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Growth, mortality and exploitation of buccaneer anchovy (*Encrasicholina punctifer* Fowler, 1938) from the north Persian Gulf and Oman Sea

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Abstract

The population parameters of *Encrasicholina punctifer* (buccaneer anchovy) from commercial fisheries in the Persian Gulf and Oman Sea coastal waters were studied from October 2014 to September 2015. A total of 13951 length-frequency data were collected monthly by pair-boat purse seine and beach seine methods. The asymptotic length ($L\infty$) and Von Bertalanffy growth function (K) were 11.5 cm and K=1.4 per year, respectively. The value of t_o was calculated as -0.14 year. Longevity was estimated as 2 years. The total length ranged from 2.9 to 10.1 cm, with an average of 6.5 cm. The probability of capture was calculated in total length as L_{25}=6.05 cm, L_{50}=6.48 cm and L_{75}=6.93 cm. Four cohorts were distinguished annually with mean lengths of 4.56, 5.77, 7.21 and 8.50 cm. The length-weight relationship was determined as W= 0.0051 $L^{3.1114}$. Total, natural and fishing mortality parameters were estimated as 6.15, 2.84 and 3.32 yr^{-1} respectively. The current rate of exploitation (E) was 0.54, and the values of exploitation ratio was found reasonable for current fishing effort. From the yield-per-recruit analysis, E_{max}, was estimated as 0.91. The results indicated that the buccaneer anchovy stock was not overexploited. Since $E<E_{max}$, it confirmed the good potential of anchovy stock in the area.

Keywords: *Encrasicholina punctifer*, Growth, Mortality, Persian Gulf, Oman Sea

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Introduction

Anchovies are also ecologically important, because their large biomass is a link in coastal food-webs, transferring the energy in plankton and small organisms to larger fishes, sea birds and marine mammals (Ganias, 2014). Buccaneer anchovy (*Encrasicholina punctifer)* belonging to the family Engraulidae, is an important small pelagic fish occurring in commercial quantities in the north of the Persian Gulf and Oman Sea coastal waters. In recent years, anchovy fisheries increased due to the development of pair-boat purse seine in the Iranian coastal waters (Alizade and Oliaei, 2015). The estimated potential yield for anchovies in the Persian Gulf and Oman Sea was calculated around 173000 tons (FAO, 1981). Buccaneer anchovy is the dominant species of anchovies in the study area (FAO, 1981; Owfi, 1991; Van Zailinge *et al*., 1993). Fishing season of buccaneer anchovy in the Persian Gulf and Oman Sea starts from early autumn to late spring, the peak of fishing has been reported in winter (Alizade and Oliaei, 2015). Over 99% of anchovies landing in Iranian adjacent waters comes from the three major fishing grounds including Bandar Lengeh, Qeshm Island and Bandar Jask areas (Qorbanzadeh and Nazari, 2012). Landing of 37000 tons anchovies was reported by Alizade and Oliaei (2015) from the study area in 2014. The buccaneer anchovy is broadly distributed throughout the Indo-Pacific region and has been reported from several locations, including the east coast of Africa, India, Persian Gulf, southeast Asia, Japan, the Philippines, the central tropical Pacific and Hawaii (Strasburg, 1960, Whitehead *et al*., 1988). Buccaneer anchovy is a schooling epipelagic species found both in inshore and oceanic waters, sometimes entering large atoll lagoons or deep, clear bays (Maack and George, 1999). It is a small pelagic schooling fish, with a total length of 10 cm (Paula de Silva, 1992) and a short life span of around one year (Rohdenburg, 1995). Ranks among the most important food (bait) for tuna and other large pelagic fishes (Myers, 1999; Itano, 2000; Mundy, 2005). In particular, the *E. punctifer* appears to be a major forage source for yellowfin tuna, longtail tuna, Kawakawa and large hairtail, occupying a significant ecological role in the region (Darvishi *et al*., 1993; Kamali *et al*., 2003; Daghooghi *et al*., 2010). The species is well known from coastal locations (Sreekumari, 1977; Young *et al*., 1995) but appears to be primarily an offshore species and the only member of the anchovy group capable of completing the life cycle in the oceanic environment (Gorbunova, 1973; Orlov, 1995). This species usually occurs in shallow waters from 5 to 35m depth, with highest density around the islands and creeks mouth (Myers, 1999; Fricke *et al*., 2011). Most of studies on population structure of *E. punctifer* resources, have been carried out in the Philippines (Pauly, 1978; Ingles and Pauly, 1984, Lavapie-Gonzales *et al*., 1997) and Mozambique (Paula de Silva, 1992). Reproduction and feeding of *E. punctifer* were studied by Maack and George (1999) and Chern and Tzeng (1993). Several studies have been conducted in order to study population dynamics and biology of *E. punctifer* in Persian Gulf and Oman Sea (Salarpouri *et al*., 2007 ; Salarpouri *et al*., 2008; Ataei Daryaei *et al*., 2013). Because very little is known about the population parameters and exploitation levels of *E. punctifer* in the Persian Gulf and Oman Sea, this study was undertaken to fill some of these gaps.

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Materials and methods

The study area

The study area was the coastal waters of Bandar Lengeh, Qeshm Island and Bandar Jask fishing areas, situated between 52° 30' E and 58° 30' E longitude (Fig. 1), located in the north Persian Gulf and Oman Sea, has a high level of biodiversity, supporting a wide variety of fish species.

Data sampling

Time series of *E. punctifer* length–frequency from the commercial pair–boat purse seine and beach seine catches were collected monthly based on simple random sampling in the Persian Gulf and Oman Sea fishing grounds from October 2014 to September 2015. A total of 13951 specimens were collected for further length measurement.

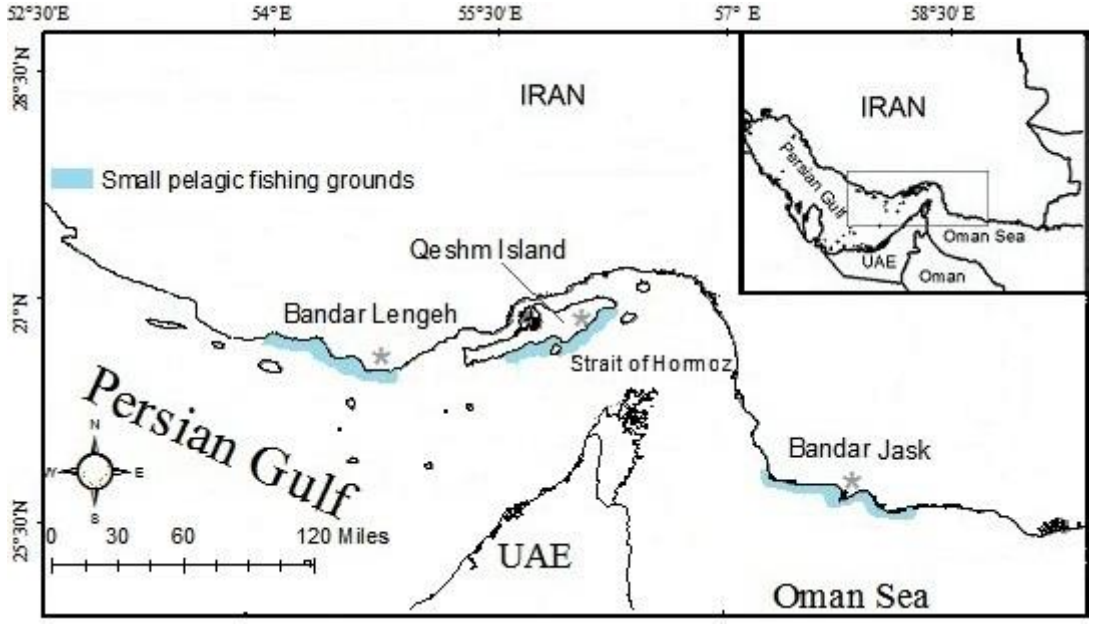

Figure 1: Map of the study area in the Persian Gulf and Oman Sea

Data analysis

The method of Sparre and Venema (1998) was used. During each sampling day, random sub-samples of fish were obtained from well-mixed catches. The total length and weight were recorded to the nearest mm and gram, respectively. Generally, at least 350 fish were measured in each sampling area and 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 (1998) using the least squares method:

$W=aL^b$

The length data were pooled and grouped into 0.5 cm size class in order to have about 16 length classes, as suggested by (Gayanilo *et al*., 2005). Growth parameters were determined using FiSAT (FAO–ICLARM Stock Assessment Tools) software (Gayanilo and Pauly, 1997). The Von Bertalanffy growth equation was used to describe growth in length (Sparre and Venema, 1998):

$L_t= L\infty [1-\exp(-k (t- t_0))]$

Where L_t is the total length (cm) of a fish at age t, $L\infty$ is the asymptotic length (cm), K is growth coefficient ($year^{-1}$), and t_0 is age (year) when L=zero (Sparre and Venema, 1998). T_0 was calculated from Pauly (1983) empirical function:

$Log_{10}(-t_0)=-0.3922-0.2752Log_{10}(L\infty)-1.038Log_{10}(K)$

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The starting point may be fixed or variable. The variable starting point allows for several possible choices of the starting points and only that with the best fit is retained (Gayanilo and Pauly, 1997). The seeded value of $L\infty$ used was *L*max, and the largest length was observed during the course of this study, which was 10.1 cm total length. For comparison of the Von Bertalanffy growth of *E. punctifer* studied with other anchovy species, the following formula was used for comparison of the Von Bertalanffy growth parameters (Pauly and Munro, 1984).

$\acute{O} = \text{Log}_{10} K + 2 \text{Log}_{10} L\infty$

The length-converted catch curve accounting for growth was employed to estimate the total mortality, as incorporated in FiSAT (Gayanilo and Pauly, 1997). The instantaneous rate of total mortality coefficient *Z* was therefore estimated using the following formula:

$$N_{i+1} = N_i \times e^{-Z(t_{i+1}-t_i)}$$

Where N_i is the (initial) number of fish at time t_i, N_{i+1} the number of fish remaining at time t_{i+1} and *Z* the instantaneous rate of total mortality (Gayanilo and Pauly, 1997). An advantage of such decay rates is that they can be added or subtracted. Thus, there is a second equation:

$Z = M + F$

where *M* is the instantaneous rate of natural mortality and *F* the instantaneous rate of fishing mortality; when $F = 0$, $Z = M$, which means that natural mortality has the same value as total mortality when there is no fishing, i.e. an unexploited stock. Natural mortality, fishing mortality and exploitation rates were all calculated as given by FiSAT (Pauly, 1983; Gayanilo and Pauly, 1997). For the calculation of the natural mortality, the mean environmental temperature, in this case 26.5C° (Ebrahimi *et al*., 2005; Ebrahimi *et al*., 2006; Ebrahimi *et al*., 2012) was incorporated into the Pauly (1980) formula as found in FiSAT. Pauly's empirical formula was used to determine natural mortality:

$\text{Log}_{10}(M) = -0.0066 - 0.2791 \text{Log}_{10}(L\infty) + 0.6543 \text{Log}_{10}(K) + 0.4634 \text{Log}_{10}(T)$

The exploitation rate (E) was estimated using the following formula:

$E = F/Z$

The probability of capture for anchovy fishery was estimated from the left ascending arm of length-converted catch curve. The right descending part of the catch curve was extrapolated backward such that fish that ought to have been caught, had it not been for the effect of incomplete selection or recruitment, were added to those in the curve, with the ratio of expected numbers to those that are actually caught being used to estimate probabilities of capture. By plotting the cumulative probability of capture against mid-length, a resultant curve was obtained. From this curve, the length at first capture *L*c was taken as corresponding to the cumulative probability at 50%. The entire length–frequency data were used to reconstruct the seasonal recruitment pattern of the fish by projecting backward along a trajectory defined by the computed VBG function, all the restructured length–frequency data on to a 1-year time scale (Pauly, 1987). The potential longevity of *E. punctifer* was calculated using the formula given by Pauly and Munro (1984):

$T\text{max} = 3/K$

The relative yield-per-recruit model of Beverton and Holt (1956) was modified by Pauly and Soriano (1986) and incorporated in the FiSAT Programme. The knife-edge selection and selection Ogive procedures were used to estimate relative yield/biomass per recruit. The computed exploitation rate was compared with the expected values of *E*max (the value of

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exploitation rate giving maximum relative yield-per-recruit), $E_{0.1}$ (the value of E at which marginal increase in Y/R is 10% of its value at $E = 0$) and $E_{0.5}$ (the value of E at 50% of the unexploited relative biomass-per-recruit)(Gayanilo and Pauly, 1997; Sparre and Venema, 1998). The yield isopleths diagram was used to assess the impact on yield created by changes of exploitation rate E and the ratio of length at first capture to asymptotic length (Lc /$L\infty$) in relation to changes in mesh size.

Results

Morphometrics

The total length ranged from 2.9 to 10.1 cm, with average 6.5±1.18 cm. The total weight ranged from 0.56 to 6.36 g, with average 2.17±0.95 g.

Length weight relationship

The length–frequency class given in Fig. 2, the most frequent of length class was calculated as 6.5-7.0 cm. The relationship between length (cm) and weight (g) was estimated for 2172 specimens (both sexes) as $W= 0.00515L^{3.1114}$(R^2=0.91) (Fig. 3).

Growth parameters

The estimation of growth parameters of *E. punctifer* is given from monthly length frequency. The asymptotic length, $L\infty$ was 11.5 cm; growth rate, K was 1.4 per year, t_0 was -0.14 yr; without respect to seasonal oscillation. The above estimates of growth parameters were obtained from length frequency analysis using ELEFAN I program incorporated in FiSAT II and growth curve so obtained is shown in figure 4. The growth performance index, $Ø$ was 2.26. The potential longevity of *E. punctifer* was estimated at 1.99 years or approximately 24 months. This represents the maximum life span of *E. punctifer* in its natural environment. Four cohorts were distinguished annually on Bhattacharya's method with mean lengths of 4.65, 5.77, 7.21 and 8.50 cm. The recruitment pattern is given in Fig. 5, indicating double recruitment peaks per year. The major recruitment peak occurred at 16.03% in September.

Mortality and exploitation rate

From the length-converted catch curve procedure (Fig. 6) total mortality Z, was estimated at 6.15 per year, while natural mortality (M) of 2.84 per year was estimated from Pauly (1980) empirical formula. The fishing mortality (F) of 3.32 per year was obtained. The exploitation rate (E) was estimated as 0.54 per year. The probability of capture was calculated in total length as L_{25}=6.05 cm, L_{50}=6.48 cm, L_{75}=6.93 cm (Fig. 7). Relative yield-per-recruit and relative biomass-per-recruit as computed using the Knife-Edge selection and Selection Ogive procedures. Yield per Recruit isopleths diagram with M/K=2.02 for *E. punctifer* given in Fig. 8. The yield contours predict the response of relative yield-per-recruit of the fish to changes in Lc (length at first capture) and E (exploitation rate); $Lc/L\infty$=0.56. $Lc/L\infty$ values represent varying scenarios equivalent to changes in mesh size. E corresponds to changing levels of F/Z. The optimum exploitation rates were estimated as follows: E_{max}=0.91; $E_{0.1}$=0.75; $E_{0.5}$=0.38. The dotted line is the computed value of the critical ratio and the exploitation rate is 0.91 (Fig. 9).

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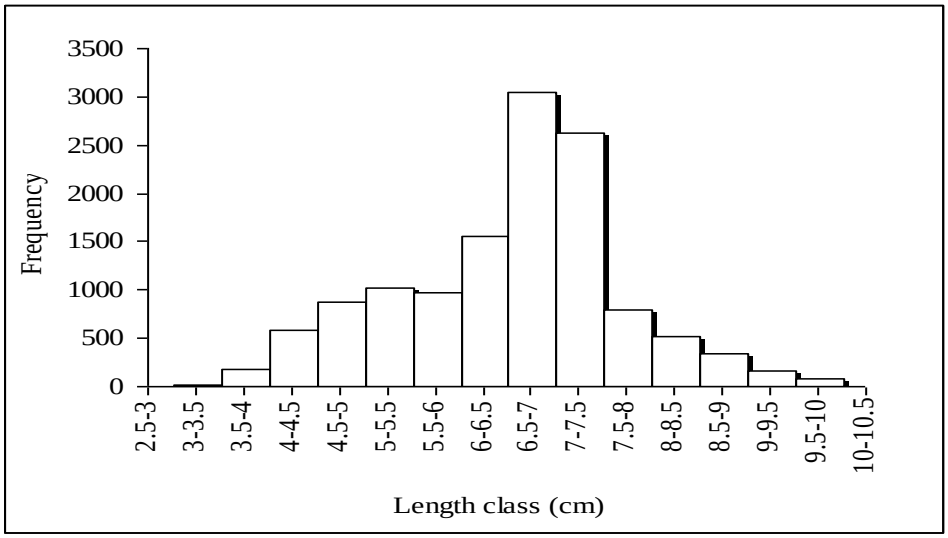

Figure 2: Length frequency distribution for *Encrasicholina punctifer* from the north Persian Gulf and Oman Sea.

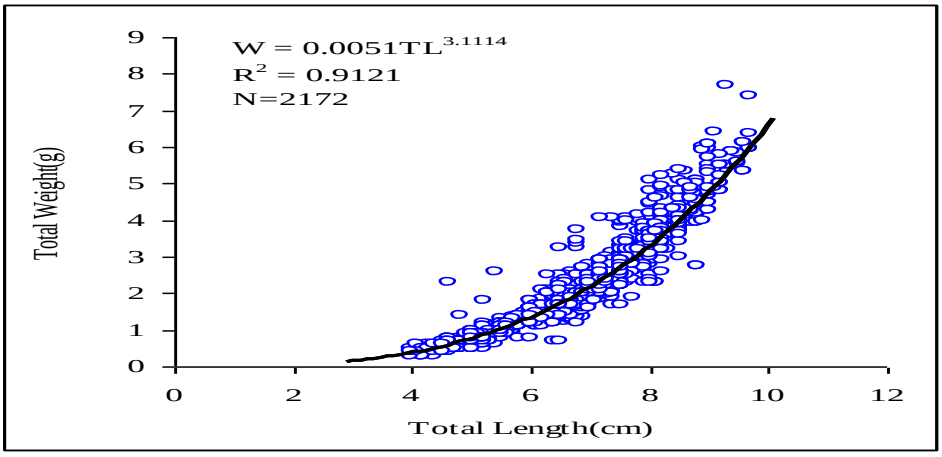

Figure 3: Length-weight relationship curve for *Encrasicholina punctifer*.

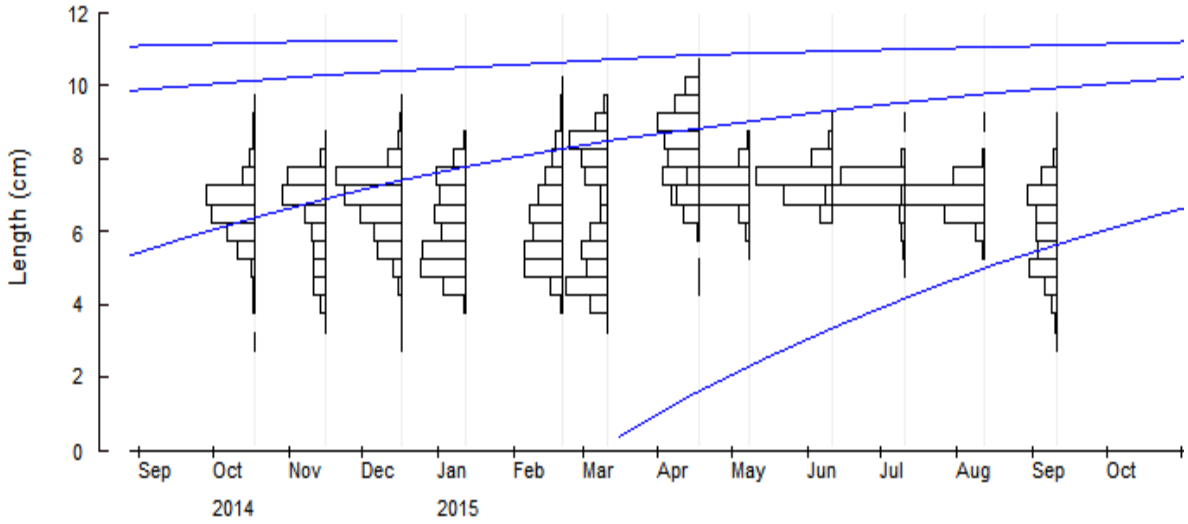

Figure 4: Restructured length- frequency histogram for *Encrasicholina punctifer* with super imposed growth curve (L∞=11.5 cm, K=1.4 per year, t_0=-0.14, Ø=2.26).

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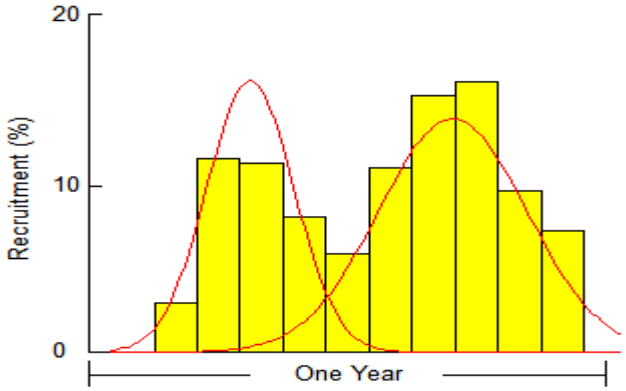

Figure 5: Recruitment pattern of *Encrasicholina punctifer*, indicating double peaks per year.

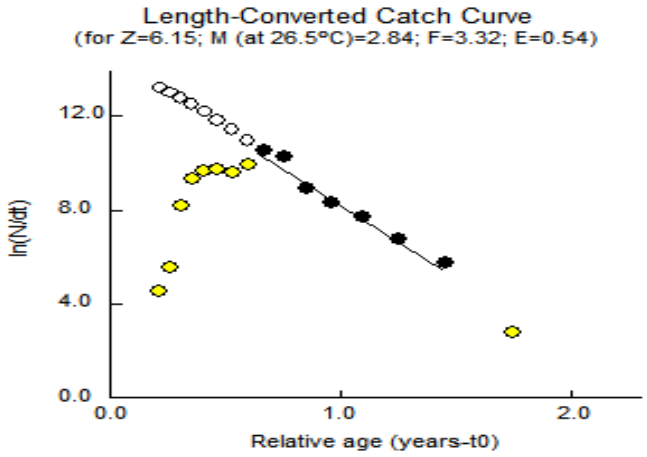

Figure 6: Length-converted catch curve for *Encrasicholina punctifer*. Regression statistics: *y*-intercept, *a* = 15.16; slope, *b* = -6.15; *r* = 0.98; *n* = 7; *Z* =6.15 per year.

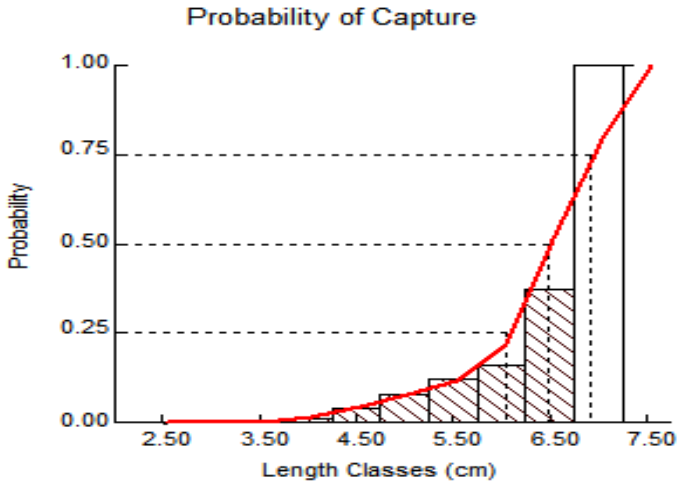

Figure 7: Probability of capture of each length class of *Encrasicholina punctifer* (L_{25}=6.05 cm, L_{50}=6.48 cm, L_{75}=6.93 cm).

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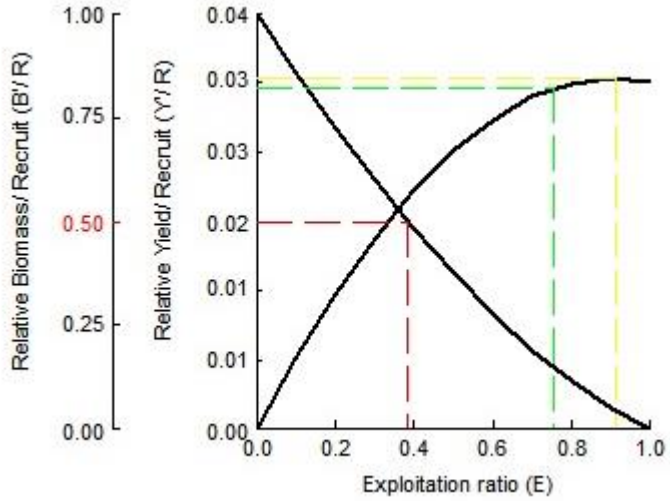

Figure 8: Yield per Recruit isopleths diagram with *M/K* = 2.02 for *Encrasicholina punctifer*. The yield contours predict the response of relative yield-per-recruit of fish to changes in *L*c (length at first capture) and *E* (exploitation rate).

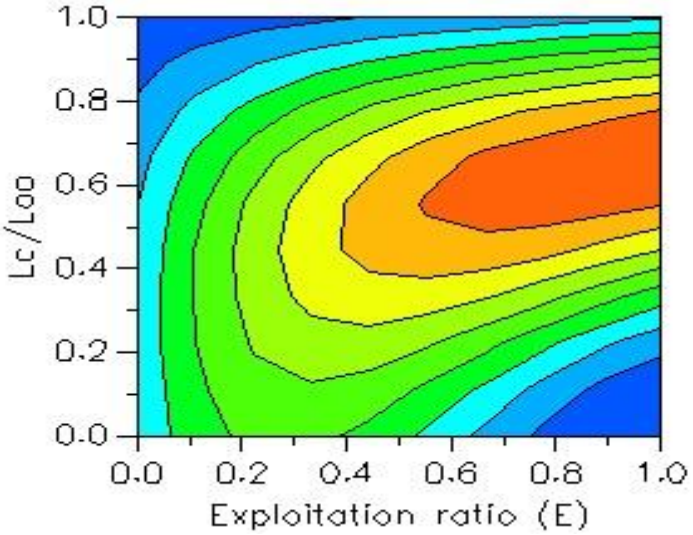

Figure 9: Relative yield-per-recruit and relative biomass-per-recruit as computed using ogive selection (E_{max} = 0.91, $E_{0.1}$ = 0.75, $E_{0.5}$ = 0.38).

Discussion

In this study, the total length of *E. punctifer* ranged from 2.9 to 10.1 cm, with an average of 6.5±1.18 cm. Whitehead *et al*. (1988) reported the maximum length for *E. punctifer* at 13 cm. The range of total length for *E. punctifer* from Mozambique were reported between 2.75 to 10.25 cm (Paula de Silva, 1992). The total length of *E. punctifer* ranged between 5.0 and 10.5 cm with major mode at 8.5 cm in the Indian coastal waters (Agenbag *et al*., 2003; Rohit and Gupta, 2008). A closer look at the length–frequency data in Fig. 2 will readily show the normally distributed *E. punctifer* stock with more middle aged fishes in the Persian Gulf and Oman Sea coastal waters, confirming that the gear mesh size are not suitable for anchovy fishing, and maybe the stock is going to be subject to fishing pressure (Gayanilo and Pauly, 1997). The *a* and *b* coefficients of

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the length-weight relationships were estimated as 0.0051 and 3.11 respectively. The value of *b*=2.87 for *E. punctifer*, *b*= 3.12 for *E. devisi* were reported from India (Rohit and Gupta, 2008), and *b*=3.12 for *E. punctifer* from Indonesia (Maack and George, 1999). In general, *b* values of fishes are closer to 3, despite the many variations of fish forms (King, 2007). Length- weight relationships are required in population dynamics and fisheries stock assessment (Gulland and Rosenberg, 1992). Several factors affect the accuracy of the length-weight relationships, e.g., condition of fishes caught in different seasons, sex, length ranges, sample size and fishing methods (Haimovici and Canziani, 2000).

In this study, the growth rate *K*=1.4 year^{-1} and the asymptotic length $L\infty$=11.5 cm. A comparison of growth performance of *E. punctifer* from different sources is given in Table 1. Generally, the growth performance index (Ø) is a species-specific parameter, i.e. its values are usually similar within related taxa and have narrow normal distributions. Gross dissimilarity of Ø 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). It must be realized however, that Ø can be used only to compare the growth performance of fish with similar shapes (Gayanilo *et al*., 2005). Preliminary analyses Moreau *et al*. (1986) suggest that the C.V. of Ø for several stocks of the same species should not exceed 5 percent, which may provide some guidelines as to which values of Ø are credible and which are not (Gayanilo and Pauly, 1997). The coefficient of variation of 4.04% together with other measures of dispersion (range = 0.24, SD = 0.093 and mean = 2.30) for Ø values in Table 1 is low. The Ø=2.26 of buccaneer anchovy in this study is; however, next to the other studies. Such differences can result partially from the different techniques used but more likely reflect slight environmental differences such as food availability, temperature, etc. (Ragonese and Bianchini, 1998). The similarity in the relative growth performance of this tropical anchovy and those from other regions suggests that phylogeny may influence growth independent of local environmental conditions. It also suggests that their position in the food web as lower-order secondary consumers places a constraint on overall growth performance in any environment (Milton *et al*., 1993).

Four cohorts were distinguished annually with mean lengths of 4.56, 5.77, 7.21 and 8.50 cm. The double recruitment peaks per year obtained here (Fig. 5) conform to the assertion of Pauly (1982) that the double recruitment pulses per year are nearly a general feature of tropical fish species. Sardine and anchovy, present peculiarities in their population dynamics and interesting phenomena are related to their recruitment (Bakun, 2010; Petitgas *et al*., 2012). Tropical species are known to have recruitment all through the year (Sparre and Venema, 1998). Recruitment of small pelagic fishes, especially anchovies, fluctuates widely in response to both fishing and environmental effects. Yet, their life history style is extremely flexible and enables populations to persist, even at very low levels (Beverton, 1990).

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Table 1: Comparison of growth performance of the *Encrasicholina punctifer* (Mean=2.30, range= 0.24, CV=4.04, S.D. =0.093).

Ø	*L*∞	*K*	Area	Source
2.22	11.6	1.23	Philippine	(Pauly, 1978)
2.32	10.6	1.85	Philippine	(Ingles and Pauly, 1984)
2.46	12	2	Mozambique	(Paula de Silva, 1992)
2.27	12.4	1.2	Philippine	(Lavapie-Gonzales *et al*., 1997)
2.26	11.5	1.4	Persian Gulf and Oman Sea (Iran)	This study

The instantaneous rates of total mortality Z= 6.15 year^{-1}, fishing mortality F=3.32 year^{-1}, natural mortality M=2.84 year^{-1} and exploitation rate E=0.54 were estimated in this study. Rohit and Gupta (2008) were estimated the rates of Z= 8.97 yr^{-1}, F=5.79 yr^{-1}, M=3.18 yr^{-1} and E=0.65 for *E. punctifer*, the rates of Z= 8.19 yr^{-1}, F=5.08 yr^{-1}, M=3.11 yr^{-1} and E=0.62 for *E. devisi*, from Indian coastal waters. The rate of mortalities and the exploitation rate in this study were lower than *E. punctifer* and *E. devisi* reported by Rohit and Gupta (2008). The value of exploitation rate (*E*) of 0.54 estimated here confirms that the stock of *E. punctifer* of the Persian Gulf and Oman Sea coastal waters is not experiencing fishing pressure yet. There are obvious factors responsible for the observed optimum fishing. The mortality and exploitation rates showed that the *E. punctifer* population is in suitable fishery conditions. This species studied here comprises predominant coastal small pelagic fishes in this area and the general conclusion to be drawn from these results is that the level of exploitation is near to optimum level of *E*=0.5 (Pauly, 1982). It seems that for short-lived species like anchovy with high reproduction potential, maybe *E* more than 0.5 is reasonable.

With a maximum age of 24 months, *E. punctifer* is a relatively short-lived species and it is confirmed by the high natural mortality recorded in this study. In addition, this result confirms the super imposed growth curve (Fig. 4) from restructured length- frequency. *E. punctifer* lifespan is around a year (Rohdenburg, 1995). Intuitively, we would consider longevity as something more closely related to mortality than *K*, *L*∞ or ambient temperature. As longevity is usually as difficult to observe as the natural mortality the relationship between mortalities and life span does not make it any easier as to estimate *M*, but it presents the concepts in way, which may be easier to grasp (Sparre and Venema, 1998). The short-lived tropical species grow much more rapidly than their temperate relatives, which suggests that they may have better growth performance and therefore be more desirable for culturing (Milton *et al*., 1993). Beverton and Holt (1956) found that values of the ratio *M*/*K* mostly lie in the range of 1.5–2.5 (Sparre and Venema, 1998). In this study, *M/K* for *E. punctifer* was 2.02. The relative yield-per-recruit(*Y/R*) model of Beverton and Holt (1956) estimates *Y/R* values based on few inputs, i.e., mean length at first capture/asymptotic length (*Lc/L*∞), ratio of natural mortality on growth (*M/K*) and exploitation rate (*E=F/Z*) (Pauly and Soriano, 1986). The relative yield per recruit was maximum when the exploitation rate (*F/Z*) was 1. This indicates that F should be very high compressed to *M* so that the ratio *F/Z* tends to be 1.

All these add credence to the validity of the results in this study. The computed current exploitation rate *E* of 0.54 is far from the predicted *E* max of 0.91. The exploitation observation indicated that the *E. punctifer* was in optimum exploitation in the Persian Gulf and Oman Sea region because of fishing activities, gear

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expansion, food availability and spawning success. This further strengthens the argument that the *E. punctifer* stock is not under fishing pressure. Based on the critical size ratio of ($Lc/L\infty$) (which is a proxy of mesh size) and the current exploitation rate E which is a proxy of effort, Pauly and Soriano (1986) have shown that relative yield isopleths could be grouped into four categories (quadrants) each with its distinct properties. When compared with the yield isopleths diagram in this study, the $Lc/L\infty$ of 0.56 and exploitation rate of 0.54 falls within quadrant *B* of (Pauly and Soriano, 1986). The implication is that the small fish were caught at lower effort levels.

In conclusion, the analyses of mortality rates, exploitation rates, yield-per-recruit and biomass-per-recruit carried out here all indicate that the purse seine fishery of *E. punctifer* of the Persian Gulf and Oman Sea coastal waters have not yet noticeably put fishing pressure on anchovy stock. Analysis indicates the anchovy fishery is in the growth phase, and it confirmed the reliable potential of anchovy stock in the area. Anchovy stock needs monitoring of the effort level and exploitation rate (E), there is no need for interventions. Furthermore, the fishery requires to stabilize its effort to achieve stable exploitation rates in anchovy fisheries.

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References

Agenbag, J., Richardson, A., Demarcq, H., Fréon, P., Weeks, S. and Shillington, F., 2003. Estimating environmental preferences of South African pelagic fish species using catch size-and remote sensing data. *Progress in Oceanography*, 59(**2**), 275-300.

Alizade, E. and Oliaei, M., 2015. Report of fisheries statistics of Hormozgan Province, Iran (year 2014). 88P (in Persian).

Ataei Daryaei, H., Kamrani, E., Salarzadeh, A. and Salarpouri, A., 2013. Otolith size and shape parameters of buccaneer anchovy (*Encrasicholina punctifer* Fowler, 1938) from Persian Gulf and Oman Sea. *Journal of Aquatic Animals and Fisheries*, 4(**13**), 37-44 (in Persian).

Bakun, A., 2010. Linking climate to population variability in marine ecosystems characterized by non-simple dynamics: conceptual templates and schematic constructs. *Journal of Marine Systems*, 79(**3**), 361-373.

Beverton, R., 1990. Small marine pelagic fish and the threat of fishing; are they endangered? *Journal of Fish Biology*, 37(**sA**), 5-16.

Beverton R. and Holt S., 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. *Rapports et Proces verbaux des Réunions, Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée, 140, 67-83.*

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[DOR: 20.1001.1.15622916.2018.17.2.5.5]

Chern, Y.T. and Tzeng, W.N., 1993. Feeding strategy of two larval Anchovies, *Encrasicholina punctifer* and *Stolephorus insularis*, in the Tanshui River Estuary, Taiwan: I. ontogenetic dietary shifts and morphological correlates. *Journal of Fish Society, Taiwan*, 20, 33-48.

Daghooghi, B., Momeni, M., Darvishi, M., Salarpouri, A., Seraji, F., Safaei, M. and Kaymaram, F., 2010. Investiagtion on feeding of sardines and major tuna fishes in west of Oman Sea (Jask area), Iranian Fisheries Research Organization, 117P (in Persian).

Darvishi, M., Behzadi, S. and Salarpouri, A., 1993. Spawning, fecundity and feeding of longtail tuna (*Thunnus tonggol*) in the Persian Gulf and Oman Sea (Hormozgan Province). *Pajouhesh and Sazandegi*, 59, 70-75, (in Persian).

Ebrahimi, M., Khodadadi Jokar, K. and Azini, M., 2012. Study on physicochemical properties of the Iranian waters in the Oman Sea. Iranian Fisheries Research Organization, 100P, (in Persian).

Ebrahimi, M., Mohebbi, L., Saraji, F., Eslami, F., Salimzadeh, M., Ejlali, K. and Aghajary, N., 2006. Hydrology and hydrological monitoring in the northeastern part of the Persian Gulf and Strait of Hormoz (Hormozgan Province water). Iranian Fisheries Research Organization, 109P (in Persian).

Ebrahimi, M., Mortazawi, M.S., Ejlali, K., Aghajari, N., Khodadadi Jokar, K., Akbarzadeh, G., Saraji, F. and Aghajari, S., 2005. Hydrology and hydrobiology studies on Persian Gulf in Hormozgan, south of Iran. Iranian Fisheries Research Organization, 130P (in Persian)

FAO., 1981. Pelagic resources of the Gulf and the Gulf of Oman. Regional fishery survey and development project. 104P.

Fricke, R., Kulbicki, M. and Wantiez, L., 2011. Checklist of the fishes of New Caledonia, and their distribution in the Southwest Pacific Ocean (Pisces). *Stuttg Beitr Natkd Ser A (Biol)*, 4, 341-463.

Ganias, K., 2014. Biology and ecology of sardines and anchovies: CRC Press. 382 P.

Gayanilo, F.C., Sparre, P. and Pauly, D., 2005. FAO-ICLARM stock assessment tools II: User's guide: Food and Agriculture Org.

Gayanilo, J. and Pauly, D., 1997. FAO-ICLARM stock assessment tools (FiSAT): Reference Manual, Vol. 8. FAO Computerized Information Series (Fisheries).

Gorbunova, N., 1973. Vertical distribution of eggs and larvae of fish in the western tropical pacific. Israel Program for Scientific Translation (Jerusalem), pp. 256-269.

Gulland, J.A. and Rosenberg, A.A., 1992. A review of length-based approaches to assessing fish stocks: Food and Agriculture Org. FAO Fisheries Technology Papers, 323, 100.

Haimovichi, M. and Velasco, G., 2000. Length- weight relationship of marine fishes from Southern Brazil. *Naga, The ICLARM Quarterly*, 23(**1**), 19-23.

Ingles, J. and Pauly, D., 1984. An atlas of the growth, mortality and recruitment of Philippines fishes. International Center for Living Aquatic Resources Management, Manila, Philippines. ICLARM Technical Report, 13, 127.

Itano, D.G., 2000. The reproductive biology of yellowfin tuna (*Thunnus albacares*) in Hawaiian Waters and the

[Downloaded from jifro.ir on 2026-11-19]

[DOR: 20.1001.1.15622916.2018.17.2.5.5]

western tropical Pacific Ocean: Project summary. SOEST Publication 00-01, JIMAR Contribution 00-328, 69P.

Kamali, E., Dehghani, R., Behzadi, S., Salarpouri, A., Darvishi, M. and Valinassab, T., 2003. Study on stock condition of cutlassfishes in Hormozgan waters. 75P (in Persian).

King, M., 2007. Fisheries biology assessment and management fishing. Second Edition. Blackwell publishing Ltd, 382P.

Lavapie-Gonzales, F., Ganaden S.R. and Gayanilo F.C., 1997. Some population parameters of commercially important fishes in the Philippines. Bureau of Fisheries and Aquatic Resources, Philippines. 114P.

Maack, G. and George, M.R., 1999. Contributions to the reproductive biology of *Encrasicholina punctifer* Fowler, 1938 (Engraulidae) from West Sumatra, Indonesia. *Fisheries Research*, 44(**2**), 113-120.

Milton, D., Blaber, S. and Rawlinson, N., 1993. Age and growth of three species of clupeids from Kiribati, tropical central south Pacific. *Journal of Fish Biology*, 43(**1**), 89-108.

Moreau, J., Bambino, C., Pauly, D., Maclean, J., Dizon, L. and Hosillos, L., 1986. The first Asian fisheries forum. Proceedings of the The first Asian fisheries forum, 1986. Asian Fishery Society.

Mundy, B.C., 2005. Checklist of the fishes of the Hawaiian Archipelago: Bishop Museum Press.

Myers, R.F., 1999. Micronesian reef fishes. Second Ed. Coral Graphics, Barrigada, Guam. 298P.

Orlov, A., 1995. Aggregations of Anchovy, *Encrasicholina punctifer* (Engraulididae), in the Open Philippine Sea. *Journal of Ichthyology*, 35(**3**), 151-156.

Owfi, F., 1991. Report on sardine fishes from the Persian Gulf and Oman Sea. Iranian Fisheries Research Institute-Bushehr Center, 7P (in Persian).

Paula de Silva, R., 1992. Growth of the buccaneer anchovy *Encrasicholina punctifer* off Mozambique, based on samples collected in research surveys. *Revista de Investigação Pesqueira*, 21, 69-78.

Pauly, D., 1978. A preliminary compilation of fish length growth parameters. Ber. Inst. Meereskd. Christian-Albrechts-University Kiel, 55, 1-200.

Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. *Journal du Conseil*, 39(**2**), 175-192.

Pauly, D., 1982. Studying single-species dynamics in a tropical multispecies context. Proceedings of the theory and management of tropical fisheries. ICLARM Conference Proceedings, pp. 33-70.

Pauly, D., 1983. Some simple methods for the assessment of tropical fish stocks. FAO Fisheries Technical Paper, 234, 52P.

Pauly, D. and Munro, J., 1984. Once more on the comparison of growth in fish and invertebrates. *Fishbyte*, 2(**1**), 21.

Pauly, D. and Soriano M. 1986. Some practical extensions to Beverton and Holt's relative yield-per-recruit model. Proceedings of the 1. Asian Fisheries Forum, Manila (Philippines), 26-31.

Pauly, D., 1987. A review of the ELEFAN system for analysis of length-frequency data in fish and aquatic invertebrates. Proceedings of the ICLARM conf. Proc, pp. 7-34.

[Downloaded from jifro.ir on 2026-11-19]

[DOR: 20.1001.1.15622916.2018.17.2.5.5]

Petitgas, P., Alheit, J., Peck, M. A., Raab, K., Irigoien, X., Huret, M., and Dickey-Collas, M. 2012. Anchovy population expansion in the North Sea. *Marine Ecology-progress Series*, 444, 1-13.

Qorbanzadeh, R. and Nazari, S., 2012. Statistical yearbook of the Iranian Fisheries Organization. Department of Planning and Development Management, 60P (in Persian).

Ragonese, S. and Bianchini, M.L., 1998. Growth, mortality and yield-per-recruit of the poor cod, *Trisopterus minutus capelanus*, from the Strait of Sicily. *Naga, the ICLARM Quarterly*, 21(**1**), 61-70.

Rohdenburg, H., 1995. Beitrag zur Baganfischerei und zur Bestandsabschätzung von *Encrasicholina punctifer* (Engraulidae, Pisces) vor der Küste Padang (West Sumatra, Indonesien). Universität Bremen, 47P.

Rohit, P. and Gupta, C.A., 2008. Whitebait fishery of Mangalore-Malpe, Karnataka during 1997-2002. *Indian Journal of Fisheries*, 55(**3**), 211-214.

Salarpouri, A., Taherizadeh, M.R. and Yahyavi, M., 2007. Growth and mortality parameters of Buccaneer anchovy, *Encrasicholina punctifer* in the coastal waters of Qeshm Island, Persian Gulf. *Iranian Journal of Marine Science and Technology*, 6(**1&2**), 65-74.

Salarpouri, A., Darvishi, M., Behzadi, S. and Seraji, F., 2008. Reproduction and feeding of Buccaneer anchovy (*Encrasicholina punctifer*) from coastal waters of Qeshm Island, the Persian Gulf. *Iranian Scientific Fisheries Journal*, 17(**1**), 44-54.

Sparre, P. and Venema, S.C., 1998. Introduction to tropical fish stock assessment-Part 1: Manual: FAO. 337P.

Sreekumari, A., 1977. Development and distribution of the larvae of the whitebait *Stolephorus zollingeri* Bleeker (Engraulidae, Pisces) along the southwest coast of India. Proceedings of the Symposium on Warm Water Zooplankton, National Institute of Oceanography, pp. 440-449.

Strasburg, D.W., 1960. A new Hawaiian engraulid fish. *Pacific Science*, 14, 395-399.

Van Zailinge, N.P., Owfi, F., Ghasemi, S., Khorshidian K. and Niamaimandi, N., 1993. Resources of small pelagics in Iranian waters, a review. 370P.

Whitehead, J., Nelson, G. and Wongratana, T., 1988. FAO species catalogue. Clupeoid fishes of the world (*Suborder clupeioidei*), An annotated and illustrated catalogue of the Herrings, Sardines, Pilchards, Sprats, Shads, Anchovies and Wolf-herrings Part 2. Engraulidae. FAO Fish. Synop, 125P.

Young, S.S., Chiu, T.S. and Shen, S.C., 1995. Taxonomic description and distribution of larval anchovy (Engraulidae) occurred in the waters around Taiwan. *Acta Zoologica Taiwanica*, 6(**1**), 33-60.

[Downloaded from jifro.ir on 2026-11-19]

[DOR: 20.1001.1.15622916.2018.17.2.5.5]