Length based data-limited methods: Application on the Narrow-barred Spanish mackerel, *Scomberomorus commerson* (Lace´pède, 1800) in the Persian Gulf & Oman Sea

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Abstract

Narrow – barred Spanish mackerel, *Scomberomorus commerson*, is a species of economic and artisanal importance throughout the Indo-West Pacific region. In this study a total of 2973 *S. commerson* were examined in a comprehensive study of length frequency structure and maturity assessment along the northern Persian Gulf & Oman Sea. Length maturity 50% was estimated. LBSPR, and LIME were used to analyze length frequency distributions from commercial gill net catches between 2011 and 2023. The results indicate that the stock is overfished, with low proportions of mature and optimal- sized individuals and an excessive harvest of juveniles, as shown by the model estimates of F/M ratios and SPR values below target levels. this study highlights the importance of using multiple models and choosing appropriate priors to improve the quality of stock assessments in data-limited fisheries.

Introduction

Narrow- barred Spanish mackerel, *Scomberomorus commerson*, belongs to epipelagic species throughout the coastal tropical waters of the Indo- pacific (Mc pherson, 1992) and family of

Scombridae with 15 genera and 49 species (Collette and Nauen, 1983). This fish is considered the most important commercial pelagic species (AL Hosni and Siddeek, 1999). This species is one of the endangered species of the neritic tuna which is controlled by RECOFI in the Persian Gulf & Oman Sea and IOTC in the whole distribution area competence in the Indian Ocean. RECOFI regulations include a recently introduced fishing ban period between 15 August and 15 October as well as mesh size regulations, minimum landing size and restrictions on the time at sea for different types of artisanal vessels. The Spanish mackerel has been captured with two types of gillnets (drifting & set) and three types of lines (longlines, handlines and trolling). Gillnets have been predominant in terms of landings in the RECOFI area (Roa- Ureta et al., 2019).

The last assessment by data – limited methods was conducted for narrow-barred Spanish mackerel in the Indian Ocean in 2023. Based on the CMSY assessment, the stock appears to be overfished and subject to overfishing (IOTC ,2024), but the Commission has not adopted limit reference points for this species. Since, at least 4 genetic populations of Spanish mackerel were identified within the IOTC area of competence which increases the uncertainty (IOTC-2024-SC27-R).

To determine the statue of the Spanish mackerel in the northern Persian Gulf & Oman Sea, a length-based approach was used following the description of Hordyk et al. (2015) who named it Length -based Spawning Potential Ratio (LBSPR). The spawning potential Ratio (SPR) in an exploited population is a function of the ratio of fishing mortality to natural mortality (F/M), selectivity and the two life history ratios M/K and L_m/ $L\infty$, K is the von Bertalanffy growth coefficient, Lm is the size of maturity, and the $L\infty$ is the asymptotic size (Hordyk et al.,2015). The inputs to the LBSPR are: M/K, $L\infty$ and the size of maturity specified in terms of L50 and

L95, the size at which 50% and 95% of a population are determined as matures as shown in Table 1.

A few studies have applied to *Scomberomorus commerson* by Siddeek (1993) in Indian Ocean (Kedidi et al., 1993), Bertignac and Yesaki, (1993) Govender (1993) in Saudi Arabia, Oman and South Africa coastal waters. Some studies were carried out by Hosseini et al., 2000, Ghodrati shojaei et al., 2007, Taghavi, et al., 2008, in the coastal waters of Iran.

The aim of this study was to assess and understand the stock status of S. commerson based on length frequency time series data and life history parameters by four length-based assessment methods, namely, LBI, LBB, LBSR, and LIME. (Lm50%), Here we aim to determine biological reference points based on life history parameters.

These results could be relevant to the management of S. commerson and additionally offer insights on the application potential of different length-based assessment models in data-poor fisheries in *Scomberomorus commerson* in Iranian waters of the Persian Gulf & Oman Sea.

Materials and Methods

The size frequency data were collected by gill net commercial catches of *S. commerson* made off the northern coast of the Persian Gulf & Oman Sea from October 2006 to September 2007 (Figure1). Fish samples were selected randomly from landing sites; lengths were taken using a measuring board and recorded to the nearest 1 cm fork length (FL) with monthly target sample size of 60 fish. Biological data were collected during the first weeks of each month. Fish were sexed by macroscopic examination of the gonad which was dissected out to estimate length of maturity .The maturity development stages were assessed according to the five stages (Grandcourt et al.,2005).The mean size at first maturity (Lm) was estimated for female by fitting the logistic function to the proportion of mature fish in 20 cm (LF) size categories and determined as the size

at which 50% of individuals were mature (King,2007). The growth parameters $L\infty$, k, and t_0, female maturity size, and natural mortality values are based on those from the study (Francis et al., 2020), which are used as the prior values for length-based models (Table 1).

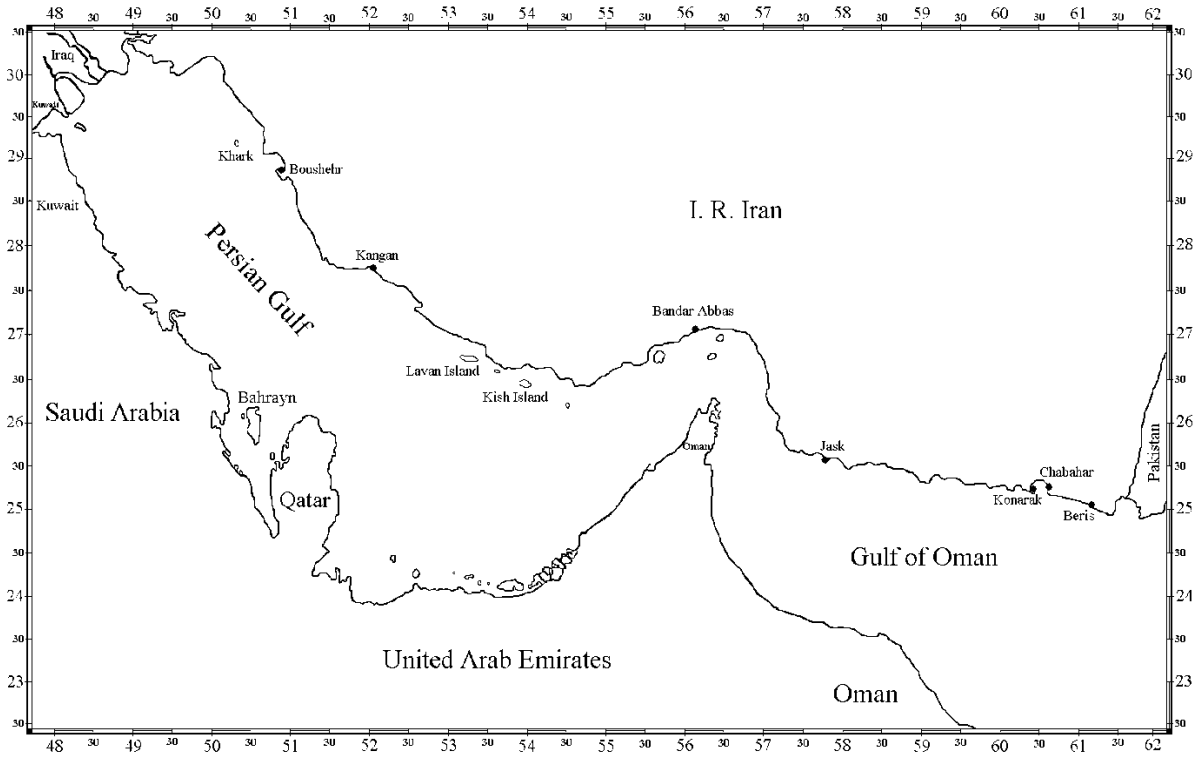

Figure 1. Sampling sites of *Scomberomorus commerson* in the Iranian coastal waters of the Persian Gulf and Oman Sea

Table 1- Input of life history parameters (Francis et al., 2020) to assess the stock status of *S. commerson* in the Persian Gulf & Oman Sea using length- based data-limited methods.

paameter	value	model
K	0.24	
Linf	156	
M	0.49	
Lm50	72	
Lm90	78	

The LBSPR model is based on the life history parameters (Table 1) and length frequency distribution of an exploited population. It estimates the spawning potential ratio (SPR), which reflects the reproductive capacity of a population under fishing pressure compared to its unfished state. In other words, SPR is calculated by comparing the equilibrium spawning biomass under current fishing pressure to the equilibrium spawning biomass without fishing pressure (Hordyk et al., 2015).

Results & Discussion:

Length maturity

A total of 1120 biological samples were collected, ranging in size from 29 to 154cm FL (Females). Length at first maturity of *S. commerson* measured for females. The mean size at first sexual

maturity (Lm50 %) was 77.7 Cm (Figure3). The smallest mature and largest immature female were respectively 52 and 100 Cm.

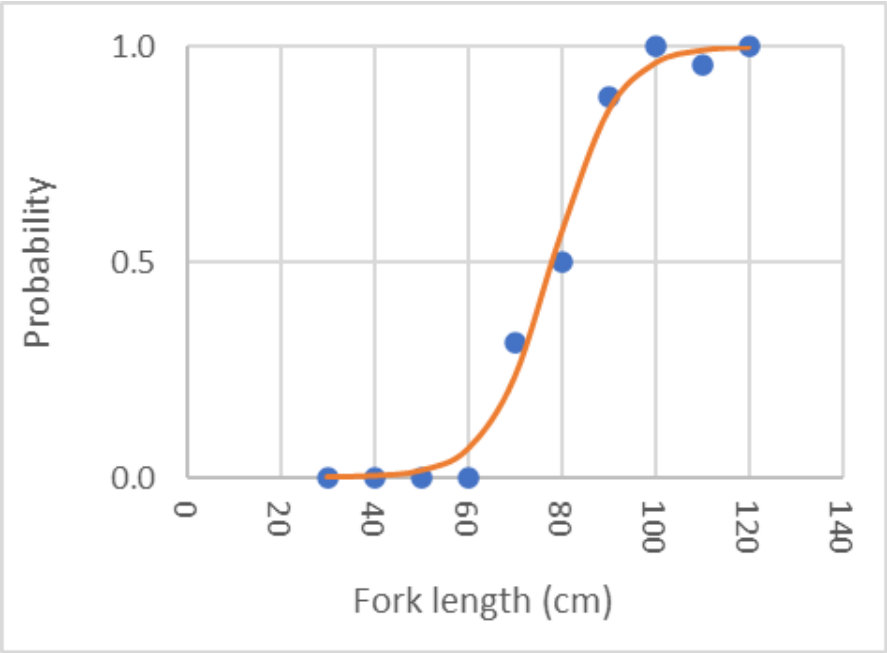

Figure 3. Cumulative relative frequency of the length at first maturity *S. commerson* (female) in the Persian Gulf & Oman Sea (Oct.2022- Sep. 2023)

Devaraj (1983) estimated the size at first sexual maturity 75 cm FL in the northern Indian Ocean, compare to the estimated size at spawning of 75-80cm FL given by Dudley et al.,1992 for males

and females combined off Oman. Claereboudt et al., 2005 estimated the size at first sexual maturity (also off Oman) at 80.4 cm FL for females. *S. commerson* has been found to mature between 70-80cm FL off Madagascar, Papua New Guinea, Fiji and north eastern Australia (Collete and Russo, 1979; McPherson, 1993). The mean size at first sexual maturity of this species was also found in our study 77.7 cm FL for females which coincide well with the published value of size at first maturity of Francis et al. (2020) (Table 2). Whilst our values compare well with those from other regions, histological diagnosis of the maturity development stage would have improved the estimates.

Table 2: Length of maturity of *S. commerson* reported by various studies

Length frequency range	L_m 50% (cm)	Region	Reference
?	79	Australian Coast	Mcpherson ,1993
40-170	70.7	Arabian Sea	Claerboudt et al.,2005
40-170	80.7	Oman Sea	Claerboudt et al.,2005
44.1-155.2	86.3	Southern Persian Gulf	Grandcourt et al.,2005
29-154	83.6	Northern P.G & O. S	Kaymaram et al.,2010
17-152	85	Northern Persian Gulf	Niamaimandi et al., 2017
?	78.7	Southern Persian Gulf	Francis et al.,2020
46.5 - 148	68	Western Pacific Ocean	Weng et al., 2020
		Northern P.G & O. S	Present study

As mitochondrial DNA studies indicated that these are one genetic stock in the Persian and Oman Gulf (Hoolihan et al., 2006) and the current data set only belongs to one year, therefore future joints studies and researches should address the issue of migration, particularly during the reproduction season between northern and southern coasts of the Persian Gulf (Hoolihan et al., 2006).

Conclusions on sources of variation in maturity sampling

Sampling time, locations and levels are the main considerations when maturity determination is one of the main goals. Is the timing of the sampling suitable for distinguishing mature fish from immature fish?

Uniformly distribution of the stock in space is one of the key questions. If spawning takes place in localized areas, it is necessary to sample both on and off the spawning grounds. Information on the sampling locations is then essential and commercial data might be unsuitable.

Is it necessary to sample in a length stratified way? Random sampling avoids many problems with raising the data, but might require higher sample sizes than length stratified sampling. For many stocks, commercial data are not appropriate and existing surveys are in the wrong period.

However, all results related to length – based data limited analysis should be taken with caution as there are many different sources of uncertainty in these types of models. Remarkably, most of these models suggest that selectivity is asymptotic by default (Hordyk et al., 2015) If large or small fish are absent, the model assumes that they do not exist in the population. The logistic selectivity assumption is generally violated in highly size-selective fisheries, such as the case of

the gillnet, which is the main gear deployed by the Iranian fishermen operating in the studied area. Consequently, it is recommended to carry out future sampling programs on other fishing gears such as line fishing to cover large specimens.

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