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Growth, mortality and exploitation rate of narrow-barred Spanish mackerel, *Scomberomorus commerson* in the Persian Gulf and Oman Sea, Iran, Hormozgan's waters

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Abstract
Growth, mortality and exploitation rate of kingfish, *Scomberomorus commerson* was studied. A total of 475 fish were collected monthly from fish-landing sites Jask, Bandar Abbas, Bandar Lengeh and Parsian in the North of Persian Gulf and Oman Sea coastal waters during October 2008 to September 2009. The FISAT II software was used to perform the estimate of growth, mortality and exploitation rate. The asymptotic length ($L\infty$) was 151.2cm and growth coefficient (K) was 0.46/year. Estimations from the probability of capture routines gave the length-at-first capture, Lc as 66.47cm.The annual instantaneous rate of total mortality (Z) was 1.93/year and the natural mortality (M) was 0.54/year. Fishing mortality (1.39/year) was higher than the biological reference points (F_{opt}=0.27 and F_{limit}=0.36) and the exploitation rate (E) was 0.72.

Key words: *Scomberomorus commerson*, Growth, Mortality, Persian Gulf and Oman Sea.

Introduction

The narrow-barred Spanish mackerel, *Scomberomorus commerson* the preferred species, which is heavily captured due to high demand by different gears in the Persian Gulf and Oman Sea. It is an epipelagic predator distributed widely in the Indo-Pacific waters from the Red Sea and South Africa to the Southeast Asia, in the North to China and Japan and South to Australia (Randall, 1995).
Kingfish fishery is an open access fishery without any input or output controls in GCC area and hence, the resource is heavily harvested by the fishers using a variety of gears such as drift and set gillnet, hand lines and trolling lines and rarely by beach seines. Due to high demand and unregulated fishing practice in the GCC waters, overexploitation of the kingfish stock has led to decline in the catches in recent years (Jayabalan et al., 2011).
Experiments on gillnet selectivity for kingfish indicated that the stretched mesh measuring 110 mm captured about 55% of fish below the length at first maturity (Jayabalan et al., 2011).
The *S.commerson* catch in the Southern waters of Iran was fluctuated from 3939 mt in 1997 to 18310 mt in 2011 or 8% of the total production of large pelagic fishes (Iranian Fisheries

Organization, 2012). Most artisanal fleets using drift gillnets for fishing tuna species (Kaymaram et al., 2010). Some results of studies on population dynamics and biological characteristics of *S. commerson* in the region reviewed by: Dudley et al. (1992); Edwards et al.(1985);Jayabalan et al. (2011);Pillai et al. (1993);Darvishi et al. (2012);Taghavi Motlagh and Ghodrati Shojaei (2009);Claerboudt et al.(2005);Grandcourt et al .(2005) and etc.

The goal of this study was to evaluate the fishery of *S. commerson* through estimation population parameters, with a view of evolving management strategies for its sustainable exploitation in the region.

Material and methods

Length frequency data was collected monthly from fish landing sites Parsian, Bandar Lengeh, Bandar Abbas and Jask in the North of the Persian Gulf and Oman Sea (Fig.1), from October 2008 to September 2009. The total sample size was 475.

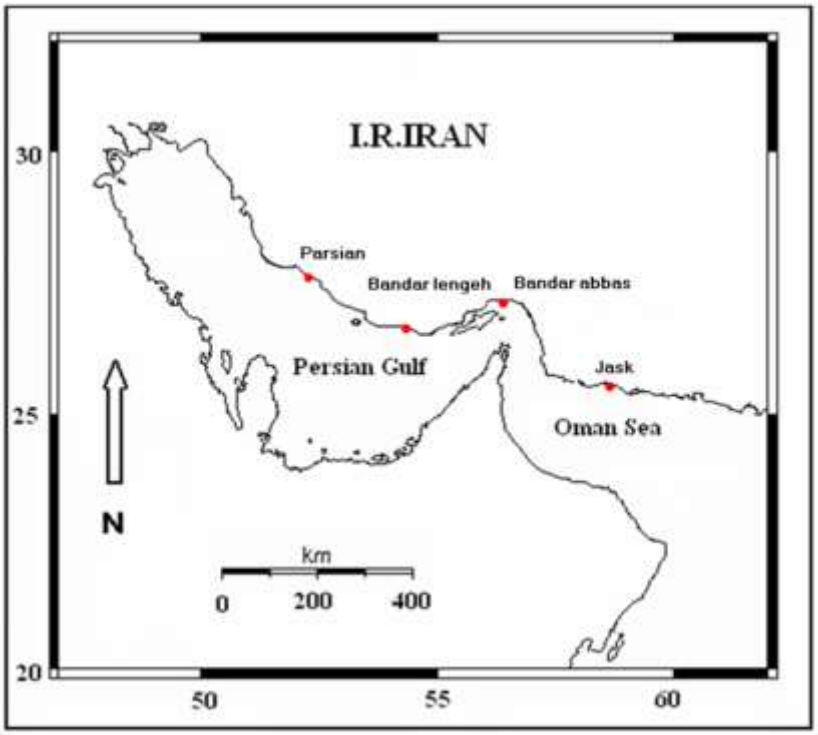

Fig. 1: Map showing *S. commerson* landing sites along the coasts of the Persian Gulf and Oman Sea

The fishes were measured to the nearest 1 cm (Fork Length) and the pooled length data were grouped into 3 cm size groups.Data analysis was based on K scan technique (shepherd's method) computer program of FiSAT (FAO-ICLARM Stock Assessment Tools) software (Gayanilo et al., 1996). The growth performance index (Φ') was calculated using the formula (Pauly and Munro, 1984):

$\Phi' = \log K + 2 \log L\infty$

The natural mortality coefficient (M) was estimated following Pauly's empirical formula (Pauly 1980), linking the natural mortality with the Von Bertalanffy parameters, K per year, L∞ (cm) and mean annual temperature (T, °C) of water in which fish stock lives (in this case 26.5°C):

$M = 0.8 * \exp [-0.0152 -0.279 * \ln L\infty + 0.6543 * \ln K + 0.463 \ln T]$

Fishing mortality coefficient (F) was calculated from the equation (Sparre and Venema, 1992):

$F=Z-M$

Where "M" is the instantaneous rate of natural mortality and "*F"* the instantaneous rate of fishing mortality. The exploitation rate (the fraction of death caused by fishing) was estimated using the formula (Sparre and Venema, 1992):

$E=F/Z$

The potential longevity of *S. commerson* was calculated using the formula of Pauly and Munro (1984):

$T_{max}= 3/K$

The probability of capture was estimated for gill net selectivity and the mean size at first capture (Lc) was derived by plotting the cumulative probability of capture against midlength.From the resultant curve, Lc was taken as corresponding to the cumulative probability at 50%. (Sparre and Venema, 1992; Gayanilo et al., 1996).

Resource status was evaluated by comparing estimates of the fishing mortality rate with target (F_{opt}) and limit (F_{limit}) biological reference points which were defined as; $F_{opt}= 0.5\ M$ and $F_{limit} =2/3\ M$, following Patterson (1992).

Results:

A total of 475 specimens were collected (Fig. 2) ranging in size from 29 to 138 cm. The mean fork length of *S. commerson* was estimated 69 ±20.7 cm (±SD), with the highest frequency in 53-56 cm length range (Fig.2).

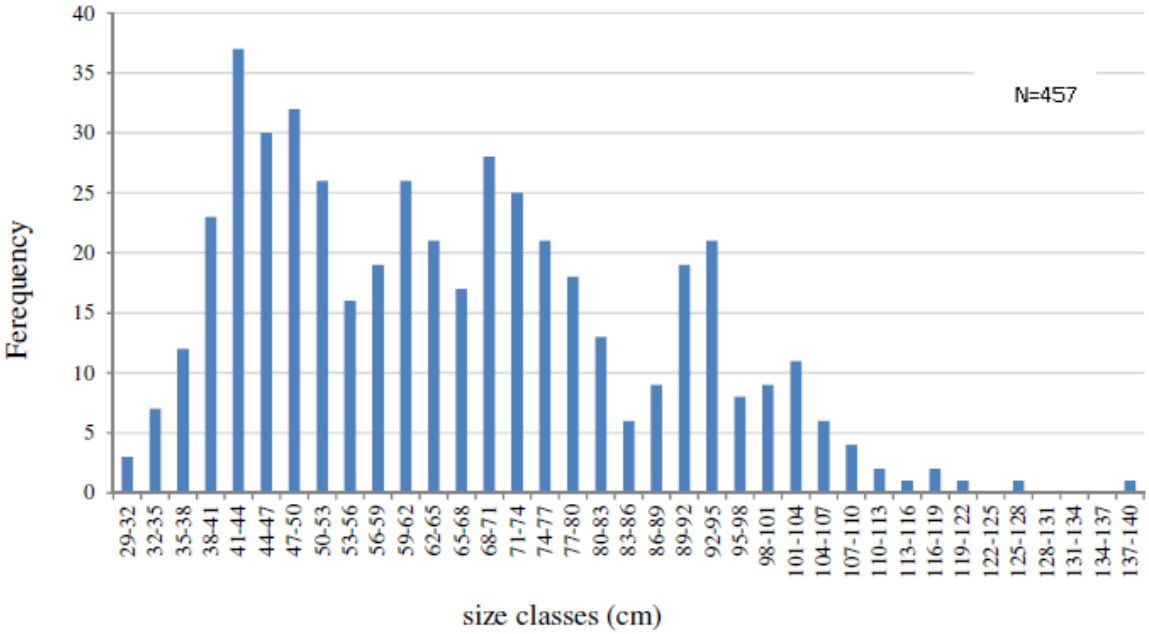

Fig. 2: Length frequency distribution of *S. commerson* catches in the Persian Gulf and Oman Sea (Hormozgan Province Waters) (2008-09)

Monthly length frequency data of the Persian Gulf and Oman Sea showed distinct modes during the 12 months of sampling with a clear progression of these modes over this time period (Fig. 3).

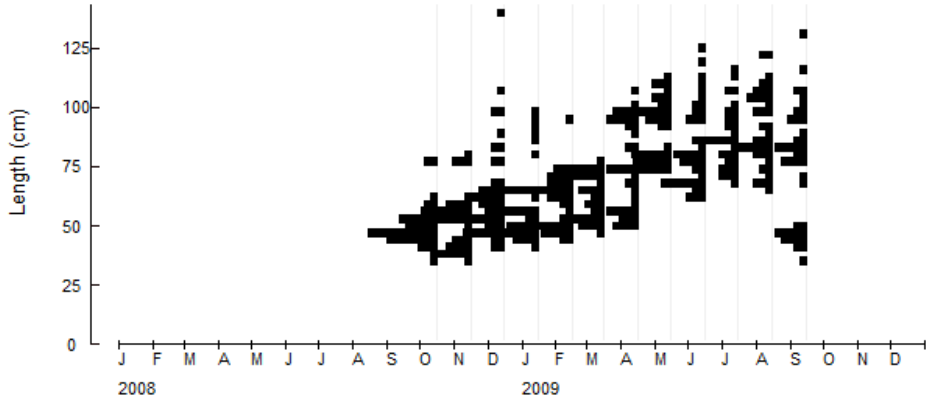

Fig.3: Monthly length frequency data collected from Persian Gulf and Oman Sea, 2008- 09

The K-scan technique indicated an L∞ of 151.2cm FL and a K value of 0.46 year^{-1} for the original data set (Fig. 4).The growth performance index (ǿ) estimated as 4.02.

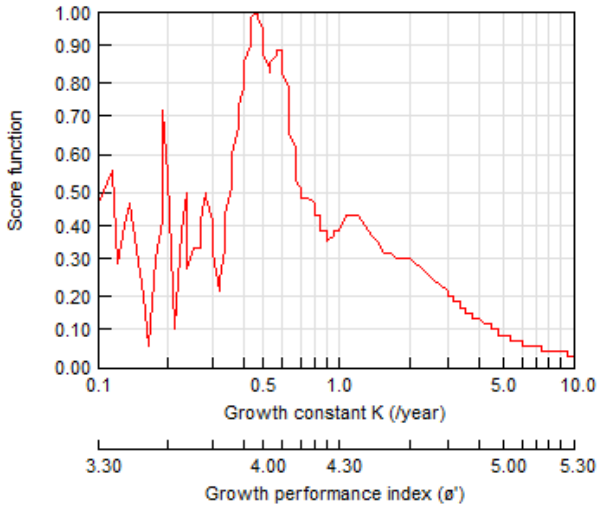

Fig.4: K-scan values curve by Shepherd's method for *S. commerson*

The annual instantaneous rate of total mortality derived from the length converted catch curve was 1.93/year and the natural and fishing mortality estimated respectively were 0.54 and 1.39 per year (Fig. 5).The annual instantaneous fishing mortality rate was higher than the biological reference points derived from the Patterson (1992) equation (F_{opt} = 0.27 and F_{limit} = 0.36). Exploitation rate was calculated as 0.72. The life span of *S. commerson* in its natural habitat (potential longevity) was computed around 7 years.

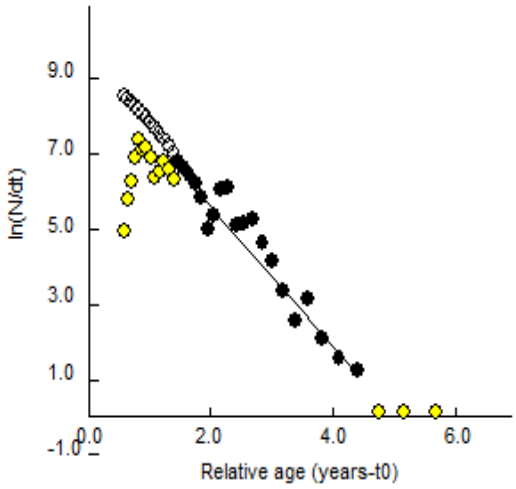

Fig.5: Length-converted catch curve of *S. commerson* in the Persian Gulf and Oman Sea (Z=1.93 / year)

Lc estimated at 66.47 cm (Fig. 6), Lc/ L∞ and M/K were 0.43 and 1.17respectively.

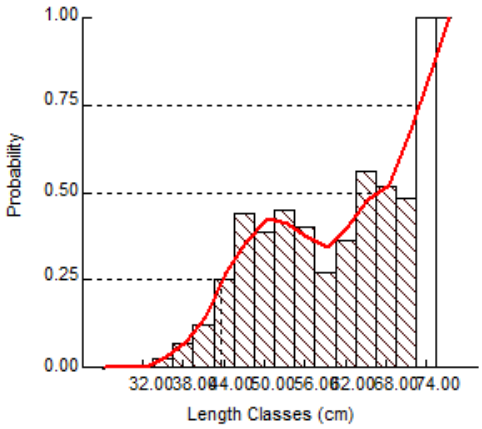

Fig.6**:** Probability of capture of each length class of *S. Commerson* (*L25* = 43.46 cm, L_{50} = 66.47 cm, L_{75} =72.55 cm).

Discussion:

S.commerson is important to fisheries globally (FAO, 1999).There are available references related to biology, growth and reproduction but the difficulties we face in monitoring and assessment are not these fundamental characteristics of the species, but those that relate to local boundaries are, how large and productive these local stocks are, and, what the real impact is by fishers on local population. It is clear that the primary research problems are about developing methods that yield information on these aspects of the different sub region fishery in the IOTC area (Buckworth and Clarke, 2001). Moreover it should be mentioned that data collected from gillnet catches are difficult to use for the estimation of growth parameters and mortality rates or gill net samples does not give us any information which can be used for the separation of cohorts and the estimation of length – at –age data (Sparre and Venema,1992).
As a result of the importance of growth estimation on the population dynamic studies, in this case it is necessary to use ageing techniques.

Parameters of the Von Bertalanffy growth function including L∞, K and Φ’ are presented (Table.1).

Table 1. Summary of growth parameters of the Von Bertalanffy of *S. commerson*

Country/Region	K (Per year)	L∞(cm)	Φ'	Reference
Queensland	0.20	141.25	3.60	Sumpton & O' Neil ,2004
United Arab Emirates	0.21	138.60	3.60	Grandcourt et al.,2005
India	0.78	146.00	-----	Pillai et al., 1993
Oman	0.21	144.40	3.70	Mcllwain et al., 2005
Southern Persian Gulf	0.26	183.60	3.94	Kedidi et al., 1993
Iran	0.42	140.00	3.91	Shojaei et al.2007
Oman	0.21	232.40	4.10	Al-Hosni & Siddeek,1999
Iran	0.45	175.26	4.10	Darvishi et al., 2012
Oman	0.40	176.00	4.09	Jayabalan et al.,2011
Iran	0.46	151.20	4.02	Present study

The differences among the studies could be due to the variations of sampling methods and time, the number of specimens in the studied regions. It should be noted that sometimes, different populations of the same species or the same population in different years can display changeable values perhaps due to the different feeding conditions (King, 2005).

The estimated L∞ and K in the present study are comparable with the earlier studies in the region. The high value of growth performance index (Ø'= 4.02**)** in the present study and in reports from Oman (4.01) (Al-Hosni and Siddeek, 1999); Saudi Arabia (3.94) (Kedidi et al., 1993) and Iran (Shojaeiet al., 2007(3.92) and Darvishi et al., 2012 (4.1)) indicated faster growth for the species in the Persian Gulf and Oman Sea (Jayabalan et al., 2011).

A comparison of Z, M, F and the exploitation rate of *S. commerson* from various studies is given in Table. 2. Since M is linked with the longevity and the latter to the growth coefficient K, the M/K ratio is found to be constant among closely related species and sometimes within the similar taxonomic groups (Beverton and Holt, 1959). The M/K ratio usually ranges between 1 and 2.5 (Beverton and Holt, 1959). In the present study, the M/K ratio for *S. commerson* was calculated at 1.17.

Table 2. Summary of mortality and exploitation rate of *S. commerson*

Country/Region	Z	M	F	E	Reference
Sri Lanka	1.63	0.60	1.03	0.63	Dayaratne, 1989
India	3.28	0.78	2.50	0.76	Pillai et al., 1993
Oman	1.32	0.44	0.87	0.66	Mcllwain et al., 2005
Saudi Arabia	0.78	0.36	0.39	0.52	Kedidi et al., 1993
Iran	1.47	0.49	0.98	0.64	Shojaei et al.2007
Oman	1.59	0.5	1.09	0.69	Jayabalan et al., 2011
Iran	1.98	0.5	1.48	0.74	Darvishi et al., 2012
Iran	1.93	0.54	1.39	0.72	Present study

The average length of capture (Lc) estimated in this study at 66.47 cm was well below the length at first maturity reported from earlier studies in the region (Jayabalan et al., 2011; Grandcourt et al., 2005; Sadeghi et al., 2009 and Darvishi et al., 2012). Value of The mean size at first capture in present study was considerably bigger than reported (Grandcourt et al., 2005) (Jayabalan et al., 2011) (Kaymaram et al., 2010). It should be noted that estimated Lc in this study was bigger than Lc estimated by Grandcourt et al. (2005).

The maximum age determined by length frequency data for *S. commerson* (7 years) in present study was smaller than the maximum absolute age by otolith estimated by Grandcourt et al (2005) (16.2 years); Dudleyet al. (1992) and McPherson (1992) (14 years).

The estimated higher fishing mortality (F = 1.39) than the value of M (0.54) in the study and the higher exploitation rate (E) of 0.72 indicate overexploitation of the resource. It has been recommended that the E should be ≈ 0.4 for pelagic migratory species like the kingfish.

In consequence the difference in the growth parameters estimated by earlier authors may be due to the fact that the data used for different analytical methods by them were obtained by different gears such as drift gillnets hooks and lines, troll and trawls (Pillai et al., 1993). More generally, data from neighboring countries which cover the stock migration route may be combined to discern the modal progression of cohorts and hence derive reliable growth parameter estimates. This emphasizes the need for joint assessment of the *S.commerson* shared stock. In this regard mithochondrial DNA studies indicated that these are one genetic stock in the Persian Gulf and Oman Sea (Hoolihan et al., 2006), therefore an ongoing data collection program using life history parameters must be initiated and future joint studies and researches should address the issue of migration, particularly between northern and southern coasts of the Persian Gulf and Oman Sea (Hoolihan et al., 2006).

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