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RESEARCH PAPER

Management Suggestions Based on a Data-Poor Stock Assessment Method to Avoid an Artisanal Fishery Collapse in Mexico

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Abstract

Fishing is a beneficial activity for populations settled near bodies of water. It can be split into industrial and artisanal fishing; the latter is more important from global, cultural, economic, and social points of view. Mugilids are of great commercial interest for artisanal fisheries due to their wide distribution and diverse uses; in Mexico, this resource stands out because it ranks fourth in the specific composition of catches and has shown a growing trend in yields in recent years (2008-2020). Therefore, a stock assessment was carried out and the trend and stages in the historical catch series and estimated exploitable biomass were analyzed with respect to resource sustainability. We suggest that an active regulation measure be taken along with already existing passive measures. In 2022, the exploitable biomass was estimated at 4,839 t, B_{MSY}=7,723 t, and MSY=2,112 t. The resource is overexploited, and it could collapse if no action is taken. Therefore, we propose incorporating a temporal ban and an annual catch quota of 2,112 t to the current regulation, as well as using the methods and parameterization in this study for future evaluations.

Introduction

According to the FAO (2021), artisanal or small-scale fisheries represent approximately half of all worldwide catches and provide jobs for over 90% of people working in the fishing sector (approximately 20,533,000 individuals).

Mugilids are of great commercial interest for artisanal fisheries of the Mexican Pacific coast and Gulf of California due to their diverse uses (direct/indirect consumption and as live bait); moreover, due to their wide distribution they support high fishing pressure and catches of up to 15,853 annual tons have been reported (SAGARPA, 2019). The interest of fishing on the species of this family is not limited to Mexico; they are also an important part in aquaculture and coastal fisheries in other regions of the world-wide (Crosetti, 2016).

In the Eastern Tropical Pacific Ocean this family comprises eight species (*Mugil cephalus*, *M. setosus*, *M. incilis*, *M. liza*, *M. longicauda*, *M. margaritae*, *M. rubrioculus*, and *M. trichodon*) that share morphological and meristic characteristics (size, color, and body shape) (Robertson and Allen, 2015).

Based on worldwide fishery trends for the past few years, international agencies forecast a significant impact on traditionally exploited species and on those species that are replacing already exhausted or threatened species (Liedo-Galindo et al., 2007). Given that Mexico occupies the 14th position globally in fisheries production in marine and continental waters (FAO, 2018), and artisanal fishery is a fundamental economic activity for Mexico that generates economic, social, and cultural sustenance (Martínez and González, 2016). Data on fish biology and population dynamics are needed for better use of exploited resources (Liedo-Galindo et al., 2007).

Not much effort has been devoted to research on the evaluation on these fishery resources, highlighting five studies worldwide (Bell et al., 2005; Mendonça and Bonfante, 2011; Modou et al., 2013; Panda et al., 2018; Lovett et al., 2022) that address aspects of the evaluation and/or management of some species of mugilide.

The objective of the present study was to evaluate the mullet resource off the Sinaloa coast, Mexico, estimating biological reference points (BRP) and suggesting an adaptive management approach based on active regulation measures (catch quotas). The results could suggest about the current state of the resource and contribute to a sustainable socio-economic fishing for a long time.

Materials and Methods

Data

Fishery statistics from landing log books of the artisanal fishery in Sinaloa were available from 2000-2022. These were obtained from fisheries offices of SADER (Secretaria de Agricultura y Desarrollo Rural: Secretary of Agriculture and Rural Development). The 23-year time series includes a total of 52,589 catch and effort records. In Mexico, white mullet *Mugil curema* is captured along with the flathead grey mullet *Mugil cephalus,* Official catch records do not distinguish the species and are included in the category of "*lebrancha*" or "*lisa*", both species are recorded as "mullet" due to their morphological similarities and are caught using similar fishing gear. Therefore, in this study, mullets were considered a multi-species resource. The catch per unit effort (CPUE) was calculated based on mullet fishery landing records (catch and effort) to integrate this into the analysis as a relative indicator of resource abundance. A graphical examination of the catch, effort, and CPUE data was performed to detect changes in the trend of the historical data series, identifying potential fishery developmental stages, which were validated with a one-way analysis of variance (Zar, 2000).

Biomass estimate and fishery reference points

The BSM method (Bayesian state-space; Froese et al., 2017) was used to estimate biomass, based on catch data and CPUE, as well as to estimate target reference points (MSY, B_{MSY}, and F_{MSY}). The model requires prior information in addition to annual catch data to perform the estimates, as follows: 1. A time series of biomass or CPUE (relative indicator of abundance), 2. r- resilience, 3. λ_{001}-λ_{002}- Level of stock depletion in the first year of the time series, 4. λ_{01}-λ_{02}- Level of stock depletion in an intermediate year of the time series, 5. λ_1-λ_2- Level of stock depletion in the last year of the time series and, 6. K- Carrying capacity. The information used in the model parameterization is shown in Table 1.

Recommendations by Froese et al. (2017) were followed to establish depletion levels in the initial (λ_{001}-λ_{002}), intermediate (λ_{01}-λ_{02}), and final (λ_1-λ_2) years of the time series. r values were obtained from records available on Fishbase (Froese and Pauly, 2022) for the two species; however, *M. cephalus* was selected as the representative species in this genus due to the amount of available information. The K interval was estimated based on catch data and resilience, taking into account the depletion level in the last year of the time series (λ_1-λ_2). If it was assumed that λ_1-λ_2<0.5, equation 1 (Eq. 1) was used and if it was assumed that λ_1-λ_2>0.5, equation 2 (Eq. 2) was used:

$$K_{low} = \frac{maxC}{r_{high}}, K_{high} = \frac{4(maxC)}{r_{low}} \quad (1)$$

$$K_{low} = \frac{2(maxC)}{r_{high}}, K_{high} = \frac{12(maxC)}{r_{low}} \quad (2)$$

The BSM model is based on two equations. The first is Schaefer's (1954) surplus production model (Eq. 3):

$$B_{t+1} = \left[B_t + rB_t\left(\frac{B_t}{K}\right) - C_t\right] \quad (3)$$

Where B_{t+1} is the exploited biomass in the subsequent year t_{+1} and in consecutive years in the time series, B_t is the current biomass, C_t is the catch in year t, *r* is the intrinsic rate of population growth, and *K* is the carrying capacity of the habitat for the stock.

The second equation is incorporated if biomass falls below ¼ k. According to Froese et al. (2017), it is used to account for depensation or reduced recruitment at severely depleted stock sizes, such as predicted by all

Table 1. Parameterization data for the BSM model for mullets exploited by the artisanal fishery off the Sinaloa coast, Mexico.

r/a^{-1} (FishBase)	K	λ_{001}-λ_{002}	intermediate year	λ_{01}-λ_{02}	λ_1-λ_2
0.34-0.77	4,318-39,112	0.2-0.6	2018	0.5-0.9	0.2-0.6

common stock–recruitment functions (Beverton and Holt 1957; Ricker 1975; Barrowman and Myers 2000), a linear decline of surplus production, which is a function of recruitment, somatic growth, and natural mortality (Schnute and Richards 2002) (Eq. 4).

$$B_{t+1} = B_t + 4\frac{B_t}{K}r\left(1 - \frac{B_t}{K}\right)B_t - C_t | \frac{B_t}{K} < 0.25 \quad (4)$$

The term 4 Bt/K assumes a linear decline in recruitment below half of the biomass that is capable of producing the MSY; the parameters have the same meaning as in equation 3.

Once all model parameters are obtained, annual exploitable biomass estimates are undertaken using equations 3 and 4. Each simulation takes a different pair of r-K values within the interval ranges presented in Table 1. The viability of each pair of values (r-K) and calculated biomass were evaluated under the following three conditions (*LL(ϑ)*); pairs of values not meeting these conditions were discarded from the analysis:

1.- The stock does not collapse before the last year of the catch series (Eq. 5); 2.- The estimated biomass for the intermediate year of the catch series is within the stock reduction range assumed a priori (λ_{01} and λ_{02}) (Eq. 5); and 3.- The estimated biomass for the last year of the catch series is within the stock reduction range assumed a priori (λ_1 and λ_2) (Eq. 5).

$$LL(\theta) = \left\{ B_{n+1} > K_{0.01}, \lambda_{001} \le \frac{B_{n+1}}{K} \le \lambda_{002}, \lambda_{01} \le \frac{B_{n+1}}{K} \ge \lambda_{02}, \lambda_1 \le \frac{B_{n+1}}{K} \le \lambda_2 \right\} (5)$$

Once the simulations were finished and the pairs of r-K values that met the conditions (Eq. 5) were separated. The mean of the predicted biomass values for each year was used as the most probable biomass and the 2.5th and 97.5th percentiles were used as indicators of the range that contained 95% of the biomass predictions. The following target reference points were estimated with these parameters based on the density functions of the estimated r and K values.

Biomass at which maximum sustainable yield is obtained (B_{MSY}):

$$B_{MSY} = \frac{K}{2} \quad (6)$$

Maximum sustainable yield (MSY)

$$MSY = \frac{rK}{4} \quad (7)$$

Mortality from fisheries at maximum sustainable yield (F_{MSY}):

$$F_{MSY} = \frac{r}{2} \quad (8)$$

The mean and percentiles (2.5th and 97.5th) were calculated; these two values represent the biomass estimate and confidence intervals, respectively.

Once the annual exploitable biomass was calculated, trend changes in the series were analyzed graphically, identifying possible developmental stages that were validated using a one-way analysis of variance.

Kobe Diagram

This diagram was used to graphically analyze the state of the resource over time. This diagram comprises four panels with particular characteristics (1. Full exploitation, 2. Decline, 3. Overfishing, and 4. Recovery) (Maunder and Aires-da-Silva, 2011). The horizontal axis shows the relationship between estimated exploitable biomass over time *t* and the biomass that produces maximum sustainable yield (B_{MSY}), whereas fishing pressure is shown on the vertical axis; it represents a reference point, as it is related to effort or fishing mortality that produces maximum sustainable yield (F_{MSY}). These axes create four zones that describe different fishing scenarios, such as areas where biological sustainability of the resource can be guaranteed, high-risk areas that suggest a fishing resource is in critical condition or severely exhausted, and a threshold area, where a resource could be subject to overfishing or exploited outside safe biological limits (Maunder and Aires-da-Silva, 2011; Arrizabalaga et al., 2012; Carvalho et al., 2018).

Results

Catch, Effort, and CPUE Data

Four phases were identified in the catch series ($F=21.47$, $P<0.05$) (Figure 1A). Phase 1 (2000-2009): during the first 10 years of the time series, the lowest catch volumes were recorded and there were large interannual variations; Phase 2 (2010-2015): increasing trend in catch volumes with small interannual variation; Phase 3 (2016-2019): period with a marked increase in catches, recording the largest catches in the time series (3,324 t in 2019); and Phase 4 (2020-2022): after 2019, there was a sharp decline in the catch almost as low as that recorded in Phase 1.

Similarly, like the interannual variations in catch, the fishing effort (fishing trips) presented four phases during the period analyzed ($F=155.3$, $P<0.05$) (Figure 1B). In phases 1 (2000-2007) and phase 2 (2008-2015) a small increase in fishing effort was recorded, and the trend of fishing effort in phases 3 (2016-2019) showed a significant increase, reaching the maximum historical fishing effort (5,823 fishing trips in 2019), and a sharp decrease in phase 4 (2020-2022).

In relation to fishing success (CPUE, tons per unit effort), five phases were identified (Figure 1C). In general, a negative slope is observed in the CPUE time series. The maximum value of this relative index of abundance was recorded in phase 1 (2000-2004) CPUE=2.65 t in 2002, later, in phase 2 (2005-2006) and phase 3 (2007-2010) a continuous decrease was recorded in CPUE between 1.5 to 1 t; then, in phase 4 (2011-2015) the CPUE registered a slight increase up to 1.5 t, in the final part of the time series, phase 5 (2016-2022) values of 0.5 t of CPUE were presented.

Biomass Estimates and Fisheries Reference Points (Targets and Limits)

As a result of the simulations, a total of 9,000 combinations of r-K values were accepted since they met the three conditions indicated in the methods section.

The selected r and K estimates ranged between 0.303 and 0.968, and between 10,200 and 23,500 t, respectively (Figures 2A, 2B). Regarding the TRP calculation, MSY was between 1,440 and 3,330 t (Figure 2C), B_{MSY} was between 5,080 and 11,700 t (Figure 2D), and F_{MSY} was between 0.151 and 0.484 (Figure 2E).

Position data of the estimates are shown in Table 2. In fisheries management, the mean of each estimate is considered the TRP, and the percentiles are considered the confidence intervals.

The comparison between fishery annual yields, MSY, and confidence intervals (Figure 3A) showed that, on average, catches obtained between 2000 and 2010 ($\bar{x}$=1,677.46 t) were slightly under the lower MSY estimate; between 2011 and 2015 ($\bar{x}$=2,180.39 t) catches increased and fluctuated around the estimated MSY; between 2016 and 2020 catches increased drastically ($\bar{x}$=2,846.64 t), and were 384 t above the upper MSY estimate; and in the last two years of the series (2021 and 2022), catch levels were 105 t below the lower MSY estimate. These changes in yield (in particular, the drastic increase in catches in 2016-2020) suggest that there is an urgent need to take immediate management measures, as apparently the current measures do not allow the resource to stay in a state of full exploitation.

The analysis of the historical trend of exploitable biomass (EB) indicated four phases in the catch series (F=55.2, P<0.05) (Figures 3B, 3C). Phase 1 (2000-2006): High interannual variation, with an EB fluctuating from 9,325 t to 11,719 t, with mean EB 45% above B_{MSY} (Figures 3B, 3C); Phase 2 (2007-2013): low interannual variation, with a tendency towards stability and slight biomass reduction, EB ranging from 10,113 t to 10,641 t, and mean EB 35% above B_{MSY} (Figures 3B, 3C); Phase 3 (2009-2019): Biomass decline with an uninterrupted negative trend, EB decreasing from 9,629 t to 7,724 t, and only 13% above B_{MSY} (Figures 3B, 3C); and Phase 4 (2019-2022): the negative trend of EB increased even more, decreasing from 6,944 t to 4,839 t, 26% below B_{MSY}. This suggests that this fishery reached a level of overexploitation (BE < B_{MSY}) (Figures. 3B, 3C).

Kobe Diagram

The cause-effect relationship between fishing mortality and mullet biomass showed that from 2000 to 2015 the fishery was in a state of full exploitation with a type of cyclical trend. From 2016 until 2019, the state of the resource was in decline due to a decrease in abundance; this responded to an increase in fishing mortality ($F>F_{MRS}$) (Fishing effort Figure 1B). In 2020 and 2021 there was a tendency towards recovery of abundance, responding to a decrease in fishing effort and slight increase in CPUE. Finally, in 2022 there was again a negative trend in abundance, associated with a slight increase in fishing effort. In general, the trend shown by the Kobe diagram (Figure 4) indicated that if active management measures are not taken, or the fishing effort does not decrease, the negative trend in resource abundance will continue, and this fishery could continue fluctuating within an overexploitation phase.

Discussion

Data from mullet catches were analyzed (*Mugil curema* and *M. cephalus*) caught off the Sinaloa coast, as official capture records do not separate by species. Pauly (1983) reported that tropical fisheries often exploit a great number of species simultaneously, and consequently, obtaining detailed information on catch and effort data for each species and/or exploited resource is difficult.

The artisanal fishing off the Sinaloa coast routinely catches at least 30 species, of which the mullet ranks fourth in importance. This suggests that it is under

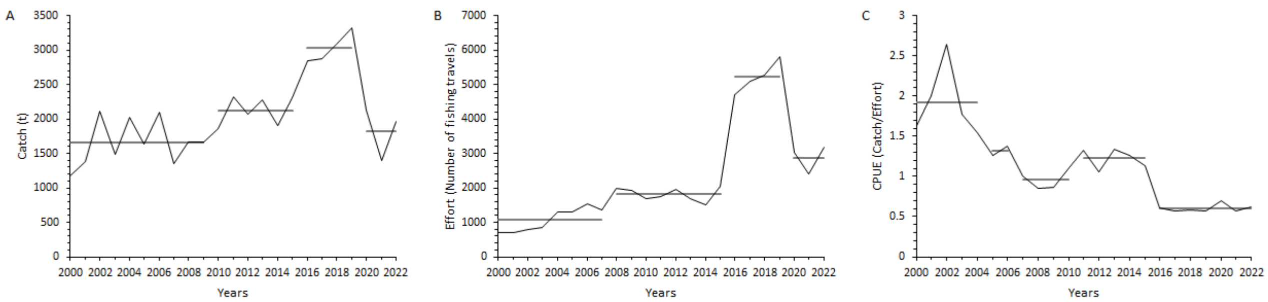

Figure 1. Catch historical series of the mullet resource off the Sinaloa coast, Mexico (solid gray line) and catch averages by phase, represented by a solid black line.

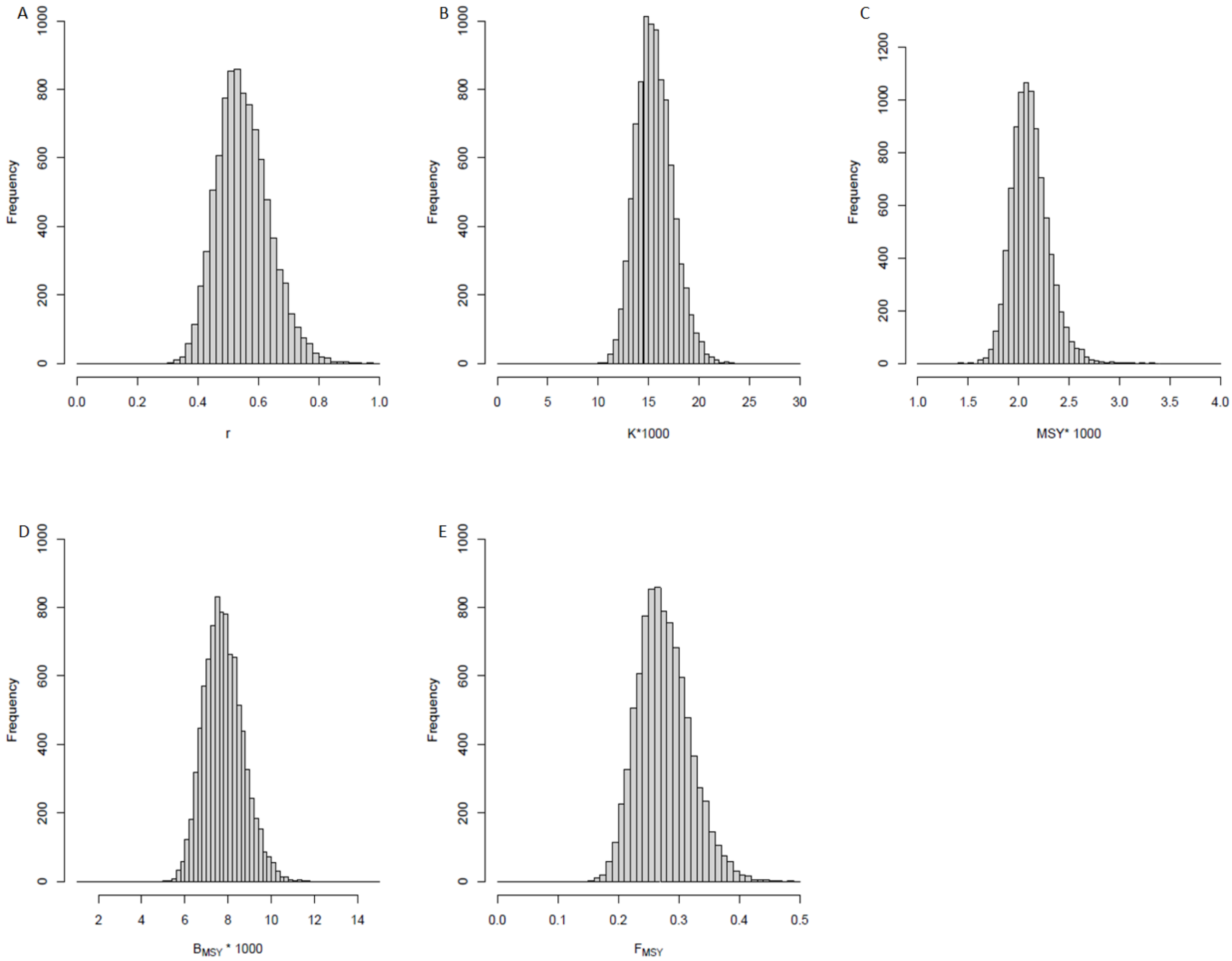

Figure 2. Simulation of objective reference points estimated from accepted pairs of r and K values for the mullet resource captured by the artisanal fleet fishing off the Sinaloa coast.

Table 2. Position data for the parameters in Schaefer's model (1954) and target reference points estimated for mullets captured by the artisanal fleet fishing off the Sinaloa coast.

BRP	r	K	MSY	BMSY	FMSY
Mean	0.547	15,446.034	2,112.144	7,723.017	0.273
Percentile (2.5%)	0.402	12,341.317	1,784.264	6,170.658	0.201
Percentile (97.5%)	0.744	19,331.807	2,500.275	9,665.904	0.372

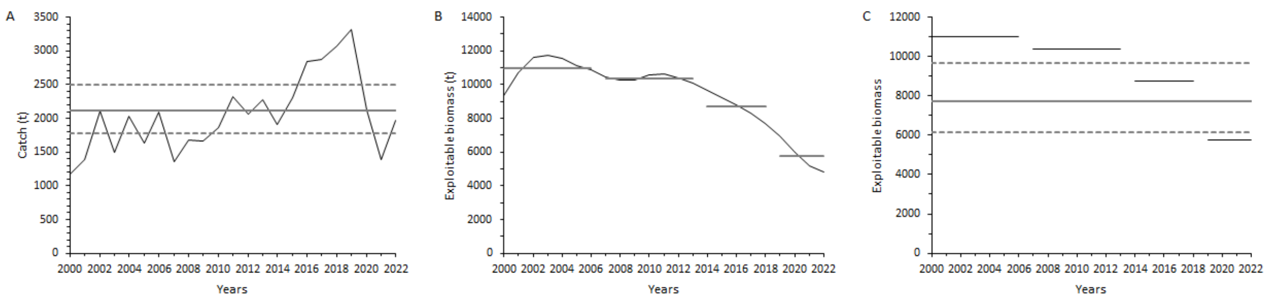

Figure 3. A: Historical catch series (solid gray line), Maximum sustainable yield (solid black line), and confidence intervals (dotted black lines). B: Historical series of exploitable biomass (solid gray line), biomass averages by phase (black dotted lines), and B_{MSY} estimates (black solid line).

considerable fishing pressure; however, the complexity of the evaluation of multi-species fisheries (*e.g.* artisanal fisheries) combined with the limited capacity of studying the numerous resources that are being exploited in Mexico, leaves a great number of unstudied resources without regulation of fishing efforts.

Barman (2021) commented within the context of population dynamics analysis, evaluation of fishing resources is needed to mediate or mitigate fishing pressure and guarantee sustainability, because management decisions on resources should be taken as a function of results obtained by evaluations. Also, the periodic assessment of the abundance of exploited fishery resources in individual numbers or biomass, is vital for resource management; these quantifications allow us to know several essential aspects of populations, such as: the health status, exploitation level, understanding response to fishing pressure, predicting recruitment, predicting changes in biomass levels, and making suggestions regarding resource management to obtain optimal use.

There are a great number of methods that allow making the already mentioned quantifications, among which: dynamic biomass models (e.g. Schaefer, 1954; Fox, 1970; Pella and Tomlinson, 1969), stock-recruitment relationships (e.g. Ricker, 1954; Cushing, 1971; Chapman, 1973; Parrish and MacCall, 1978; Deriso, 1980; Sheperd, 1982; Gómez-Muñoz, 1986), models structured by age (e.g. Derzhavin, 1922; Gulland, 1965; Pope, 1972; Doubleday, 1976; Pope and Shepherd, 1982; Fournier and Archivald, 1982; Methot, 2000), predictive models (e.g. Thompson and Bell, 1934), counts of daily production of eggs and larvae (e.g. Lockwood et al., 1981; Lo et al., 1992; Parker, 1980), as well as hydroacoustic models. However, there is not a model that is better or worse than others, as independently of the selected method, the precision of biomass or abundance quantifications depends on data quality and a correct parameterization of the methods or models used.

With the limited quantity and quality of data available for this resource (data-poor fishery) the most adequate option was the implementation of dynamic biomass models that only consider changes to the exploitable biomass (Schaefer, 1954; Schaefer, 1957, Ricker 1975; Hilborn and Walters, 1992; Polacheck et al., 1993) and simplify all aspects of a population's dynamics (recruitment, growth, and mortality) in a single function, in which stock is considered undifferentiated biomass (Haddon, 2011). Therefore, the objective of these models is to determine the optimal effort level at which there is a maximum sustainable yield that can be maintained for long periods of time without affecting stock productivity (Pin and Defeo, 2000), also called "Maximum Sustainable Yield". We used the Bayesian State-Space model (Froese et al. 2017), designed to evaluate data-poor when only catch data and some relative indicator of abundance (e.g. CPUE or biomass estimates) are available, which was successful to estimate reference points and biomass of mullet resource.

Results shows that the biomass of the resource has diminished drastically from 2011 to 2022, decreasing by 45.47%, however, while the biomass decreased, the catches increased, this is understood as the phenomenon of "catch hyperstability". (Sadovy and Domeier, 2005). This series of events has led the state of the resource to a situation in which, the exploitable biomass of the resource is below the biomass level at which maximum sustainable yield (B_{MSY}) and/or the point of greatest stock productivity $\left(\frac{1}{2}K\right)$ has been reached, Similar trends have occurred in other parts of the world where the resource is also exploited, Hwang et al. (1990) reported a decrease in the biomass and recruitment of *M. cephalus* off the coast of Taiwan, which triggered a significant decrease in catches; Bell et al. (2005) identified drastic declines in recruitment of *M. cephalus* off the east coast of Australia during 1993 and 2001-2002, which also led to reduced catches and abundance of the resource; Mendonça and Bonfante (2011) estimated that the mullet resource of the south coast of São Paulo, Brazil, is overexploited due to the high levels of fishing effort to which it has been subjected; Modou et al. (2013) estimated that *M. cephalus* that is distributed in the marine zone in the Grande Côte, Senegal, was overexploited, however, the fishing effort affects mainly the larger organisms, reducing the spawning population; Panda et al. (2018) analyzed the stock status of *Chelon parsia* , *C. planiceps* and *M. cephalus* at Chilika Lake, India, reporting that the rate of exploitation and catches relative to MSY indicate that the resource is overexploited; and finally, Lovett et al. (2022) identified the same trend as the previous authors, the resource mullet *M. cephalus* has had a decrease in spawning biomass on the east coast of Australia from 1899 to 2021, being in the last two decades below the target reference point. These negative trends in catches, recruitment and abundance of resources can lead to a decrease in the resilience capacity of the resource.

This risk was explained by Stephen et al. (1999), who referred to the Allee effect, which is defined as a "positive association between an individual adaptation component and population number or density". According to the same author, this could be interpreted as the fact that the adaptation ability of an individual in a small population decreases as the size of the population also decreases.

Valenzuela-Figueroa et al. (2022) indicated that this situation occurs in populations that are or have been overexploited, due mainly to the absence of fisheries regulations or of good fishing management. These authors commented that this phenomenon occurs when the size of the population is so reduced that survival rates and/or reproductive rates decrease because individuals are not reproducing, as they do not find individuals of the same population.

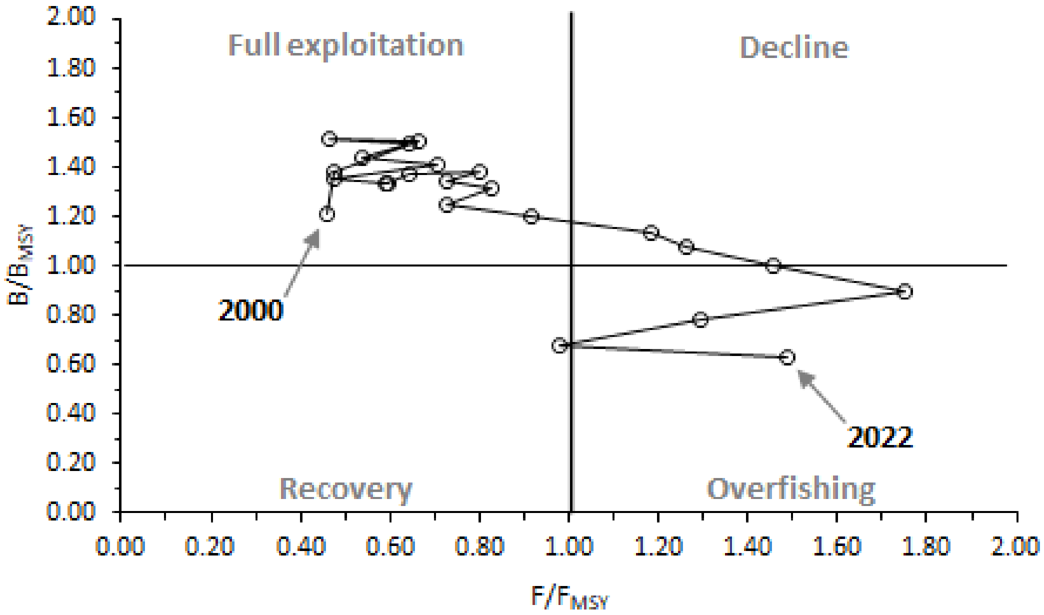

Figure 4. Kobe diagram showing the historical behavior of the mullet resource captured by the artisanal fleet operating off the Sinaloa coast.

This effect has been called by different names, among the most used is "depensation". Although this is not yet the case for the mullet resource analyzed in this study, it is important to understand why some populations face extinction at low population densities.

This shows how delicate the current state of the resource is and only reflects the behavior of exploitable biomass. Analyzing the status of the resource shown in the Kobe diagram, the mullet resource is in a declining phase since 2016.

To understand the causes of changes in the status of the resource and carry out predictions with less uncertainty, it is important to understand the behavior of the dynamics of this resource. According to Hilborn and Walters (1992), there are three basic behaviors that can occur: 1.- stable, 2.- unstable, and 3.- cyclical, and each of these could have sub-behaviors.

Results of this study and in particular, the Kobe diagram, indicate that the mullet resource presents a "cyclical with local stability" behavior, in which the system tends to endure a certain level of perturbation and has the capacity to return to its original state. However, there is a tolerance limit to these perturbations, and when this limit is surpassed, the system cannot return to its original state and moves to a different state. In this case, catch levels represent perturbations and the tolerance limit is the MSY. This limit was surpassed in 2016 and coincides with the point in which the stock passed from the full exploitation quadrant to the decreasing quadrant, and in 2018 it changed to the overfishing quadrant, given current exploitation levels. In this regard, Lovett et al. (2022) comments that in the mullet stock on the east coast of Australia, the resource also behaves cyclically, unfortunately the available data do not allow this to be verified.

Moreover, the pattern of resource catches shows a trend that coincides with the fishery development diagram proposed by Hilborn and Walters (1992) that comprises six phases: 1. Pre-development, 2. Growth, 3. Full exploitation, 4. Overexploitation, 5. Collapse, and 6. Recovery. The trend of the artisanal mullet resource fishery in Sinaloa seems to be moving from phase 4 to phase 5, which suggests taking immediate action to avoid potential collapse.

Costello et al. (2008) commented that a strategy that has been shown to be effective to stabilize stocks, prevent, and even revert fisheries collapse is the establishment of catch quotas based on annual exploitable biomass estimates, such as those obtained in the present study.

The mullet fishery is currently regulated in Sinaloa through passive management measures (temporal ban), which goes from December 1 to January 31 for *M. cephalus* and from April 1 to June 30 for *M. curema*. These fisheries management measures could be supported by some biological reference points determined in some localities, such as the incorporation of a legal catch size suggested by Vélez-Arellano et al. (2022) for *M. curema* in the southeastern Gulf of California.

Therefore, the results in this study suggest keeping the mullet resource temporal fishing ban in Sinaloa and adding an annual catch quota of 2,112 tons for the two species combined. The quota value corresponds to the estimated MSY and is considerably higher than the average catches of this resource in the study area from 2000 to 2015 (1,835 t), but it is a conservative estimate since it is below the catches reported in the 2016-2022 period (2,515 t).

This analysis could be undertaken for later years in order to update the catch quota and even move the analysis to other areas where mugilide are caught, and having the catch-effort data time series available, as well as biological data of the stock, as the species of this family display relatively similar behavior. One of the potential areas to replicate this approach could be the coast of the Gulf of Mexico and Caribbean Sea, where there is an important fishery on the mullet resource. However, that fishery is regulated by the official standard NOM-016-SAG/PESC-2014 (DOF, 2015) and the existence of a Fisheries Management Plan for *Mugil cephalus* and *Mugil curema* off the coast of Tamaulipas and Veracruz (DOF, 2014), it is important to undertake biomass estimates, to know the status of the mullet resource and have more information to guarantee the sustainability of the resource.

In conclusion, the resource is overexploited, and it is urgent to design and apply additional management strategies to the existing ones, otherwise the resource could collapse.

Ethical Statement

It is not required, since in this document no living organisms were sacrificed or experiments were performed.

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Author Contribution

First Author: Manuscript redaction and data analysis; Second Author: Manuscript redaction and brainstorming; Third Author: Manuscript redaction and contribution to the discussion section; Fourth Author: Manuscript redaction and contribution to the discussion section; Fifth Author: Manuscript redaction and contribution to the discussion section, and Sixth Author: Manuscript redaction and brainstorming.

Conflict of Interest

The author(s) declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper.

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