



Stock assessment of Dolphinfish, *Coryphaena hippurus* (Linnaeus, 1758) off southwest coast of India

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Original Article

Abstract

Based on the data collected from three fisheries harbours of Kerala during 2008-09, the age, growth, mortality and stock assessment of dolphin fish, *Coryphaena hippurus* was carried out. Asymptotic length (L_{∞}) and growth coefficient (K) were estimated as 194.25 cm and 0.40 per year respectively while average total, natural and fishing mortality coefficients were found as 0.97, 0.60 and 0.37 respectively. The relative yield per recruit and average biomass per recruit were determined as a function of L_t/L_{∞} and M/K where it was 0.28 and 1.5 respectively. The exploitation ratio (E) is worked out to be 0.38 and therefore the stock is considered underexploited. The results of the present study revealed that there is scope for increasing fishing effort targeting *Coryphaena hippurus* along the southwest coast of India to increase the level of fishing of this species.

Keywords: *Coryphaena hippurus*, growth, mortality, recruitment, yield per recruit, exploitation.

Introduction

Coryphaena is the only genus in the family Coryphaenidae and there are only two species *Coryphaena hippurus* (Linnaeus, 1758) and *Coryphaena equiselis* (Linnaeus, 1758) in the family (Castro *et al.*, 1999). (Collette, 1981) and (Palko *et al.*, 1982) reported the characters used for differentiating the above two species. *C. hippurus* is a popular angling species and an excellent food fish that often congregates

around fish attracting devices (Dempster, 2004). Dolphinfish supports important recreational and commercial fisheries in the Caribbean (Mahon *et al.*, 1982), southeastern United States (Beardsley, 1967), East Africa (Williams, 1956), Taiwan, Japan, China, and Hawaii (Hagood *et al.*, 1981), and is thus a shared resource among multiple countries (Kara and Jeffrey, 2007). *Coryphaena hippurus* is a circumtropical oceanic pelagic species that is common in waters of the Atlantic, Pacific and Indian Oceans (Beardsley, 1967; Rose and Hassler, 1968; Johnson, 1978).

C. hippurus (Linnaeus, 1758) is a commercially important species in tropical and temperate waters world wide. *C. equiselis* generally inhabits in open waters, and less frequently occurs in coastal waters. There is little information with respect to its geographical distribution; but it is probably distributed in more tropical and subtropical waters than *C. hippurus* (Collette, 1981). Dolphinfish, also known as *mahi-mahi*, are usually found on offshore but can occur within a few miles of the coast when winds blow steadily onshore or the Gulf stream is close to shore. This unusually fast growth rate and high turnover may make dolphinfish less susceptible to overfishing than other longer-lived, slower maturing fish (FWRI, 2008). They are usually caught by trolling and by tuna long lining; also occasionally with purse seines and driftnets

(Collette, 1981). This species is hunted commercially and is not considered currently an endangered or threatened species still, management regulations are needed to help conserve this valuable fishery. No information is presently available on the population parameters, mortality and exploitation of *C. hippurus* from Indian coast. So the present study was aimed to provide an insight into the population characteristics of *C. hippurus* collected from routine harbour survey along the Kerala Coast.

Material and methods

The data of *C. hippurus* for the present study was collected from Cochin, Munambam, Neendakara harbours in Kerala for the period 2008-2009, between 8° 54' N; 76° 38 E-10°11' N; 76° 10' E. They are mainly landed by tuna longliners, purse seiners and by trolling operations as the main by-catch species. The specimens were identified up to species level using FAO Species Catalogue (Fischer and Bianchi, 1984). The details of length, weight, sex were taken by following standard methods. The total length (TL) of the fish was measured from the most anterior part of the head with mouth closed to the farthest tip of the caudal fin (Murty *et al.*, 1992; Raje, 2000). The total weight (W) of the fish was recorded to the nearest 10g using a top-loading balance (Zacharia and Nataraja, 2003). A total of 232 specimens of *C. hippurus* in the length range of 55-185 cm were measured during the study period.

Length-based stock assessment methods were used for the present study (Ahmed *et al.*, 2003). Length data were grouped into 10 cm length groups. The monthly length frequency of *C. hippurus* was analyzed using the FiSAT computer program. The parameters of von Bertalanffy growth function (VBGF), asymptotic length (L_{∞}) and growth coefficient (K) were estimated using ELEFAN-1 routine incorporated into the FiSAT software. K Scan routine was conducted to assess a reliable estimate of the K value (Pauly and David, 1981). The VBGF was fitted to estimate the length-at-age curve using non-linear squares estimation procedures. The VBGF is defined by the equation:

$$L_t = L_{\infty} (1 - e^{-k(t-t_0)}) \text{ (Bertalanffy, 1960)}$$

Where L_t = mean length at age t; L_{∞} = asymptotic length; t = age of *C. hippurus* and t_0 = the hypothetical age at which length is zero.

Total mortality coefficient (Z) was estimated by using length converted catch curve method using ELEFAN II. Natural mortality rate (M) was estimated using Pauly's empirical relationship (Pauly, 1980).

The ascending left arm of the length-converted catch curve

was used to analyze the probability of capture of each length class according to the Pauly's method.

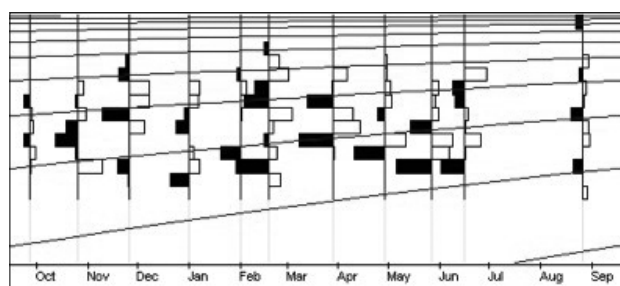
The recruitment pattern of the stock was determined by NORMSEP of FiSAT. To estimate length at recruitment (L_r) the mid point of the smallest length group in the catch was taken as length at recruitment (Murty *et al.*, 1992).

The estimated length structured virtual population analysis (VPA) were done according to the FiSAT routine. The values of L_{∞} , K, M, F, a (constant) and b (exponent) for the species were used as inputs to a VPA analysis in the FiSAT routine. The t_0 value was taken as zero (Nurul *et al.*, 2009). The relative yield/recruit (Y/R) and relative biomass per recruit (B/R) values as a function of E were determined from the estimated growth parameters and probability of capture by length (Pauly and Soriano, 1986). The Y/R and B/R were estimated by keeping the L_c constant. With the help of different exploitation ratios (E) on the 'X' axis and different sizes at first capture by using L_c/L ratios on 'Y' axis, isovalues of Y/R were plotted to generate the isopleths diagram. The calculations were carried out using the FiSAT software package. The input requirements in the procedure were the values of L_c/L_{∞} and M/K. From the analysis, the maximum allowable limit of exploitation (Emax) giving maximum relative yield/recruit was estimated. Also $E_{0.1}$, the exploitation rate at which the marginal increase in relative yield / recruit is 10% of its value at E= 0 and $E_{0.5}$, the exploitation rate corresponding to 50% of the unexploited relative biomass / recruit, were estimated.

Results

Growth parameters of von Bertalanffy growth equation for *Coryphaena hippurus* was estimated as L_{∞} =194.25 cm and K =0.40 year⁻¹ in 2008-09. (Fig.1).

Mortalities: The estimated mortality parameters viz. natural mortality (M), fishing mortality (F) and total mortality



$L_{\infty} = 194.25\text{cm}$ and $K = 0.40\text{year}^{-1}$, $C = 0$, $WP = 0$, and $Rn = 0.206$

Fig. 1. von Bertalanffy growth curves for *Coryphaena hippurus* during the period 2008-09

(Z) were 0.60, 0.37 and 0.97 respectively. According to Sparre and Venema (1992) the fishes with moderate K values are characteristic with moderate natural mortality, and it is related to age and size of the fish. K value in the present study is 1.12 year⁻¹ and the corresponding M value is 1.17. Therefore, the M/K ratio of *C. hippurus* is found to be 1.05. The fishing mortality (F) was calculated by subtraction of M from Z and it was found to be 0.37 where M was 0.60 and Z was 0.97 (Fig. 2.)

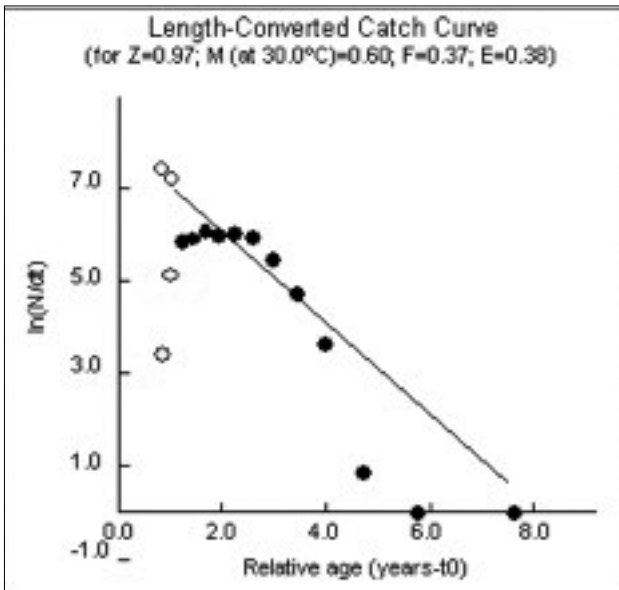


Fig. 2. Length-converted catch curve of *Coryphaena hippurus*

Virtual population analysis: Results of the VPA: using the length frequency data showed that fishing mortality (F) was maximum in the size group of 145-175 cm (Fig. 3).

Recruitment pattern: Results of the analysis of recruitment pattern of *C. hippurus* during the study period are shown in Fig 4. This can be interpreted as two recruitment

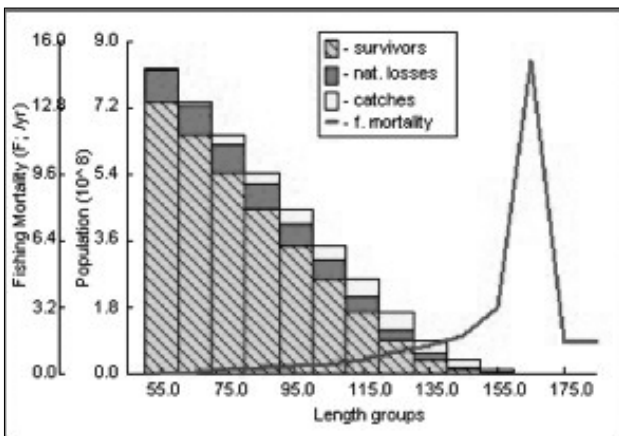


Fig 3. Length - structured Virtual Population Analysis of *Coryphaena hippurus* for the year 2008-09

peaks throughout the year, one around November and the other around April. The percent recruitment varied from 17.85% to 21.85%. The highest (21.85%) and lowest (17.85%) percent recruitment was observed in the months of April and November (Fig. 4).

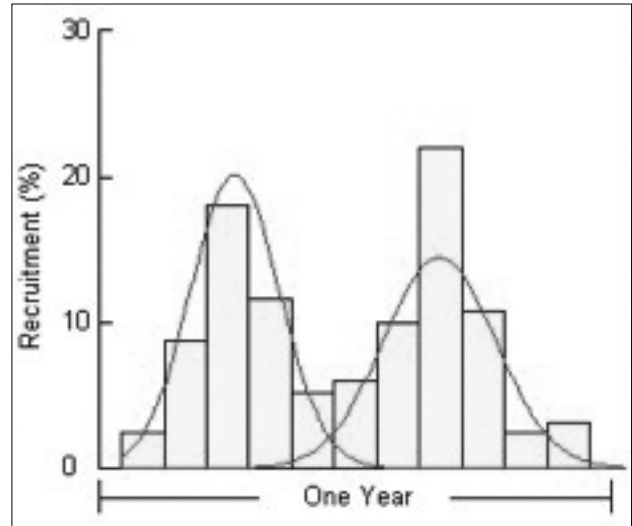


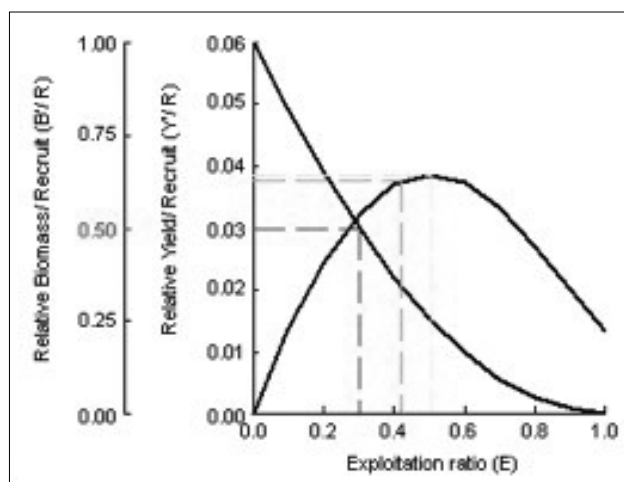
Fig. 4. Annual recruitment pattern of *Coryphaena hippurus*

Relative yield per recruit (Y/R) and Biomass per recruit (B/R): The Y/R and B/R were determined as a function of L_t/L_∞ and M/K where it was 0.28 and 1.5. The maximum (Y/R)_{max} was obtained at $E_{max} = 0.50$ as the exploitation rate increases beyond this value, relative yield per recruit decreases. The estimated values of $E_{0.1}$ and $E_{0.5}$ were 0.42 and 0.30 respectively. The results indicated that the present levels of E and F were lower than those which give the maximum (Y/R).

Discussion

The L_∞ and K values of von Bertalanffy growth equation for *C. hippurus* was estimated as $L_\infty = 194.25$ cm and $K = 0.40$ year⁻¹. The L_∞ and K values obtained in the present study are similar to the values of the growth parameters of *C. hippurus* reported from Colombia, Gulf of Mexico, Straits of Florida. (Patterson and Martinez, 1991; Oxenford, 1999). It may be seen that the present K value (0.40 year⁻¹) of *C. hippurus* from Indian waters is close to species reported from Brazil, USA, Florida and Mexican waters but the current L_∞ value (194.25 cm) is not similar with other countries except for American waters (Oxenford, 1986).

This study revealed that the recruitment pattern of *C. hippurus* shows two recruitment peaks per year. The highest (21.85%) and lowest (17.85%) percent recruitment takes place in April and November (Fig.4). It is seen that common dolphinfish, *C. hippurus* spawns in surface waters and their reproductive



$$E_{50} = 0.30, E_{max} = 0.50$$

Fig. 5. Relative yield/recruit and biomass/recruit (knife-edge selection) of *Coryphaena hippurus*

season is extensive with frequent multiple spawning (Johnson, 1978; Massutí *et al.*, 1998). Earlier studies in *C. hippurus* inhabiting Indian Ocean waters of east Africa revealed that the spawning season may last from March to early June (Enric and Morales, 1997). Dolphinfishes are also capable of spawning during their first year of growth and may reproduce several times during a single spawning season as manifested by the results of the present study. In Florida spawning season of *C. hippurus* shows a peak in March, which extends from November through July (FWRI, 2008). Studies along the Western Mediterranean also showed that while examining the size distribution of oocytes, there are at least two groups of oocytes in the ovaries, suggesting that *C. hippurus* is a multiple spawner with an extended spawning season (Enric and Morales, 1996). In earlier studies on growth and reproduction of the dolphin fish in Canary Islands of East Atlantic, the high correspondence between modal length classes and the half year classes suggests that the population of pompano dolphin is made up of two cohorts in each year, as a consequence of two separate and well-defined recruitment periods. On the other hand, the modal progression analysis of the size distribution of common dolphin fish caught in 1995 shows four size classes (Castro *et al.*, 1999).

The Relative yield per recruit and Biomass per recruit were determined as a function of L_c/L_∞ and M/K in the present study and the value were worked out as 0.28 and 1.5. The fishes with moderate K values are characteristic with moderate natural mortality and it is related to age and size of the fish (Sparre and Venema, 1992). K value in the present study is 0.40/year and the corresponding M value is 0.60. Therefore, the M/K ratio of *C. hippurus* is found to be 1.5. The M/K ratio is found to be constant among the closely related species

and the ratio in fishes generally falls within the limit of 1.5-2.5 (Beverton and Holt, 1959). The exploitation ratio (E) will be more than 0.5 for the stocks supposed to be over fished (Gulland, 1971). The exploitation ratio (E) in the present study is 0.38 which is well within the optimum E value of 0.5.

The results of the present study embark upon the need for increasing the fishing effort targeting *C. hippurus* along the southwest coast of India by which both the livelihood of fishermen and increase in the marine landings of the country can be ensured.

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