Iranian Journal of Fisheries Sciences 21(2) 516-525 2022
DOI: 10.22092/ijfs.2022.126511

Research Article

Population dynamic parameters of the Malabar trevally *Carangoides malabaricus* (Bloch and Schneider, 1801) in the Persian Gulf and Oman Sea

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Received: November 2021 Accepted: February 2022

Abstract

The population parameters of Malabar trevally *(Carangoides malabaricus)* were studied in the Persian Gulf and Oman Sea from December 2016 to November 2017. 1030 specimens were collected. The fork length ranged from 14 to 34 cm, with average 25.60±3.52 cm. The total weight ranged from 60.4 to 534.5 g, with average 329.03±113.46 g. The asymptotic length ($L\infty$) and growth coefficient (K) were 37 cm and K=0.85 per year, respectively. The probability of capture was calculated in fork length as L25%=22.47 cm, L50%=24.02 cm and L75%=25.26 cm. The length-weight relationship was determined as W= 0.06 $L^{2.62}$. The annual total mortality (Z), fishing mortality (F), and natural mortality (M) coefficients were estimated 3.1, 1.62, and 1.48 per year, respectively. The current rate of exploitation (E) was 0.52, and the value of exploitation ratio was found reasonable for current fishing effort. The results indicated that the Malabar trevally stock was not overexploited.

Keywords: *Carangoides malabaricus*, Length-frequency, Growth, Mortality, Persian Gulf, Oman Sea

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Introduction

The Carangidae are a family of ray-finned fish which includes the jacks, pompanos, jack mackerels, runners, and scads. It is the largest of the six families included within the order Carangiformes. (Nelson *et al*., 2016). Carangid fishes support more than 50 species in Indian waters (Kasim, 2003), and 11 species in Omani waters (Fouda *et al*., 1997).

Fish are of great importance in human life and are some of the most important protein sources, as well as some other useful products that are of great economic value to many people worldwide (Royce, 2013). Malabar trevally lives and reproduces in coastal rocky areas (Fischer and Bianchi, 1984). This species is resistant to low water turbulence and groups of young individuals gather in shallow sand beaches (Lin and Shao, 1999), but, they are seen individually at an older age .

A review of previous studies revealed that no research on growth, mortality, and exploitation of this species has been carried out in the waters of the Persian Gulf and the Oman Sea; Sadeghi *et al*. (2014) found the fishes as the main feeding item of this species in the Persian Gulf in 2011-12.

Considering the above mentioned, it is important to understand the biological evaluation and population parameters of fish and other aquatic species (White *et al*., 2003).Since recognizing the biological characteristics of aquatic life can be an effective guide to sustainable harvesting of its reservoirs, it has been attempted in this research to study the growth, mortality and exploitation rate of Malabar trevally (*C. malabaricus*), one of the important species of carangids in the Persian Gulf and the Sea Oman (coastal waters of the Hormozgan Province).

Materials and methods

The study area

The study was conducted in the Persian Gulf and the Sea of Oman from December 2016 to November 2017. A total of 1030 specimens were collected randomly from the coastal waters of Bandar Lengeh (26°33' N-54°52' E) , Qeshm Island (26°45' N-56°3' E), Bandar Abbas (27°10' N-56°14' E),Sirik (26°30' N-57°4' E) and the fishing areas of Bandar Jask (25°39'N-57°46' E). (Fig. 1) on a monthly basis.

Statistical analysis of data

The overall length and weight frequency distributions were tested for normality using the Kolmogorov-Smirnov (Lilliefors) (*D)* test (Zar, 1999). Non-parametric statistical methods were used to compare the overall length and weight of samples between months. The mean length and weight were compared using a Mann-Whitney U test (two-independent-samples test).

Growth and mortality estimations

During each sampling day, random sub-samples of fish were obtained from well-mixed catches.

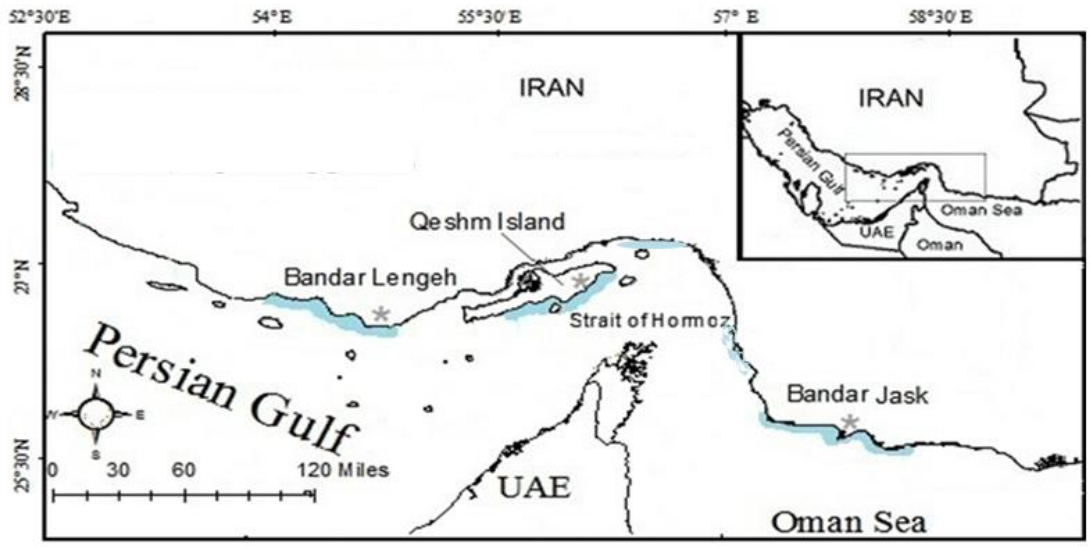

Figure 1: Map of the study area in the Persian Gulf and the Sea of Oman (waters of Hormozgan Province) in 2016-17.

The fork length and weight were recorded to the nearest cm and gram, respectively. Generally, at least 80 fish were measured in each month, except where catches were quite poor. The chosen sample size provided a reasonable database for analysis (Gulland and Rosenberg, 1992). The length-weight relationship was determined from Sparre and Venema (1992) using the least squares method:

$W=aL^b$

The FL frequency distributions were fitted to the Von Bertalanffy growth function (1) (Ricker, 1975) to estimate the main fish growth parameters following the equation: $Lt = L\infty (1 – e^{–K} (t– t_0))$ (1)

Where Lt is the length at time t, t_0 is the theoretical time at which the fish length equal zero, $L\infty$ is the asymptotic length, or the size an individual attains at the estimated maximum age, and K is the curvature parameter of the growth function. All parameters were calculated using the program FISAT (FAO-ICLARM Stock Assessment Tools) (Gayanilo et al., 2005). $L\infty$ and K were directly estimated from the fish length frequencies of the input data and the ELEFAN1 program. Pauly's empirical equation (Pauly, 1983) is then used to calculate t_0 according to the formula:

$$\log10 (-t_0) = – 0.3922 – 0.2752 \log10 (L\infty) - 1.038 \log10 K \quad (2)$$

Munro's Index (Φ') (Pauly and Munro, 1984) was also used to calculate the growth performance of fishes following the equation:

$$\Phi' = \log10 K + 2 \times \log10 L\infty \quad (3)$$

Munro's Index (Φ') allows comparison of the growth potential of the two different genders or different species, thus can serve as a criterion to evaluate growth patterns along latitudinal gradients and/or among taxonomic groups. The instantaneous rate of natural mortality (M) (Pauly,

1980) was obtained using Pauly's empirical formula:

$$\text{Ln}(M) = -0.0152 - 0.279\text{Ln}(L\infty) + 0.6543\text{Ln}(K) + 0.4634\text{Ln}(T) \quad (4)$$

Where T is the mean water temperature (°C), which was 27°C over the distribution area of *C. malabaricus* Using estimates of the growth parameters (K, L∞), the instantaneous rate of total mortality (Z) was estimated with the length-converted catch equation of Pauly (1983). The fishing mortality (F) was computed by subtracting natural mortality from total mortality as:

$F = Z - M$ (5)

The exploitation rate (E) was estimated from Z and F values as defined by the equation proposed by Ricker (1975) and Sparre and Venema (1992) as:

$E = F/Z$ (6)

The sizes at which fish had a probability of capture of 25, 50, and 75% were estimated from trawl selection using length-converted catch curve and logistic transformation.

Results

The fork length ranged from 14 to 34 cm, with average 25.60±3.52 cm. The total weight ranged from 60.4 to 534.5 g, with average 329.03±113.46 g.

Length weight relationship

The size frequency distributions of both genders showed a maximum frequency in the class 25-26 cm. The minimum and maximum average FL was 24.44 cm in October and 26.91 cm in January, respectively. Moreover, the minimum and maximum average of TW was 284.81 g in October and 370.66g in January, respectively

The relationship between length (cm) and weight (g) was estimated for 1030 specimens (both sexes) as:

As $W = 0.06\ L^{2.62}$ (R^2=0.93) (Fig. 2).

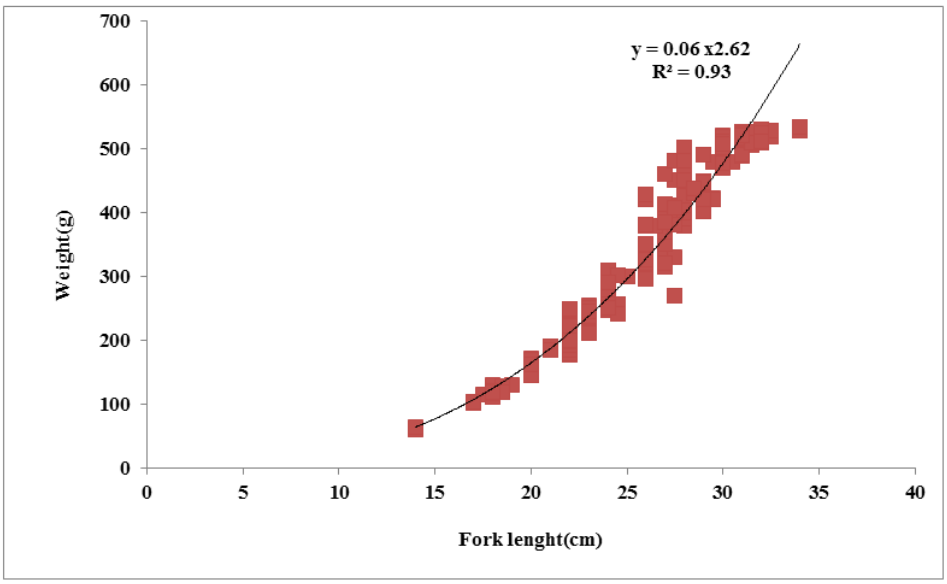

Figure 2: Length-weight relationship curve for *C. malabaricus* in the Persian Gulf and Sea of Oman (waters of Hormozgan Province) in 2016-17.

Growth parameters

The asymptotic length $L\infty$, growth rate K, and t_0 were estimated as 37 cm , 0.85 per year and -0.18 yr. , respectively .The above estimates of growth parameters were obtained from length frequency analysis using ELEFAN I program incorporated in FISAT II. The growth performance index, Ǿ was 3.06 (Figs. 3 and 4).

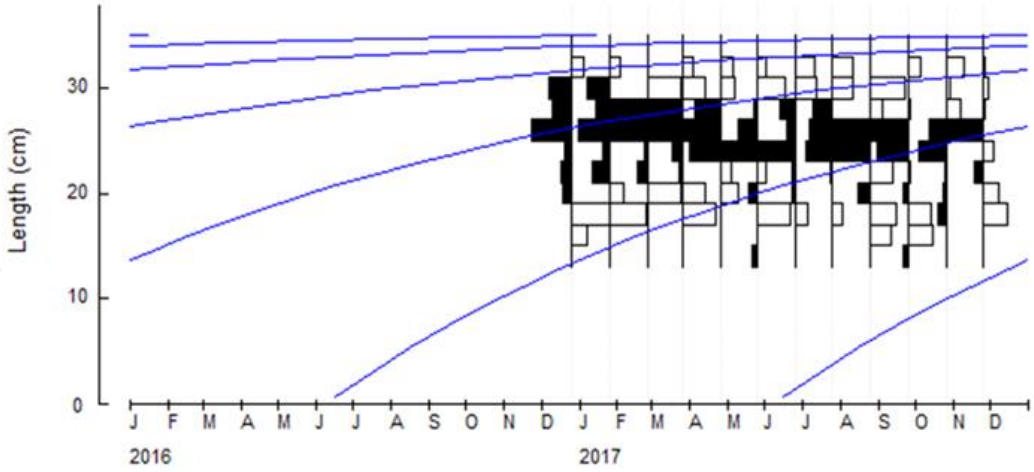

Figure 3: Fork length frequency distribution of *C. malabaricus* in the Persian Gulf and Oman Sea 2016-17.

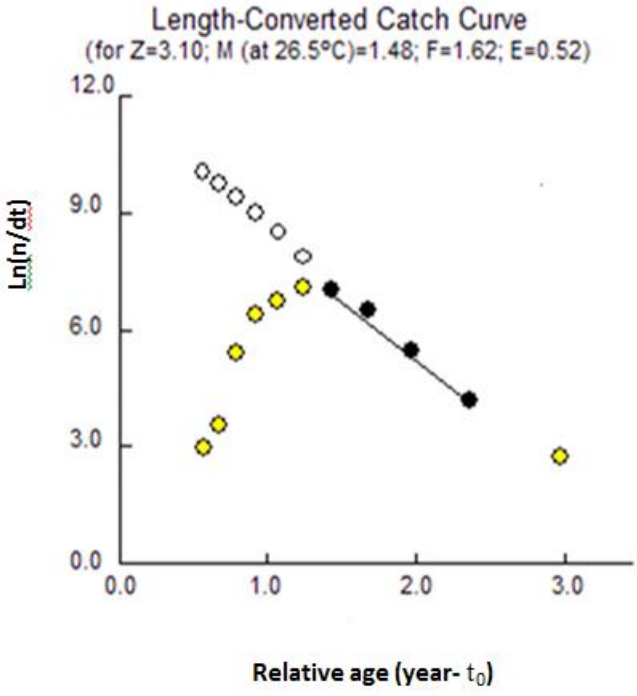

Figure 4: Length-converted catch curve for *C. malabaricus* in the Persian Gulf and Sea of Oman (waters of Hormozgan Province) in 2016-17.

Mortality and exploitation rate

From the length-converted catch curve procedure (Fig. 4) total mortality Z, was estimated 3.1 per year, while natural mortality (M) was estimated 1.48 per year from Pauli equation. The fishing mortality (F) was obtained 1.62 per year. The exploitation rate (E) was estimated as 0.52. The probability of capture was calculated in fork length as L25=22.47 cm, L50=24.02 cm, L75=25.56 cm (Fig. 5).

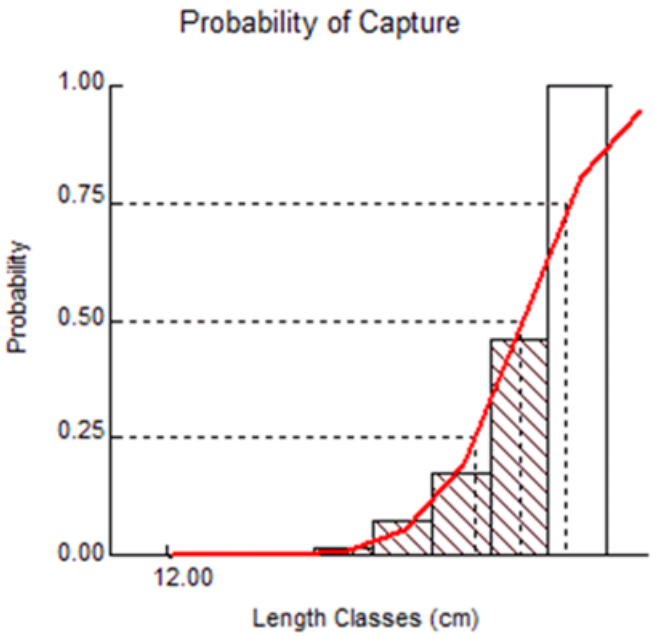

Figure 5: Selectivity curve of *C. malabaricus* showing the mean size at first capture at probabilities of 0.25 (L25), 0.5 (L50), 0.75 (L75) in the Persian Gulf and Sea of Oman (waters of Hormozgan Province) 2016-17.

Discussion

In this study, the fork length of *C. malabaricus* ranged from 14 to 34 cm, with average 25.60±3.52 cm. Bandana *et al*. (2017) reported the maximum length for *C. malabaricus* at 25.7 cm. The range of fork length reported between 11.1 to 25.7 cm and mean length 14.83 cm ±0.35 in the Portonovo Coast, Tamil Nadu, and South East of India. In the present study The total weight ranged from 60.4 to 534.5 g, with average 329.03±113.46 g while in the Portonovo Coast ranged from 15 to 180 g. (Bandana *et al*., 2017) . Since, length of fish directly is effected by factors such as food availability and feeding rates (Bagenal and Tesch, 1978), higher productivity of Persian Gulf and Oman Sea may provide more suitable environmental conditions for growing to larger size (Grandcourt *et al*., 2004).

In the present study, the most frequent of length class of *C. malabaricus* was 26 to 27 cm, while in the study of Norouzi and Valinassab (2007), the most frequent of length reported in the class of 19 to 20 cm. The length-weight relationship is considered as one of the most essential tools in the

study of stocks and management of aquatic stocks (Rodriguez-Romero *et al*., 2009).

The values of a, *b* and R^2 coefficients of the length-weight relationship were estimated as 0.06, 2.62, and 0.93 respectively. In this study, there was a significant difference of b with the number 3, which indicates allometric and heterogeneous growth in *C. malabaricus*. The value of *b*=2.94 for *C. malabaricus* was reported from the Portonovo Coast, Tamil Nadu and South East of India (Bandana *et al*., 2017) . These values were estimated as a=0.041, *b*=2.67 in the length – weight relationship of *C. malabaricus* in the west coast of Peninsular Malaysia (Ahmad *et al*., 2003).

Length- weight relationship is required in population dynamics and fisheries stock assessment (Gulland and Rosenberg, 1992). Several factors including sex, length ranges, fishing method and season affect the accuracy of the length-weight relationships (Haimovici and Canziani, 2000).The differences of b in the same species could be seasonal fluctuations in environmental parameters, physiological conditions of fish at the time of collection, sex, development, and growth of gonads and nutritional conditions in the fish environment (Biswas, 1993) .

In present study, the growth rate (K) and the asymptotic length ($L\infty$) of *C. malabaricus* were estimated K=0.85 $year^{-1}$ and the asymptotic length L∞=37 cm, respectively. In the west coast of Peninsular Malaysia, these coefficients were estimated as K=0.9 $year^{-1}$, L∞=28.7 cm and K=0.78 $year^{-1}$ and L∞=38.1 cm in the coast of Sarawak (Ahmad *et al*., 2003).

Various factors including geographic area, ecology, season and sampling methodology are likely to affect growth parameters (McIlwain *et al*., 2005). Generally, the growth performance index (Ǿ) is a species-specific parameter, i.e. its values are usually similar within related taxa and have narrow normal distributions. Gross dissimilarity of Ǿ for a number of stocks of the same species or related species is an indication of the unreliability in the accuracy of estimated growth parameters (Moreau *et al*., 1986; Gayanilo *et al*., 2005) . The range of this index has been reported among different species of carangid between 2.34-3.34 in the Philippines and India (Corpuz *et al*., 1985; Reuben *et al*., 1992).This index was estimated 3.06 in the present study. The value of phi prime index (Ǿ) of Munro is in the range calculated for Carangidae, which will be a reason for the acceptable results. In addition, the amount (Ǿ) obtained for *C. malabaricus* in the west coast of Peninsular Malaysia was estimated 2.86. (Ahmad *et al*., 2003).

The mortality rates are important for determining the optimal fishing effort in the fisheries management. The total mortality (Z) was estimated to be 3.1 $year^{-1}$ in the present study. Ahmad *et al*. (2003) estimated slightly higher rate of mortality (Z=3.76, M=1.72 and F=2.04 per year) from the east coast of Peninsular Malaysia for *C. malabaricus*.

The high rate of mortality may be due to higher annual effort expended during the study period. The fishing mortality was obtained 1.62 per year in the present study, while Z, F, and M were 8.11, 6.63, and 1.48 per year in the east coast of Sarawak (Ahmad *et al*., 2003). The variations in these values might have been caused by size specific selectivity by different fishery gears of this species or seasonal migrations. However, even small fluctuation of growth parameters may influence on calculated mortality rates.

The estimated value of exploitation rate (E) of 0.52 confirms that *C. malabaricus* of the Hormozgan coastal waters is not experiencing fishing pressure. This is based on the assumption that any stock is optimally exploited when the fishing mortality (F) is equal to the natural mortality (M), or E=(F/Z)=0.5 (Gulland, 1971). The exploitation level value in the present study was lower than those from the coast of Sarawak and east coast of Peninsular Malaysia (Ahmad *et al*., 2003). General conclusion to be drawn from present study is that the level of exploitation is near to optimum level of E=0.5 (Pauly, 1982). The computed current exploitation rate E of 0.52 is far from the predicted Emax of 0.91.

The present work is the first one to offer baseline information regarding the population dynamic parameters of *C. malabaricus* in the Persian Gulf & Oman Sea, which will be useful for the management of sustainable fisheries .The analyses of mortality and exploitation rates indicated that the fishery of this species is in the stable condition in the coastal waters of the Persian Gulf & Oman Sea.

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