed data necessary for assessing the tarek stock of Lake Van in only a limited time. Therefore, stock assessment models with limited data must be preferred. The aimed of this study was to provide essential information for the management in sustainable scale of the data-inadequate tarek stock in Van Lake, the primary stock of inland fisheries in Türkiye.

MATERIALS AND METHODS

Study area

Throughout the Earth, there are many soda lakes of different sizes spread over the continents. Among the soda lakes, Great Soda Lake, Mono Lake, and Lake Owens in the United States of America, Lonar Lake in India, Wadi Natrun Lake in Egypt, Lake Magadi in Kenya, and Lake Van in Türkiye are the most well-known lakes (Grant & Sorokin, 2011).

Lake Van has a maximum depth of 451 meters. It is the largest lake in Turkiye, with an area of 3,602 km^2 and 614 km^3 water volume. Lake Van is the largest alkaline lake in the world. It has pH = 9.7 and salinity = 21.7‰ (Fig. 2) (Degens & Kurtmann, 1978). The lake is home to tarek, known locally as the Van fish, the only species that has managed to adapt to these environmental conditions (Fig. 3) (Aydın, 2017; Demirol & Yüksel, 2022).

The tarek fishing is carried out in Lake Van with 118 boats. Monofilament gill nets are mostly used in tarek fishing, and there is an average of 3,500–4,000 m of gillnet per boat. Mesh size (knot to knot) of gill nets varied between 20 and 22 (Demirol, 2022).

Data collection

Catch data were received from Food and Agriculture Organization of the United Nations (FAO) and Turkish Statistical Institute (TurkStat) (FAO, 2022; Turkstat, 2022). Turkstat is the institution responsible for collecting and publishing all kinds of data in Türkiye. Annual catch data of tarek has been regularly collected by this institution since 1967. In Fig. 4, the data illustrates the tarek catch in Lake Van from 1967 to 2021, along with the current exploitation status of the stock.

Catch-based maximum sustainable yield model

The catch-based maximum sustainable yield (CMSY) model (R version CMSY_2019_9f.R) was used in assessing the tarek stock in Lake Van and was developed by Froese et al. (2019). In the calculations, R (v4.2.1), based RStudio

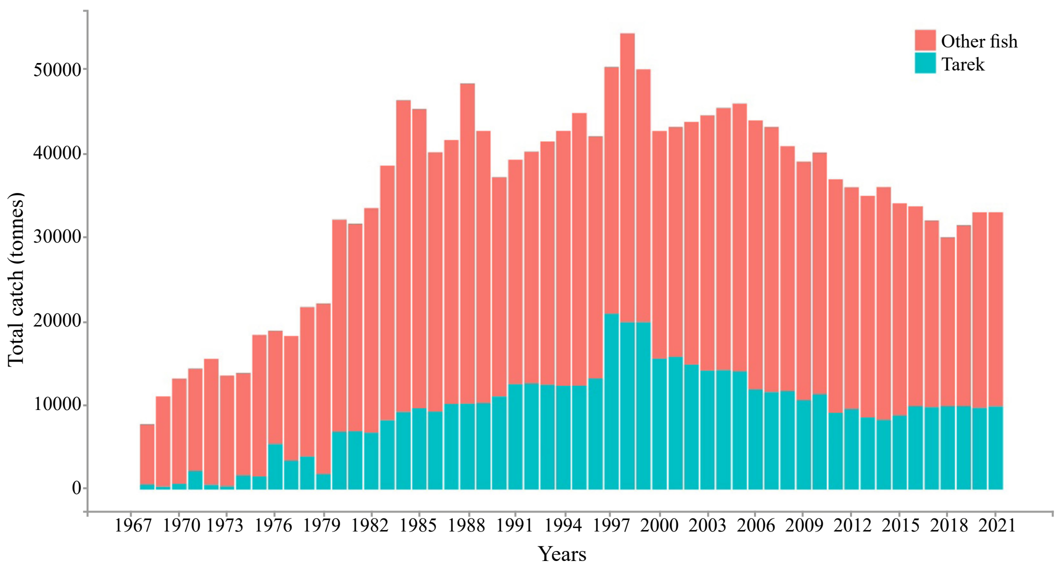


Figure 1. Annual catch data of inland fisheries of Turkiye.

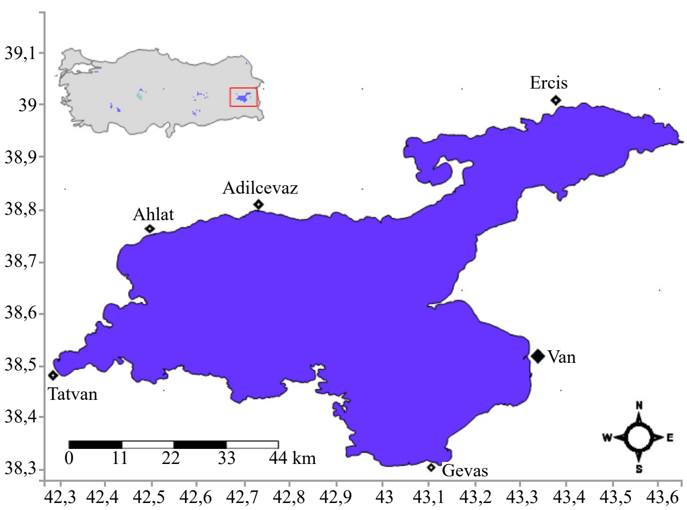
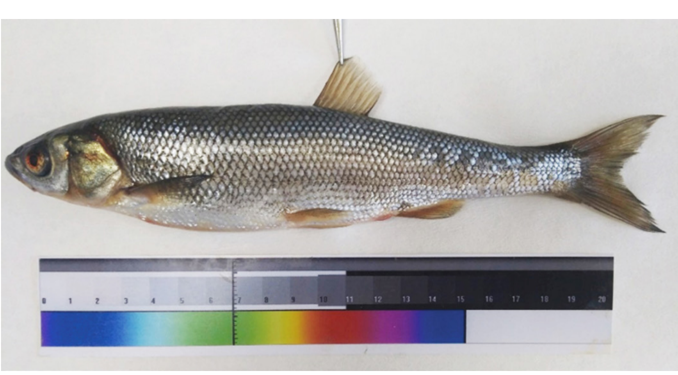


Figure 2. Location of Lake Van.



Source: Demirol and Yüksel (2022).

Figure 3. The tarek (*Alburnus tarichi* Güldenstädt, 1814).

(v2023.06.0) software, was used (R Core Team, 2022; RStudio, 2023). CMSY model, as an open-source model for assessing fish stocks, is applicable in scenarios with limited or restricted fisheries data. It is based on the historical catch data for a species and resilience of it. The term *resilience* is used to describe the capacity of a system to react to or absorb disturbances while keeping its fundamental function and structure largely unchanged (Holling, 1973).

The preliminary parameters of the CMSY are determined using current catch data. The CMSY model forecasts key fishery control parameters such as MSY, F_{MSY}, B_{MSY}, relative stock size (B/B_{MSY}) and stock exploitation level (F/F_{MSY}). It accomplishes this by leveraging resilience and catch data (Froese et al., 2019).

The CMSY method is based on the Schaefer's surplus production model (Schaefer, 1954). The difference form of the Schaefer's model predicts the biomass in the next year (B_{t+1}) from the current biomass (B_t) plus surplus production or yield (Y_t) minus catch (C_t). Thus, from one year (t) to the next ($t + 1$), the biomass (B_t) follows the Eq. 1 (Froese et al., 2019; Zhai et al., 2020):

$$B_{t+1} = B_t + r.(1 - B_t/k) \cdot B_t - C_t \quad (1)$$

Where: Bt= the biomass; r= the intrinsic rate of growth population; k= the carrying capacity (unexploited or initial biomass B_0); C_t= the catch at time at t.

The unknown parameters of Eq. 1 are r and k. The k value (in Eq. 1) can be determined using prior knowledge about r and d

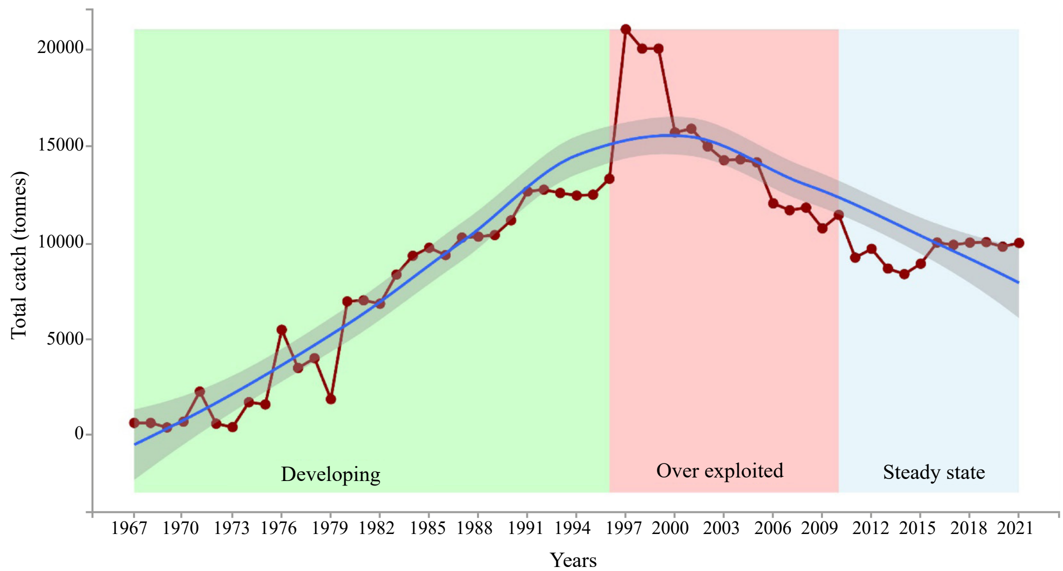


Figure 4. Annual catch and exploitation status of tarek stock in Lake Van.

(depletion) (Zhou et al., 2018). The Markov Chain Monte Carlo (MCMC) approach is utilized by the CMSY model to estimate the resilience of the studied species, the environmental carrying capacity (k), and the population growth rate (r). The depletion level (d) can be estimated following Eq. 2:

$$d = 1 - B_t/k \tag{2}$$

A pair of parameters (r, k) is applicable if the corresponding biomass trajectories predicted from the surplus production model are logical with catches in the sense that the biomass estimated by Eq. 1 does not take negative values and are consistent with priors relating to the relative biomass amounts at the starting and end of the time series (Froese et al., 2019). After finding an optimal pair of r and k, a time series of biomass (B) and fishing mortality (F) can be calculated, along with different indicators (Eqs. 3, 4, and 5) (Andrašūnas et al., 2022; Ricker, 1975; Schaefer, 1954).

$$MSY = r.k/4 \tag{3}$$

$$F_{MSY} = 0.5.r \tag{4}$$

$$B_{MSY} = 0.5.k \tag{5}$$

The status of the stock can be classified based on the ratios F/F_{MSY} and B/B_{MSY} for the last year of a time series, as indicated in Table 1.

Table 1. The status of stock in accordance with stock exploitation level (F/F_{MSY}) and relative stock size (B/B_{MSY}).

Status of stock	B/B_{MSY}	F/F_{MSY}
Healthy	> 1	< 1
Recovering	0.5–1	< 1
Fully overfished	0.5–1	> 1
Outside of safe biological limits	0.2–0.5	> 1
Severely depleted stocks	< 0.2	> 1

Source: (Froese et al., 2016).

Input parameters and data

The model considers prior relative biomass (B/k) and the resilience of species across a range of depletion levels at the beginning, middle, and end of the time series as input parameters. Resilience is a prior estimation of a species ability to recover, which is linked to the species intrinsic growth rate. The suggested resilience values include very low, low, medium, and high. The boundaries of these categories (r_{low} - r_{high}) are showed in Table 2.

Table 2. Resilience categories and r-values.

Resilience	r_{low} - r_{high}
Very low	0.015–0.1
Low	0.05–0.5
Medium	0.2–0.8
High	0.6–1.5

Source: (Froese et al., 2016).

The resilience value of the stock can be acquired from www.fishbase.org, or it can be calculated using relationships (Eq. 6) with other relevant parameters.

$$r = 2M = 2F_{MSY} = 3/t_{gen} = 9/t_{max} = 3K \qquad (6)$$

The formula for calculating resilience (r) involves several key variables: M is the natural mortality, F_{MSY} is the fishing mortality rate for MSY, t_{gen} is the generation time of the population, t_{max} is the maximum age of individuals in the population, and K is a parameter of the von Bertalanffy growth equation (Froese et al., 2017). The resilience value used in this research were identified according to the information obtained from www.fishbase.org (Froese & Pauly, 2022). According to FishBase, *A. tarichi* has medium resilience, fecundity around 10,000, and the minimum population doubling time is between 1.4 and 4.4 years.

The relative biomass (B/K) range, which is an additional input parameter for CMSY, has been assessed according to the interval suggested by Froese et al. (2019): nearly unexploited (0.75–1.0), low depletion (0.4–0.8), medium depletion (0.2–0.6), strong depletion (0.01–0.4), and very strong depletion (0.01–0.2). In this study, the pairs of r and B/K are determined through expert judgment based on the assumed depletion grade, as outlined in Table 3.

RESULTS

The CMSY approach produces a two-part report. The first part focuses on the analysis of *r-k* pairs, while the second part is dedicated into fisheries management. Figure 5 demonstrates the found *r-k* pairs (grey) and the *r-k* pairs (dark grey), which were consistent with catch and previous information entered the model. The striped rectangle indicates the scope of prior estimates based on the provided input parameters. The middle of the blue cross represents the optimal *r-k* pair predicted by the CMSY model, and the horizontal and vertical bars indicate the 95% confidence intervals for r and k.

In the context of CMSY analysis according to the scope of fisheries management, the needed parameters are estimated, which are maximum sustainable yield (MSY), biomass (B), biomass corresponding to MSY (B_{MSY}), fishing mortality (F), and fishing mortality corresponding to MSY (F_{MSY}). Table 4 displays the year 2021 catch data (C_{2021}) (9,925 tons) was lower than MSY (12,300 tons). Table 4 also shows that the catch biomass (B_{2021}) (48,000 tons) in the previous year exceeded the sustainable biomass level (B_{MSY}) (46,200 tons). Furthermore, the fishing mortality in the previous year (F_{2021}) was 0.202 year^{-1}, which was lower than the fishing mortality, corresponding to MSY (F_{MSY}) at 0.268 year^{-1}.

The stock status was evaluated according to the composition of B/B_{MSY} and F/F_{MSY} parameters, as explained in Table 1 for the

Table 3. Input of catch-based maximum sustainable yield model.

Resilience	Analyzed years	Start *B/k*	Intermediate year	Intermediate *B/k*	End *B/k*
		low-high		Low-high	Low-high
0.3–0.8	1967–2021	0.9–1.00	2000	0.4–0.6	0.3–0.6

Start: the year in which the analysis began; intermediate: a specific year selected in the time series; End: the last year of the analysis.

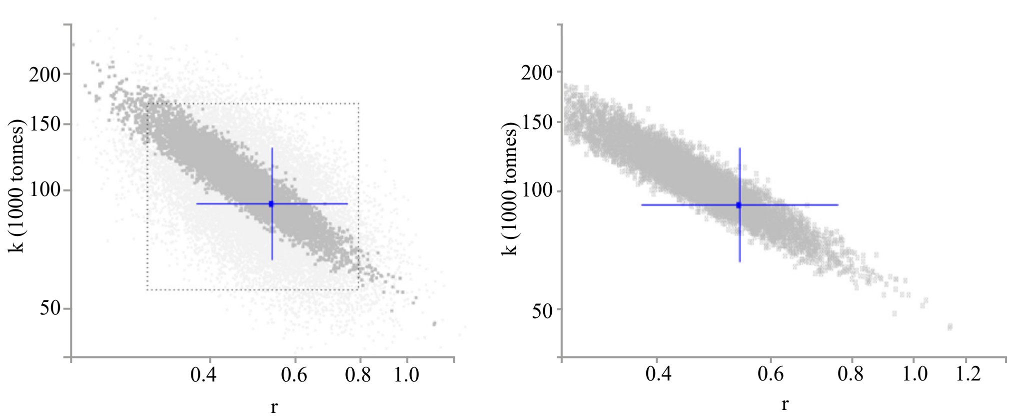


Figure 5. Finding viable r-k pairs.

Table 4. The results of catch-based maximum sustainable yield model analysis.

Stock Status	Parameters	Value	Dimension	95%CI
Healthy stocks	C_{2021}	9.925	ton (x1,000)	-
	r	0.536	year^{-1}	0.377–0.76
	k	92.4	ton (x1,000)	66.5–129
	MSY	12.3	ton (x1,000)	10.8–14.2
	B_{2021}	48.0	ton (x1,000)	29.4–55.1
	B_{MSY}	46.2	ton (x1,000)	33.2–64.3
	F_{2021}	0.202	year^{-1}	0.180–0.338
	F_{MSY}	0.268	year^{-1}	0.189–0.380
	F_{2021}/F_{MSY}	0.772	-	0.672–1.260
	B_{2021}/B_{MSY}	1.04	-	0.636–1.190

95%CI: 95% confidence interval; *MSY*: maximum sustainable yield; F/F_{MSY}: stock exploitation level; B/B_{MSY}: relative stock size.

tarek stock in Lake Van. B_{2021}/B_{MSY} is calculated as 1.04 (> 1); and F_{2021}/F_{MSY} is calculated as 0.772 (< 1). According to Table 1, the stock status has been determined to be healthy stock, based on fishing data from 2021. However, since the 95% confidence intervals of both parameters exceed the healthy stock category, it is useful to be cautious about the stock situation.

Figure 6 presents the CMSY analysis results in graphical form. In panel *A* (upper left), it illustrates catch relative to *MSY*, including 95% confidence limits shown in grey. Panel *B* (upper right) displays relative exploitation (F/F_{MSY}), while panel *C* (lower left) depicts the evolution of relative biomass (B/B_{MSY}), with the grey area representing the associated uncertainty. In

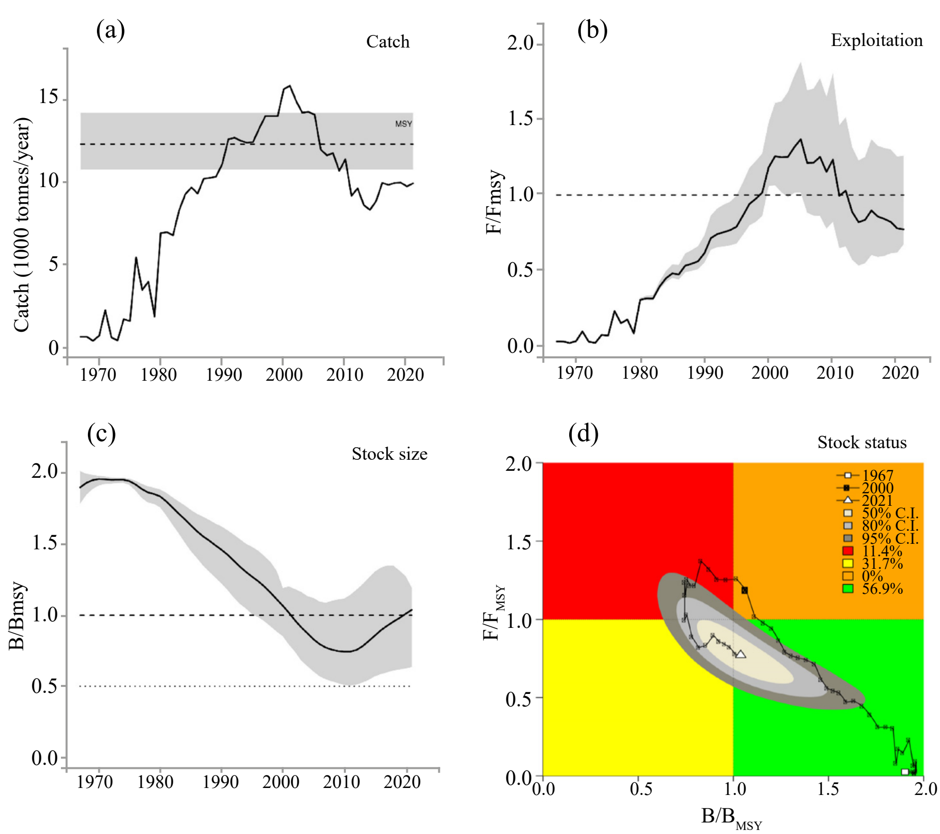


Figure 6. Result graphs of catch-based maximum sustainable yield model analysis.

the lower right corner, panel *D* displays a Kobe chart. A Kobe chart illustrates the temporal progression of fishing pressures (F/F_{MSY}) on the Y-axis and the state of the stock (B/B_{MSY}) on the X-axis. The color-coded key for the zones on the Kobe chart is as follows:

• The orange zone indicates that the stock size is reasonably healthy, but it is at risk of approaching extinction due to overfishing;

• The red zone signifies that the stock is overexploited, and the available biomass is inadequate to achieve the maximum yield;

• The yellow zone indicates that fishing effort is declining, and the stock size is gradually getting better;

• Green zone targeted by fisheries management signifies that there is relatively low fishing pressure, and there is an adequate biomass available to maximize the yield (*MSY*).

The yellow region encircling the triangle, signifying the assessment for the previous year, corresponds to 50%. The grey area is set at 80%, and the darker grey area indicates the 95% confidence level. Additionally, the legend located at the top right of the graph provides information about the percentages of the 95% confidence interval that align with each color category (Froese et al., 2019). Graph *D* illustrates that the tarek population was according to the green zone in 1967, when fishing activities started. Over the subsequent years, as fishing pressure intensified, the tarek population shifted initially towards the orange zone and then further into the red zone. Nevertheless, as fishing decreased, the tarek stock shifted into the recovery phase denoted by the yellow zone, ultimately returning to the green zone in subsequent years.

The stock of tarek in Lake Van is assessed as health stock by the CMSY model. Except for 1997–2010, the majority of the research period, F/F_{MSY} was < 1; especially in the last 10 years there was a decreasing trend. Beginning with the collection of catch data in B/B_{MSY} was higher than 1, although it began to decline from the late 1970s, decreased below 1 in 2002, and then began to rise in 2012. In 2019, it has risen above 1 again. The MSY, estimated by the CMSY model to be 12,300 tons with a 95% confidence interval ranging from 10,800 to 14,200 tons, was surpassed during the period from 1991 to 2005. Annual catch in all other years was below *MSY*.

DISCUSSION

In contemporary times, the significance of fish stock assessment studies is on the rise, driven by the fact that a substantial majority (65.8%) of marine fish stocks have reached unsustainable levels (FAO, 2020). Despite the assessment of most marine fish stocks, there is a scarcity of systematic assessments for inland fisheries (Lorenzen et al., 2016). Inland fish stocks are more vulnerable to overfishing than marine stocks, because they are in small and narrow ecosystems (Akkuş, 2021). Although capture-based fisheries are a vital component of the livelihoods of people living in many parts of the developed and developing world (Bartley et al., 2015), many freshwater fisheries are managed without stock assessment (Lorenzen et al., 2016). Lake Van was one of them until the current study. There is a very limited stock assessment study on *A. tarichi*, which is the most essential inland fish stock (in terms of annual catch amount) of Turkiye, even though the history of the fisheries dates back to ancient times (Demirol & Yüksel, 2022).

In this study, we used long-term annual catch data for assessing the tarek stock using the *CMSY* tool (Froese et al., 2019). *CMSY* is one of the valuable tools recently developed for assessing the state of stocks with limited data (Andrašūnas et al., 2022). However, *CMSY* tended to underestimate relative stock and overestimate relative fishing mortality when compared with the data-rich model results (Bouch et al., 2021). Occasionally, underestimated biomass can be observed, and this is often associated with the utilization of commercial catch statistics in *CMSY* analysis, as not all catches may be accurately recorded.

The Turkish Fisheries Act (Anonymous, 2020) enforces a closed season for tarek fishing, from April 15 to July 15 every year, to protect mature individuals that would join in spawning migration. Lake Van water has a highly salty-alkaline characteristic. However, reproduction of this species occurs in freshwater (rivers), so mature individuals preparing for spawning migration have adapted to river waters (Sarı, 2001). The *A. tarichi* schools must wait for a time in the adaptation period in river mouths both riding up to and coming down from the rivers. Unfortunately, illegal fishing may occur in that period because catching *A. tarichi* from schools is very easy by using beach seines. This illegal fishing technique is named summertime fishing and caused heavy damage to Lake Van *A. tarichi* stock from the 1970s to the 2000s (Sarı, 2001). As a type of unreported fishing type, summertime fishing is applied to *A. tarichi* stock and represents 15–25% of the total catch, even nowadays (Demirol, 2022).

The analysis process incorporated a comprehensive dataset spanning 55 years of catch data, covering the years from 1967 to 2021. Time series is a critical issue for catch-only stock assessment studies (Schijns & Pauly, 2022). Schijns and Pauly (2022) reported that shortened time series could affect the estimation of reference points and cause incorrect or insufficient decisions. The data set used is evaluated as quite suitable compared to other studies. When the catch data of other studies were examined, Zherdev et al. (2020) used 21 years (from 1999 to 2019), Nisar et al. (2021) used 36 years (from 1990 to 2015), Al-Mamun et al. (2022) used 21 years (from 1999 to 2019), Andrašūnas et al. (2022) used 21 years (from 2000 to 2020), and Hashemi and Doustdar (2022) used 23 years (from 1997 to 2019).

In this study, it was determined that the stock of *A. tarichi* was exposed to heavy ever-increasing fishing pressure from the beginning of unexploited years (1967–1996) and ultimately overfished in later years (1997–2010). It was thought that summertime fishing is negatively affected by the overfishing process, yet 91% of the total commercial *A. tarichi* catch was based on summertime fishing in 1994–1996 fishing seasons (Sarı, 2001). The stock status is determined as overfished at the end of 2001 in this study, which conforms with Sarı (2001), who suggested some management comments (such as summer fisheries should be forbidden, minimum landing size should be increased, use of beach seine should be ban, and mesh size of gill nets should be raised) for the sustainability of the *A. tarichi* stock, which was the first time the stock was overfished. After the forbidding of summertime fishing (in 1997), which caused a serious lowering of recruitment, it was observed that the recovery period of stock started at the beginning of the 2000s (Figure 6-d). Finally, it has been revealed that the stock of *A. tarichi* has reached a sustainable level nowadays. This finding is in accordance with Demirol (2022), who assessed the *A. tarichi* stock of Lake Van using age-based virtual population analysis and reported that the overfishing period of the stock has ended and a steady-state period has started.

CONCLUSION

The current study has determined that the stock of Lake Van *A. tarichi*, which has been a very important food source for local people for centuries, is at a sustainable level. However, it is very important to obey the fisheries management rules (close season, minimum landing size, minimum mesh size for set nets, etc.) to continue this situation.

It is believed that an annual catch of approximately 10 thousand tones is considered sustainable for the preservation of the stock. The catch amount should not be increased without more comprehensive stock studies carried out. It was understood that a method such as *CMSY* based entirely on catch data was quite successful in evaluating *A. tarichi* stock in Lake Van, and the results were compatible with other studies. In this context, CMSY is recommended to other fish stocks that have limited data. As a result, instead of managing the stock without any evaluation, it would be a more correct approach to manage it in the data-limited management concept. To increase the accuracy of new stock assessment studies carried out later years by using CMSY, catch amount should be more strictly monitored (include in illegal, unreported and sportive fishing data) and collected of catch per unit effort data.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

AUTHORS' CONTRIBUTION

Conceptualization: Demirol, F.; **Data curation:** Demirol, F.; **Writing — original draft:** Demirol, F.; **Formal Analysis:** Cilbiz, M.; **Software:** Cilbiz, M.; **Visualization:** Cilbiz, M.; **Writing — review & editing:** Cilbiz, M.; **Final approval:** Cilbiz, M.

FUNDING

The authors have no relevant financial or non-financial interests to disclose.

ACKNOWLEDGMENTS

Not applicable.

REFERENCES

Akkuş, M. (2021). Van Lake fishery management and pearl mullet (*Alburnus tarichi* Guldenstaedtii, 1814) conservation studies. *Doğanın Sesi*, (8), 47-59.

Al-Mamun, M. A., Shamsuzzaman, M. M., Schneider, P., Mozumder, M. M. H., & Liu, Q. (2022). Estimation of Stock Status Using the LBB and CMSY Methods for the Indian Salmon Leptomelanosoma indicum (Shaw, 1804) in the Bay of Bengal, Bangladesh. *Journal of Marine Science and Engineering*, 10(3), 366. https://doi.org/10.3390/jmse10030366

Andrašūnas, V., Ivanauskas, E., Švagždys, A., & Razinkovas-Baziukas, A. (2022). Assessment of four major fish species stocks in the lithuanian and russian parts of Curonian Lagoon (SE Baltic Sea) using CMSY method. *Fishes*, 7(1), 9. https://doi.org/10.3390/fishes7010009

Anonymous (2020). 5/1 *Notification of commercial fish catching regulation in seas and inland water (Notificaiton number 2020/20)*. Republic of Türkiye, Minister of Agriculture and Rural Forestry, General Directorate of Fisheries and Aquaculture.

Aydın, F. (2017). *Van Lake level changes and the effects of these changes on the coasts* [MSc thesis, Yüzüncü Yıl University].

Bartley, D. M., De Graaf, G. J., Valbo-Jørgensen, J., & Marmulla, G. (2015). Inland capture fisheries: status and data issues. *Fisheries Management and Ecology*, 22(1), 71-77. https://doi.org/10.1111/fme.12104

Bouch, P., Minto, C., & Reid, D. G. (2021). Comparative performance of data-poor CMSY and data-moderate SPiCT stock assessment methods when applied to data-rich, real-world stocks. *ICES Journal of Marine Science*, 78(1), 264-276. https://doi.org/10.1093/icesjms/fsaa220

Degens, E., & Kurtmann, F. (1978). Geology of Lake Van. *MTA Publications*, (159).

Demirol, F. (2022). Hydroacoustic monitoring modelling and stock assessment of tarek (Alburnus 284 tarichi Güldenstädt, 1814) in Lake Van [PhD thesis, Munzur Universiy].

Demirol, F., & Yüksel, F. (2022). Age, growth and length-weight relationship of tarek (*Alburnus tarich*i Güldenstädt, 1814) from Lake Van, Türkiye. *Journal of Limnology and Freshwater Fisheries Research*, 8, 150-159. https://doi.org/10.17216/LimnoFish.1057782

Food and Agriculture Organization (FAO) (2020). *The State of World Fisheries and Aquaculture 2020. Sustainability in action*. FAO. https://doi.org/10.4060/ca9229en

Food and Agriculture Organization (FAO) (2022). *Fishery and Aquaculture Statistics. Global capture production 1950-2020 (FishStatJ)*. FAO Fisheries and Aquaculture Division.

Freyhof, J. (2014). *Alburnus tarichi*. *The IUCN Red List of Threatened Species*, e.T4375A19222678. https://doi.org/10.2305/IUCN.UK.2014-1.RLTS.T4375A19222678.en

Froese, R., Demirel, N., Coro, G., Kleisner, K. M., & Winker, H. (2017). Estimating fisheries reference points from catch and resilience. *Fish and Fisheries*, 18(3), 506-526. https://doi.org/10.1111/faf.12190

Froese, R., Demirel, N., Coro, G., & Winker, H. A. (2019). Simple user guide for CMSY+ and BSM (CMSY_2019_9f.R). *Oceanrep*, 1-16. Retrieved from https://oceanrep.geomar.de/33076/

Froese, R., Garilao, C., Winker, H., et al. (2016). Exploitation and Status of European Stocks. *Oceanrep*. Retrieved from http://oceanrep.geomar.de/34476/

Froese, R., & Pauly, D. (2022). *FishBase*. Retrieved from http://www.fishbase.org

Grant, W., & Sorokin, D. (2011). Distribution and diversity of soda lake alkaliphiles. In K. Horikoshi (Ed.), *Extremophiles handbook* (pp. 27-54). Springer.

Hashemi, S. A. R., & Doustdar, M. (2022). Stock assessment of Indo-Pacific King Mackerel, *Scomberomorus guttatus* (Bloch & Schneider, 1801) in the Persian Gulf and Oman Sea, southern Iranian waters, using CMSY and DBSRA. *International Journal of Aquatic Biology*, 10(1), 11-20. Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-85132035279&partnerID=40&md5=ecd029482f29643d8d2fc57cf66bccab

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, 4(1), 1-23. Retrieved from https://www.annualreviews.org/doi/abs/10.1146/annurev.es.04.110173.000245

Lorenzen, K., Cowx, I. G., Entsua-Mensah, R. E. M., Lester, N. P., Koehn, J. D., Randall, R. G., So, N., Bonar, S. A., Bunnell, D. B., Venturelli, P., Bower, S. D., & Cooke, S. J. (2016). Stock assessment in inland fisheries: a foundation for sustainable use and conservation. *Reviews in Fish Biology and Fisheries*, 26(3), 405-440. https://doi.org/10.1007/s11160-016-9435-0

Nisar, U., Ali, R., Mu, Y., & Sun, Y. (2021). Assessing five major exploited tuna species in India (Eastern and Western Indian Ocean) using the Monte Carlo Method (CMSY) and the Bayesian Schaefer Model (BSM). *Sustainability*, 13(16), 8868. https://doi.org/10.3390/su13168868

R Core Team (2022). *R: A language and environment for statistical computing*. R Foundation for tatistical Computing. Retrieved from https://www.R-project.org/

RStudio. (2023). *RStudio: Integrated Development for R*. RStudio. Retrieved from: https://posit.co/download/rstudio-desktop/.

Sarı, M. (2001). Estimating of the Van Lake Tarek (*Chalcalburnus tarichi*, Pallas 1811) stock amount and determining of the fisheries management principles. Çekül Foundation. (Scientific Works Series Press.)

Sarı, M. (2008). Integrated sustainable fisheries management for pearl mullet of Lake Van, Turkey. In G. O. Gungor (Ed.), *Environmental Technologies* (pp. 177-192). Intechopen.

Schaefer, M. B. (1954). Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. *Inter-American Tropical Tuna Commission Bulletin*, 954(1), 27-56. Retrieved from https://archimer.ifremer.fr/doc/00308/41964/41233.pdf

Schijns, R., & Pauly, D. (2022). Management implications of shifting baselines in fish stock assessments. *Fisheries Management and Ecology*, 29(2), 183-195. https://doi.org/10.1111/fme.12511

Şen, F., Paruğ, Ş. Ş., & Elp, M. (2015). Projections on past, present and future of tarek (*Alburnus tarichi*, Güldenstädt, 1814). *Yuzuncu Yil University Journal of Agricultural Sciences*, 25(3), 347-356.

Turkstat (2022). *Fishery statistics*. Retrieved from http://www.turkstat.gov.tr/PreTablo.do?alt_id=1005

Zhai, L., Liang, C., & Pauly, D. (2020). Assessments of 16 exploited fish stocks in Chinese waters using the CMSY and BSM methods. *Frontiers in Marine Science*, 7, 483993. https://doi.org/10.3389/fmars.2020.483993

Zherdev, N. A., Pyatinsky, M. M., & Kozobrod, I. D. (2020). Stock assessment and long-term dynamics of Azov Sea Roach (Russian waters), based on CMSY model for data-limited modelling in period (1999-2019). *Fisheries*, (6), 88-94. https://doi.org/10.37663/0131-6184-2020-6-88-94

Zhou, S., Punt, A. E., Smith, A. D., Ye, Y., Haddon, M., Dichmont, C. M., & Smith, D. C. (2018). An optimized catch-only assessment method for data poor fisheries. *ICES Journal of Marine Science*, 75(3), 964-976. https://doi.org/10.1093/icesjms/fsx226