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Population dynamic and biological aspects of *Scombermorus commerson* in the Persian Gulf and Oman Sea (Iranian coastal)

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Abstract

Scombermorus commerson is one of the most important and commercial species in the Persian Gulf and Oman Sea. In order to come up with the responsible fishing pattern, there was a need to identify some of the biological characteristics and population dynamic parameters. Data were collected randomly from five major traditional fish-landing sites Chabahar, Jask , Bandar Abbas, Bandar Lengeh and Parsian in the north of Persian Gulf and Oman Sea coastal(I.R.Iranian EEZ), from October 2006 to September 2007.

The average of fork length estimated 79cm. The b parameters in both female and male in this present study ($W = a.FL^b$) were close to 3 and indicating that *S. commerson* has isometric growth. The growth parameters of $L\infty$ and K were computed 175.26(cm) and 0.45 (1/ year) respectively and result showed that *S. commerson* grew very fast in the first 2 years. These parameters indicated that *S. commerson* is found to attain a fork length of 63cm at the end of first year. The fork length attained at the end of 2, 3 and 4 year to be 104, 129 and 146 cm respectively. Growth performance index (ǿ) calculated 4.1 which were in agreement with the finding of the other studies in the Indian Ocean. Total mortality, natural mortality, fishing mortality and exploitation rate were estimated 1.98,0.5,1.48(1/ year)and 0.74 respectively.

The sex ratio was no significantly different from 1:1.The fork length at first maturity estimated 83.6 cm. GSI for both male and females increased rapidly during May and June with spawning occurred from June to September**,** although small short spawning took place during April to May. The major food groups were Osteichthyes, Crustacea and Cephalopoda .Basic foods in Osteichthyes group were Engraulidae and Clupeidae.

Based on empirical equation between body length of females at first maturity and fork length, the stretch mesh size of gillnet 14.6 cm suggested for catch of *S. commerson.*

Key words:

Scombermorus commerson , Population dynamic parameters , Spawning period , Length at first maturity(LM_{50}) , Major food groups , Persian Gulf and Oman Sea.

INTRODUCTION

Tuna and seer fish species were distributed widely in the Persian Gulf and Oman Sea. The major tuna and seer fish species caught in both the Persian Gulf and Oman Sea are longtail tuna (*Thunnus tonggol*), kawakawa (*Euthynnus affinis*) , frigate tuna (*Auxis thazard*), narrow-barred Spanish mackerel (*Scomberomorus commerson*), Indo- pacific king mackerel (*Scomberomorus guttatus*) and yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*katsuwonus pelamis*) in the Oman Sea. *S. commerson* is one of the commercially important species in the Persian Gulf and Oman Sea. The *S. commerson* catch in I. R Iran was fluctuated from 3939 t in 1997 to 8778 t in 2006 or 6% of the total production of tuna and seer fishes (Figure 1). Most artisanal fisheries using drift gillnets for caught of *S. commerson* with mesh size of 95 and 120 mm but these fish are also caught by other gears such as trolling, hand-line and shrimp's trawl.

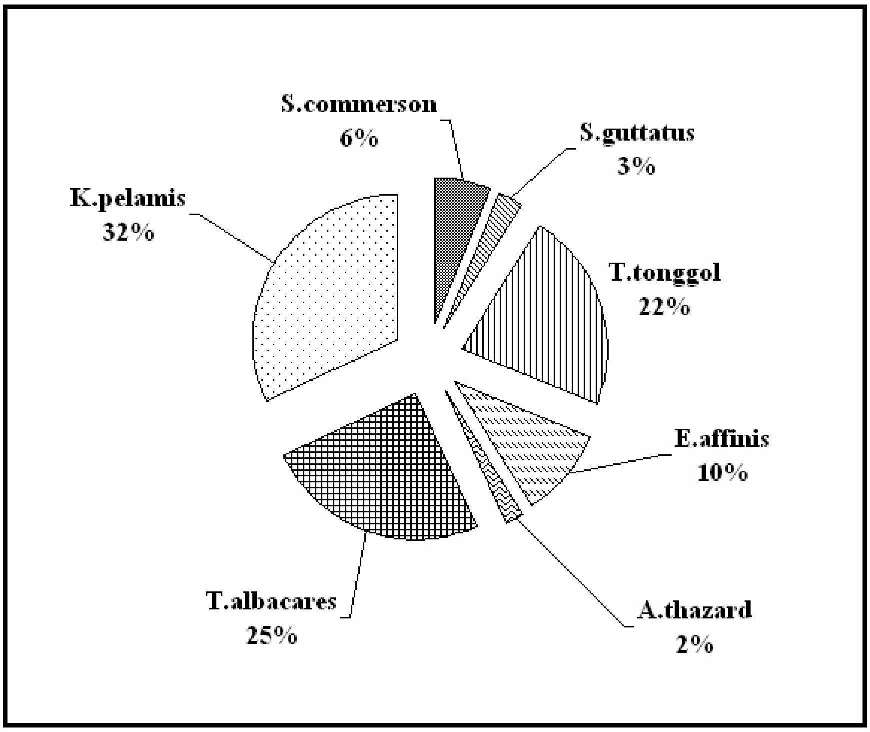

Fig. 1.The percentage of *S. commerson* catch in total production of tuna and seer fishes (I.R.Iran)

Some results of studies on population dynamics and biological characteristics of *S. commerson* in Indian Ocean reviewed by: Dudley *et* *al.,* (1992), Edwards *et al.,* (1985), Thiagarajan (1989), Pillai *et al*.,(1993) and etc.

This paper presents results of study on population dynamic and some aspects biological of *S. commerson* in the Persian Gulf and Oman Sea as the basis for the management and sustainable exploitation.

MATERIAL AND METHODS

Length and weight data were collected randomly from five traditional fish-landing sites: Chabahar, Jask, Bandar Abbas, Bandar Lengeh and Parsian in the north of Persian Gulf and Oman Sea coastal (Figure 2) (I.R.Iranian EEZ), from October 2006 to September 2007.

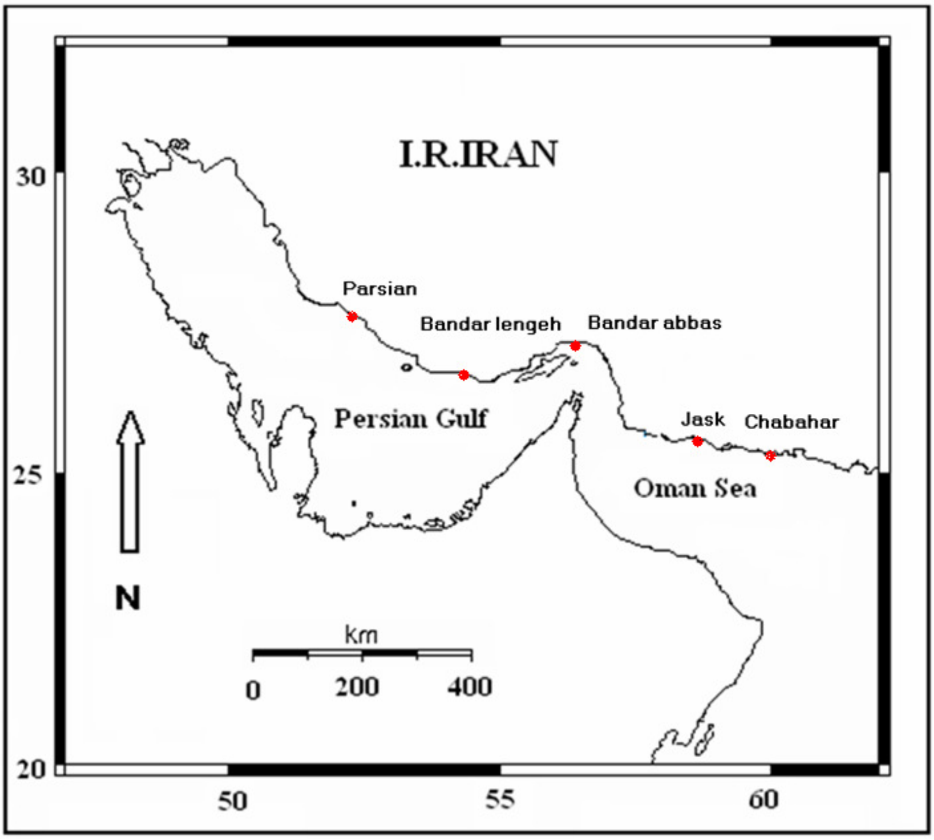

Fig 2.Landing sites for sampling of *S. commerson* in the north Persian Gulf and Oman Sea coastal

The fishes were simply measured and weighed to the nearest cm (fork length) and 50 gr respectively. The length frequencies were grouped in 3 cm intervals. The total samples size for population dynamic and biological aspects were 4515and 1120 respectively

Length – weight relationships were studied by sex (male & female)with the equation $W = a\ FL^b$, in order to verify if calculated b was significantly different from 3, the Student's t-test was employed (Zar, 1996).
The von Bretalanffy growth equation for length was taken in form of :

$$L_t = L\infty\ (1-\exp(-K(t-t_0))$$ (Sparre and Venema, 1998)

Growth parameters (K, L∞) and total mortality (Z) were estimated by FiSAT II software (FAO-ICLARM STOCK ASSESSMENT TOOLS) (Gayanilo *et al.*, 1996) with using Shepherd and length- converted catch curve methods.
In order to comparison results of this study with other studies the growth performance index (ǿ) was estimated :

$$\acute{\varnothing} = \text{Log}\ (K) + 2\ \text{Log}(L\infty)$$ (Pauly and Munro, 1984)

Natural mortality coefficient (M) was calculated with the equation of Pauly (1980) (multiplied by 0.8 : Since *Scomberomorus* species are considered schooling migratory fish some researches (e.g., Pillai *et al.*, 1993) have multiplied the M values by 0.8 to reduce bias):

$$\text{Log}\ M = 0.0066 - 0.279\ \text{Log}\ L\infty + 0.6543\ \text{Log}\ K + 0.4634\ \text{Log}\ T$$

Where T is the mean temperature of surface water, which was considered in this study as 27 ^{0}C.

The maturity development stages were assessed (Table 1) according to the criteria of Biswas (1993).The mean size at first maturity (LM_{50}) was estimated for female by fitting the logistic function to the proportion of mature fish in 20 cm (FL) size categories and determined as the size at which 50% of individuals were mature (King,2005):

$P=1/(1+\exp(-r(L-LM50)))$
Where:
P(proportion of sexually mature individuals by length L)

r(the slope of the curve)

Monthly gonad somatic index means (GSI) were calculated for both sexes by expression the gonad weight as a proportion of the total body weight. GSI was calculated using the following formula (Claereboudt *et al.* 2005):

GSI=Mass of gonad (g)/gutted fish mass(kg)

The timing and frequency of spawning were established by plotting of fish by maturity stage and gonado-somatic index against the sample period. The population sexual structure was examined using Chi-Square(χ^2) goodness of fit tests. Independent tests were conducted to determine whether sex ratio differed significantly from unity for the whole sample. The probability level was set at 0.05.

Table 1. Female maturity stages classification of *Scomberomorus commerson*

Development	Category	Description
I	Immature	Gonads about one-third length of the abdominal cavity. Ovaries thin, pinkish, ribbon like and invisible to the naked eye
II	Maturing Virgin or recovered spent	Gonads occupy about half of the abdominal cavity. Ovary pinkish translucent. Eggs visible under magnifying glass
III	Ripening	Gonads about two-thirds length of body cavity. Eggs large and readily seen with the naked eye. Ovary pinkish – yellow with granular appearance
IV	Ripe	Gonad occupy about full length of the body cavity. Ovaries distended and containing large translucent eggs
V	Spent	Gonads shrank having loose walls. Ovary may contain few ripe darkened or translucent eggs

Feeding habit described by Number method that the number of each item is recorded and expressed as a percentage of the total number of food items in the sample studied(Biswas, 1993).
Girth-Fork length relationship GL=A.FL+B (Linear equation) and LM_{50} applied to suggestion standard mesh size(Kaymaram, 2000):

GL=A.FL+B
K = GL/(4*LM50); GL in LM50
a = K*LM50
2a = stretched mesh size

RESULTS

The fork length of *S. commerson* ranged from 20 to 164 cm, with average 79 cm (Fig 3).

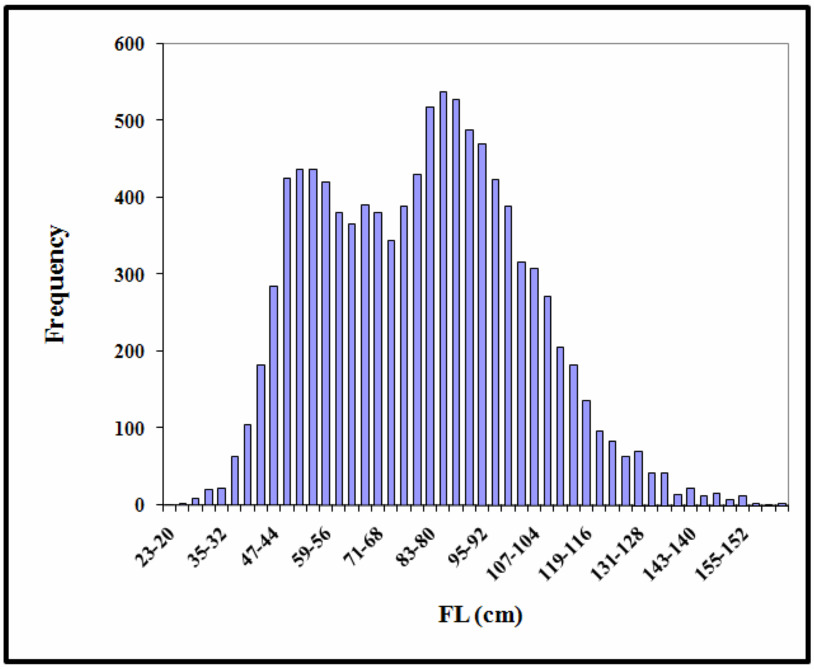

Fig 3.Fork length distribution of *S. commerson* in the Persian Gulf and Oman Sea

The "b" parameter values in the length-weight relationship model ($W=aFL^b$) for both female and male were 2.9(Figure 4 & 5)that are closed to 3 and indicating isometric growth for *S. commerson.*
The K-scan technique, indicated an $\mathbf{L}_\infty$ of 175.26cm FL and a K value of 0.45(/year) for the original dataset(Figure 6 & 7). The growth performance index (ǿ) estimated as 4.1.

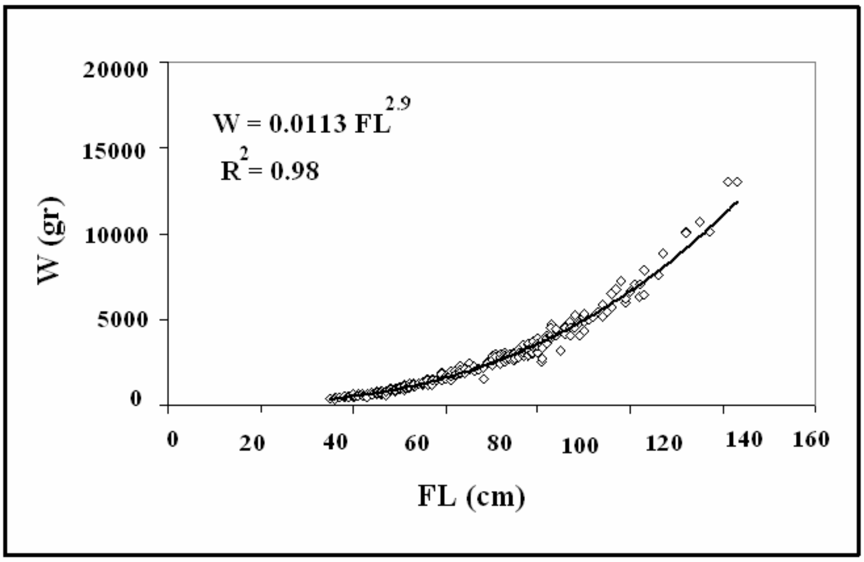

Fig 4. The length- weight relationship curve of *S. commerson* (Male) in the Persian Gulf & Oman Sea

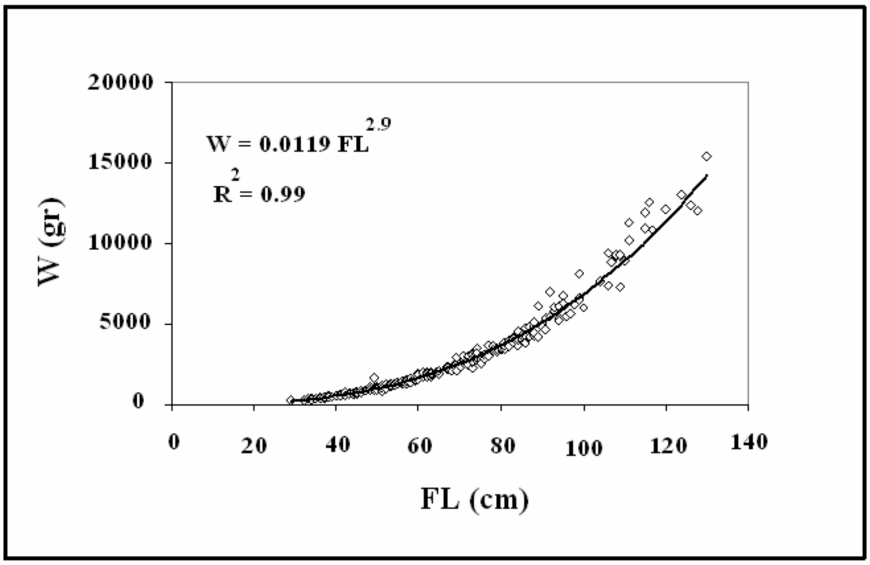

Fig 5. The length- weight relationship curve of *S. commerson* (Female) in the Persian Gulf & Oman Sea

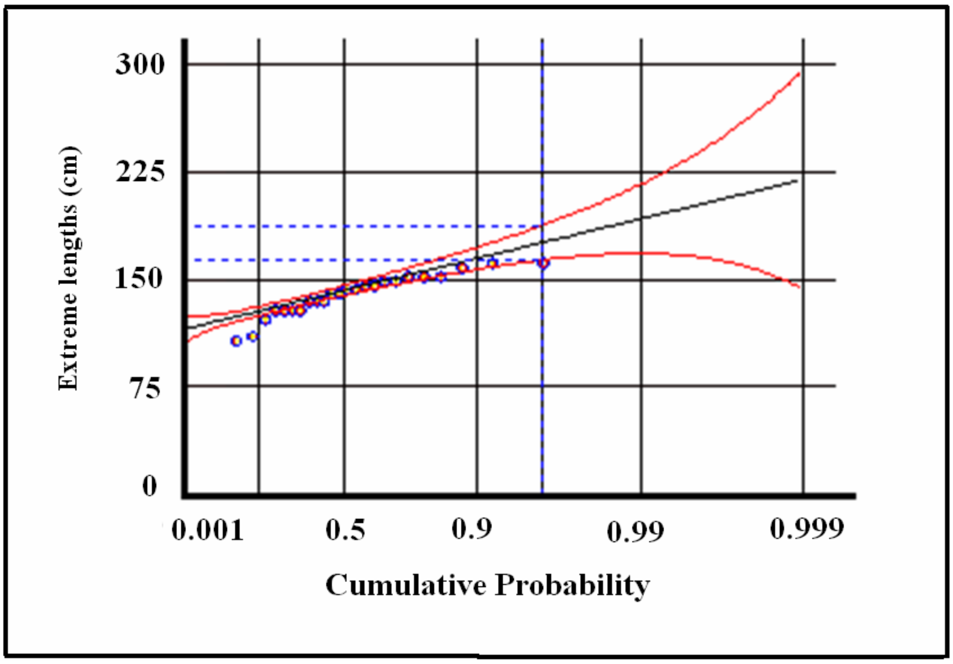

Fig 6. Cumulative probability graph for estimate of L**max**

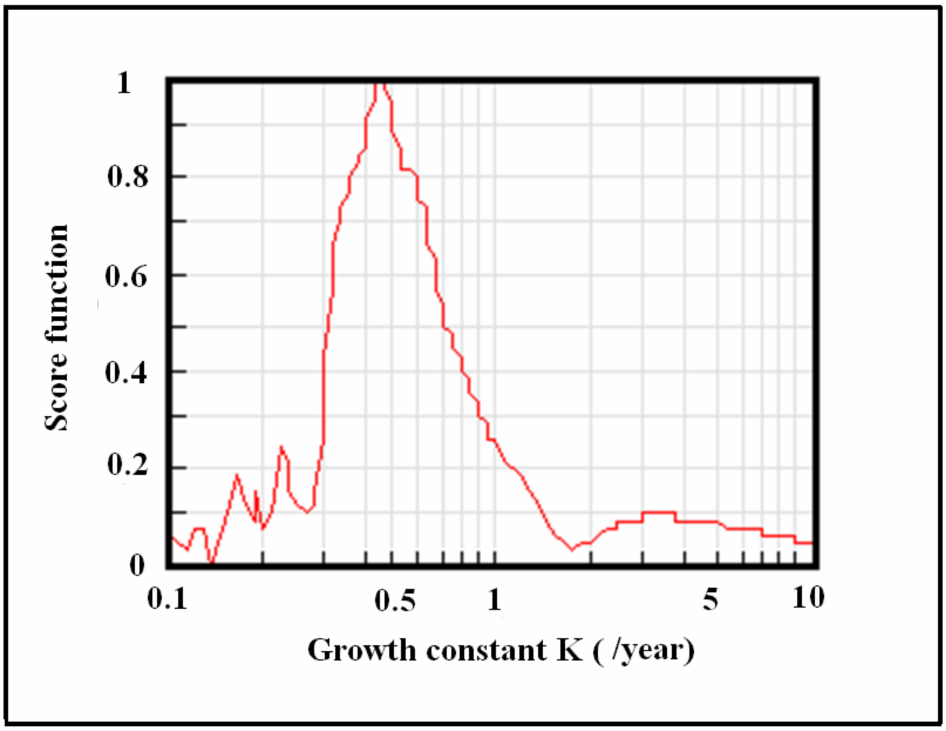

Fig 7. K-Scan values curve by Shepherd's method and best fitting for *S. commerson*

The yearly growth curve of this species using the von Bertalanffy growth parameter and above parameters indicate that fork length attained at the end of 1, 2, 3 and 4 year to be 63, 104,129 and 146 cm respectively(Figure 8).

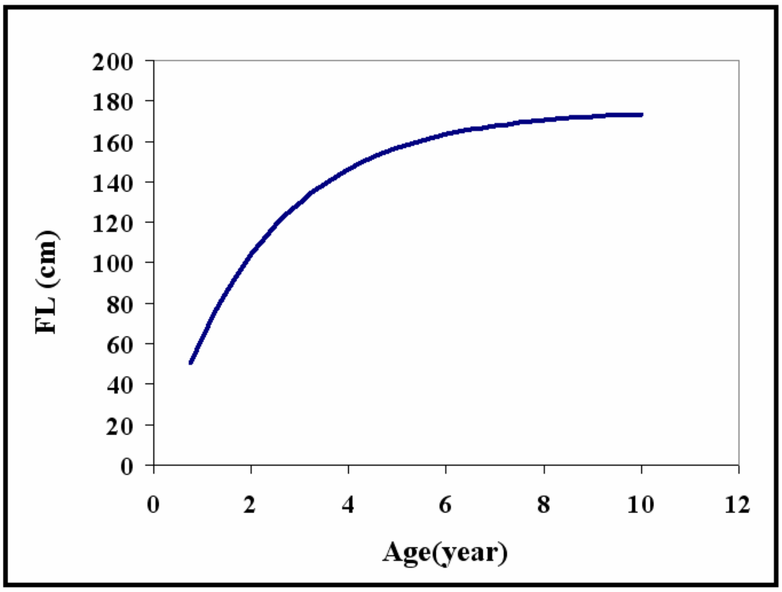

Fig 8.Growth curve of *S. commerson* (Relative length at age) in the Persian Gulf & Oman Sea

Total mortality coefficients from length-converted catch curve indicated an annual estimate, 1.83 (/year)(Figure 9).

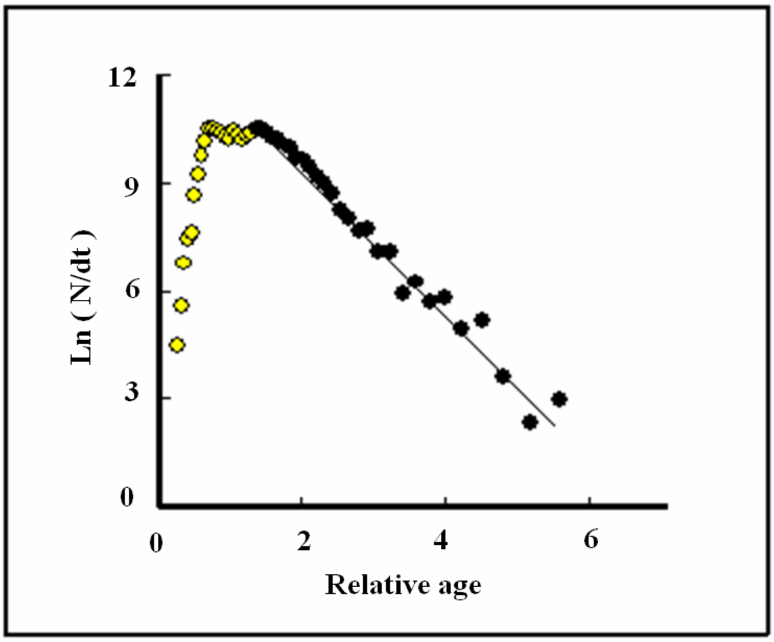

Fig 9.Length-converted catch curve of *S. commerson* in the Persian Gulf & Oman Sea (Z=1.83 (/year))

The natural mortality coefficient , M, was estimated as 0.5(Multiplied 0.8). The fishing mortality (F) and exploitation rate (E) were 1.48(/year) and 0.74 respectively. Recruitment pattern graph showed that *S. commerson* have highest recruitment in August then followed in September and October (Figure 10).

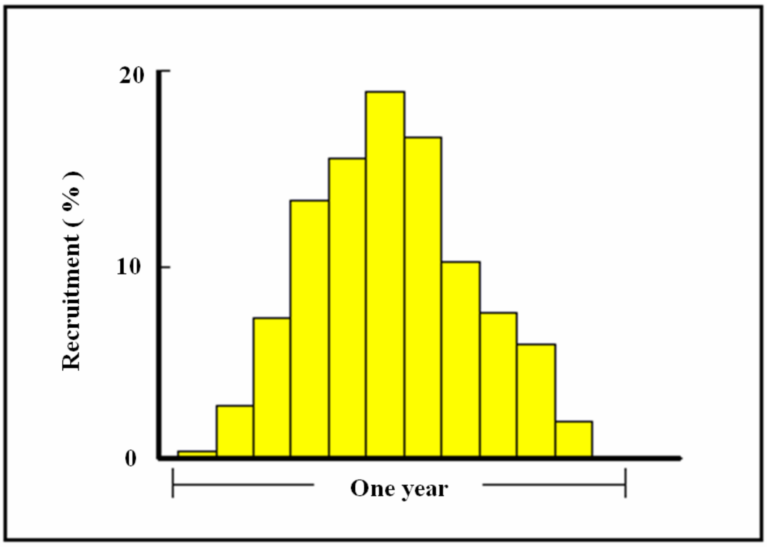

Fig 10.Recruitment pattern graph of *S. commerson* in the Persian Gulf & Oman Sea

In total males (552) and females (568) were included in the analysis. The sex ratio in the samples M: F = 0.97:1 was not significantly different ($P > 0.05$) in the overall male to female sex ratio 1:1(χ^2 test) as showed in Figure 11.

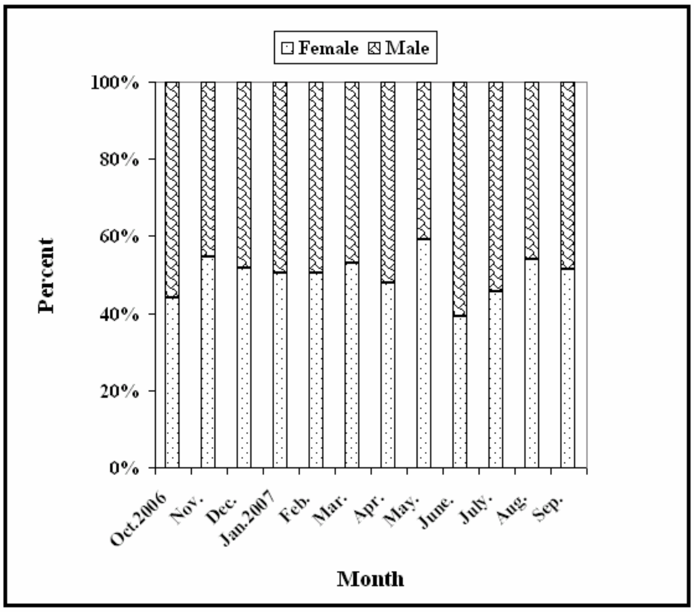

Fig 11.Sex ratio monthly percentage *S. commerson* in the Persian Gulf & Oman Sea

Frequency of immature fish (stage 1) was shown an annual cycle with and almost complete absence during June to August. The proportion of fish by maturity development stages also suggested that the peak of King fish spawning took place after June and also spawning condition being observed during this period (Figure 11).

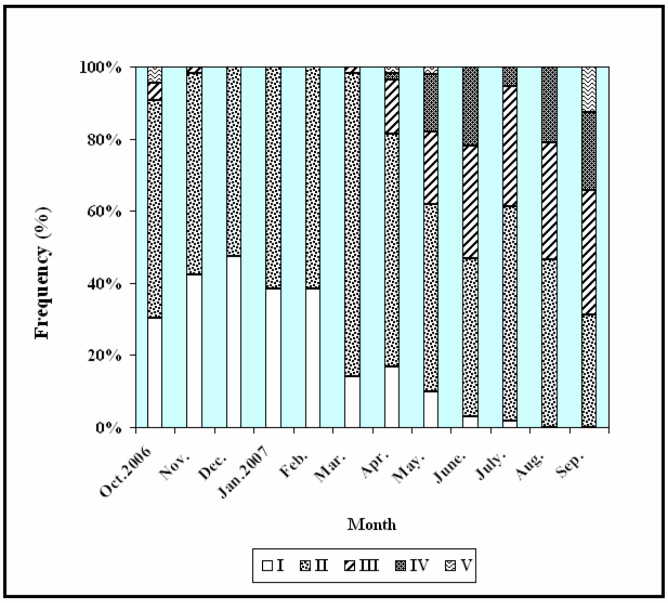

Figure 11. Reproductive stages percent of *S. commerson* (Female) in the Persian Gulf & Oman Sea

The gonadosomatic index for both males and females increased rapidly during May and June with spawning occurred from June to September (Figure 12, 13).

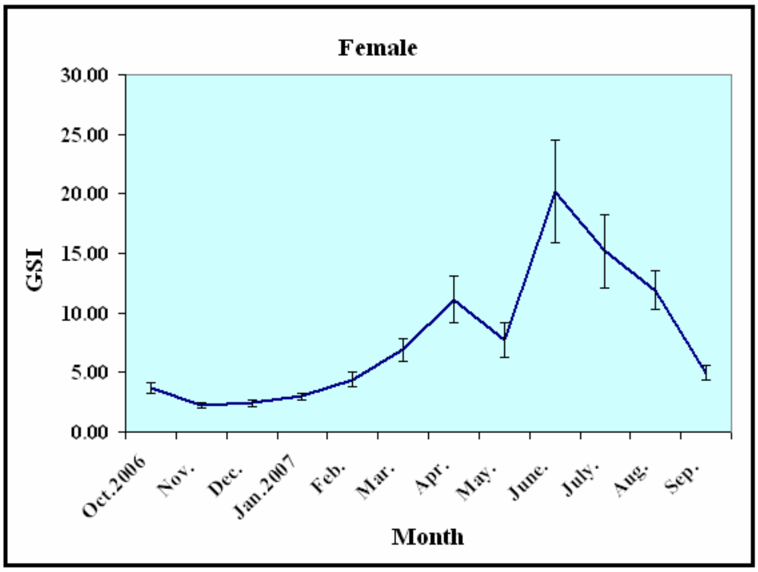

Figure 12.Mean monthly gonadosomatic index *S. commerson* (Female) in the Persian Gulf & Oman Sea

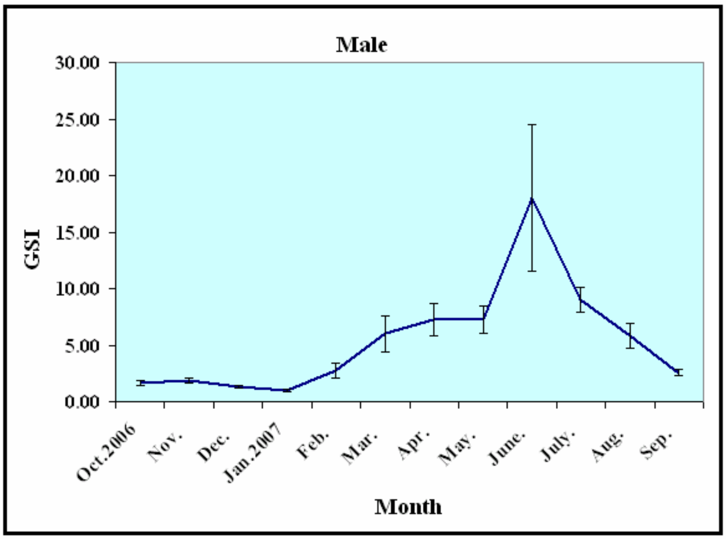

Figure 13.Mean monthly gonadosomatic index *S. commerson* (female) in the Persian Gulf & Oman Sea

The smallest mature and largest immature females were respectively 52 and 100 cm. The mean size at first sexual maturity (LM_{50}) was 83.6 Cm (Figure 14).

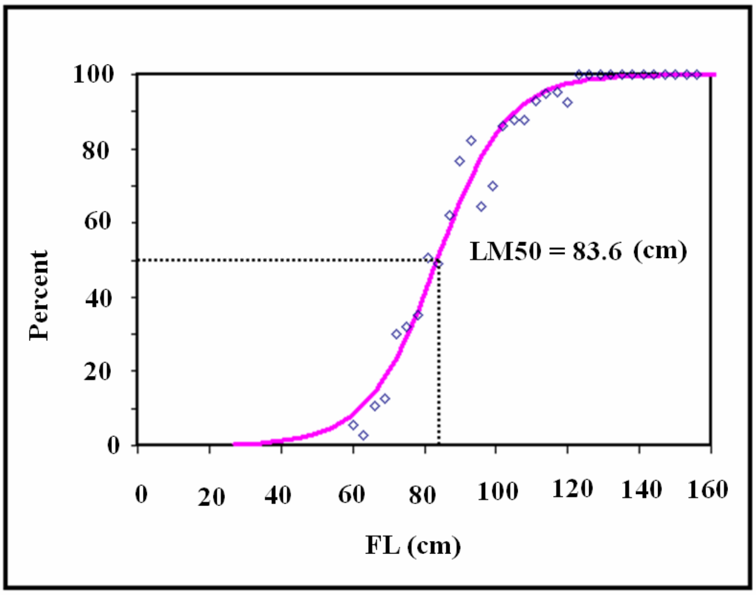

Figure 14.Cumulative relative frequency of the length at first maturity *S. commerson* (female) in the Persian Gulf & Oman Sea

Feeding habit showed that boney fish are the main prey of king fish, followed by digested item . Crustaceans and squid are negligible in the diet of north the Persian Gulf and Oman Sea *S. commerson* (Table 2).

Table 2. Percentage of food items from *S. commerson* in the Persian Gulf and Oman Sea

Food Item	Boney fish	Crustacean (Shrimp & Crab)	Squid	Other(Digested)
Percent	91.3	0.6	0.2	7.9

Based on percentage occurrence of the different identified boney fish, Clupeidae and Engraulidae were the most abundant fish items(Figure 15)

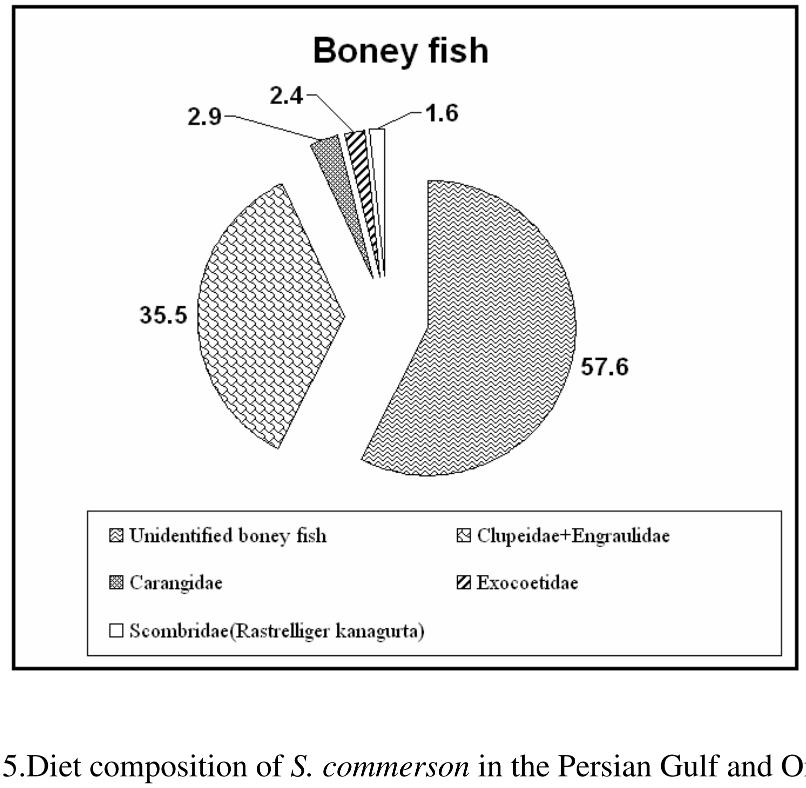

Figure 15.Diet composition of *S. commerson* in the Persian Gulf and Oman Sea expressed as frequency of boney fish occurrence

Standard mesh size(2a) suggested 14.6 cm based on Girth-Fork length relationship(Figure 16) and length at first maturity:

GL = 0.32 FL+2.33 =(0.32* 83.6) + 2.33 ~ 29 cm
K = 29/(4*83.6) = 0.0.87
a = 0.087* (83.6) ~ 7.3 cm
2a = 2*7.3 = 14.6 cm

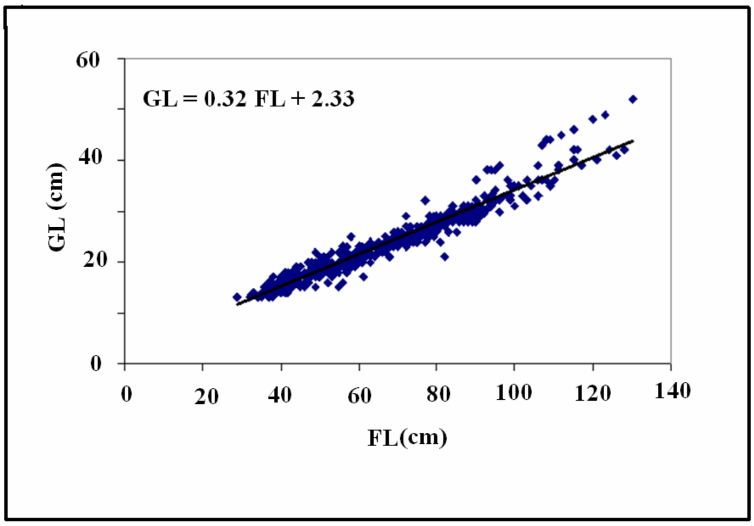

Fig 16 . Girth-Fork length relationship of *S. commerson* in the Persian Gulf and Oman Sea

DISCUSSION

In our study the calculated number for "b" ,has not shown any significant difference with 3.Table 3 presents the estimates coefficients of the general equation ($W= aL^b$) in Indian Ocean.

Table 3.The coefficients a & b in length- weight relationship of *S. commerson* (Indian Ocean)

Authors	Area	Base of length	a	b
Edwards *et al.*, 1985	Gulf of Aden, Yemen	FL	0.011	2.85
Kedidi *et al.*, 1993	Saudi Arabia	TL	0.0012	2.812
Al-Hosni and Siddeek, 1999	Oman	FL	0.0000083	3.02
Kedidi and Abushusha, 1987	Red Sea	TL	0.0012	2.812
Devaraj, 1981	India	TL	0.0096	2.857
Fishbase	West Australia	FL	0.0073	3.01

The values of a and b differ not only in different species but in the same species depending on sex, maturity stage, feeding intensity, etc (Biswas, 1993).
The values of L∞ and K were calculated as 175.26 cm and 0.45 (/year). Length- frequency analyses using various methods produce a wide range of growth parameter estimates for the same data set, and lead to conflicting management decisions (e.g., Dudley *et al*., 1992).
For *S. commerson*, differences in growth rates between regions indicated stock separations (Devries and Grimes, 1997) which has, in some cases, supported a genetic difference (Begg and Sellin, 1998). In general, the correlated parametric values adjust themselves to provide a similar growth pattern represented by ǿ (Sparre and Venema, 1998). Notably, the ǿ values estimated for north Persian Gulf and Oman Sea coastal stock were comparable to those for other stocks of *S. commerson* in the Indian Ocean, suggesting a similar growth pattern across different population (Table 4).Although the difference in the growth parameters estimated by earlier workers 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 shared stock

Table 4. Estimates of growth parameters (L∞ and K),growth performance index of *S. commerson* (Indian Ocean)

Authors	K(/year)	L∞	ó	Area
McIlwain *et al*.,2005	0.216	144.4	3.7	Oman
Sumpton *et al*.,2004	0.2	141.25	3.6	Queensland
Grandcourt *et al*.,2005	0.21	138.6	3.6	Emirates
Edwards *et al*, 1985	0.12	230	3.8	Yemen
Govender , 1994	0.29	134.3	3.7	South Africa
Pillai *et al*.,1993	0.78	146	-	India
Al-Hosni and Siddeek, 1999	0.21	232.4	4.1	Oman

S. commerson is one of the fastest- growing fish .Present study showed that *S. commerson* grew very fast in the first 2 years. Life history of *S. commerson* stocks in Oman Sea is comprised of two distinct phases. The first phase is distinguished by extremely rapid growth from the larva stage to 18 months of age. The second phase can be described as the period when growth decelerated considerably. The start of the second

phase coincides with the time at which kingfish reaches age at first reproduction (Claereboudt *et al.*, 2005). This fast growth strategy during the early stage most vulnerable to predation is typical of large –prey species like *S. commerson* (Begg and sellin,1998).
Total mortality, natural mortality and fishing mortality were estimated 1.98,0.5 and 1.48 (/year) respectively. The data set for estimating Z by the length converted catch curve method should satisfy the primary assumption that the stock was is in equilibrium (Al-Hosni and Siddeek, 1999). In a declining stock, this assumption may have been violated because of a declining trend in recruitment tends to under estimate Z by roughly the some percentage of decline(Al-Hosni and Siddeek, 1999).
Reliable estimate of M can only be obtained for an unexploited stock (Al-Hosni and Siddeek, 1999). In this case, it is equal to Z. Separating M and F from Z in a heavily exploited stock was a difficult task. Excessive fishing and inappropriate effort data prevented the use of the total mortality effort relation to estimate M. Therefore, methods based on life history and environmental parameters were used (i.e. Pauly equation). Exploitation rate in this study was 0.74. Patterson (1992) observed that the fishing rate satisfying Gulland's optimal E level of 0.5 tended to reduce pelagic fish stock abundance, and hence, the former author suggested that E should be maintained at 0.4 for optimal exploitation of those stocks. Accordingly our estimation, the north Persian Gulf and Oman Sea *S. commerson* stock appears to have been overexploited during the study period. Different estimates of mortality and exploitation rate of *S. commerson* available from Indian Ocean countries are presented in table 5.

Table 5.Summary of mortality and exploitation rate of *S. commerson* (Indian Ocean)

Author	Area	Z	M	F	E
Dayaratne, 1989	**Sri Lanka**	1.63	0.605	1.03	0.63
Pillai *et al.*,1993	**India**	3.288	0.78	2.508	0.76
McIlwain *et a*l.,2005	**Oman**	1.321	0.443	0.878	0.66
Kedidi *et al.*, 1993	**Saudi Arabia**	0.758	0.36	0.398	0.525

Our study showed that *S. commerson* has highest recruitment in August. Tropical species are known to have recruitment all through the year (Sparre and Venema, 1998). Recruitment of pelagic fishes fluctuates widely in response to both fishing and environmental effects.

In our study the sex ratio in the samples was not significantly different. The sex ratio *S. commerson* in the Indian waters, eastern Arabian Sea and Omani waters is approximately 1:1(Bal & Rao, 1990; Anon, 1995), which supported our results in this study. Observations from India (Devaraj, 1983) revealed that males were almost always slightly more abundant than females in the catches. Welch *et al*. (2002) supported the migration and aggregation in larger numbers around several reefs just prior to spawning in the spring (Govender, unpublished) and found migration to the north to Mozambique to spawn then back south again for feeding.

Devaraj (1983) estimated the size at first sexual maturity 75 cm FL in the northern Indian ocean compared 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*. (2004) 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 & Russo, 1979; McPherson, 1993). The mean size at first sexual maturity was also found in our study 83.6 cm FL for females which coincided well with the published values of size at first maturity of *S. commerson*.

The period in which there was a decline in the gonad somatic index and when fish in spawning condition were observed in our samples suggested a single spawning period from June to September. Although small short spawning took place during April to May. The results of Claereboudt *et al*.(2004) also revealed a single though earlier spawning season in May and June for king fish off Oman. The reproductive activity of *S. commerson* in waters off the east coast of Australia also peaked in the spring and summer months (McPherson, 1992) in contrast to the defined single seasonal spawning pattern for this species, Devaraj(1983) established three distinct spawning periods between January and September in the waters off the southern coast of India.

Claereboudt *et al*.(2005) supported the idea of a migration(at least partial) out of Omani water during the reproductive season (April –May), moving north –wards (Iranian coasts) to spawn in the Persian Gulf. Although the strong decrease in catches observed during the spawning season, and the decrease in GSI in large individuals support the hypothesis of a reproductive migration, part of the populations from both areas Gulf of Oman and Arabian Sea were locally engaged in spawning activity. Fully mature (stage III), spawning (stage IV) and spent (stage V) individuals have been found along both coasts in April-June and in June-September(Iranian coasts of Persian Gulf), supporting the existence of local spawning ground along three sides (Arabian Sea, Omani waters and

Iranian waters). As mitochondrial DNA studies indicated that these are one genetic stock in the Persian Gulf and Oman Sea (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).
Percentage of food items in our study showed boney fish as the main prey of king fish(91.3%). The few studies reporting on the feeding behavior of the *S. commerson* in Area 51 FAO. Teleosts were the most important item contributing 95.8% to the diet of *S. commerson* in the Egyptian Mediterranean coast (Bakhoum, 2007) .Further the most frequent species found in the stomachs of *S. commerson* were also *E. encrasicolus* (Engraulidae family),followed by unidentified fish remains and this may be attributed to the abundance of anchovy in the Egyptian Mediterranean waters(Bakhoum, 2007).Identifying the food items is necessary to understand food availability in fish natural habitat, which in turn has a potential in fisheries yield as fish grow. In general, the food consumption of most fishes is correlated with water temperature and spawning activities(Al-Zibda & Odat, 2007). Diet studies provide information on basic biology and behavior of the fish, but are also an important part of the parameterization of ecosystem models such as Ecopath/Ecosim (Allain 2005). Information such as prey diversity, prey size, and diet composition can be used in conjunction with other ecosystem indicators to detect changes in the ecosystem(Kirby *et al*. 2005).
No experimental gillnet selectivity study has been reported in Area 51(Siddeek, 1996).Our study showed the relationship between girth length and fork length as: GL=0.32FL+2.33 that can be used to determine standard mesh size, to release fish of below length at first maturity. Mesh size(2a) of gillnets that using now have 9.5 cm length in the north of Persian Gulf and Oman Sea.

CONCLUSIONS

Not only on *S. commerson* but also for Scombridae family it is necessary to immediately impose fishing regulation on the stock and this can be done by gradually increasing the mesh size of the gears or by restricting fishing for certain seasons or declaring fish sanctuaries in certain areas, especially in spawning grounds. For further studies on *S. commerson* would be conducted in collaboration countries bordering the Persian Gulf , Oman Sea and Indian Ocean.

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