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Stock Assessment of Silver Pomfret *Pampus argenteus* (Euphrasen, 1788) in the Northern Persian Gulf

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Abstract

Monthly data of length composition for silver pomfret, *Pampus argenteus*, were recorded from the Northern Persian Gulf (Khuzestan province), between April 2004 to March 2005. ELEFAN in the software package FiSAT was used to analyse the length frequency data. The maximum measured fork length and weight were 312 mm and 1191 g respectively. The parameter values of the von Bertalanffy growth function were: L_∞= 339 mm; k = 0.55 year^{-1} and t_0= -0.16 year. The estimated value of the instantaneous rate of total mortality, z based on length converted catch curve was 2.07 year^{-1}. The instantaneous rate of natural mortality, M based on the growth parameters and mean environmental temperature was 0.58 year^{-1}. The annual instantaneous fishing mortality rate, F was estimated to be 1.49 year^{-1}. The exploitation rate, E was 0.72 year^{-1} and the results from the yield-per-recruit analysis indicated that the resource was heavily over-exploited, and some measures of management should be rapidly implemented to protect the silver pomfret population in the Northern Persian Gulf.

Keywords: *Pampus argenteus*; ELEFAN; growth parameters; Persian Gulf; fisheries management.

Basra Körfezinin Kuzeyinde Gümüş Baltabaş Balığı, *Pampus argenteus* (Euphrasen, 1788) İçin Stok Değerlendirmesi

Özet

Basra Körfezinin kuzeyinde (Kuzistan vilayeti) gümüş baltabaş balığı, *Pampus argenteus* için boy kompozisyonuna ait aylık veriler, Nisan 2004'ten Mart 2005'e kadar kaydedilmiştir. Boy sıklık verilerini analiz etmek için FİSAT yazılım paketinde ELEFAN testi kullanılmıştır. Ölçülen azami çatal boyu ve ağırlığı sırasıyla 312 mm ve 1.191 g olmuştur. von Bertalanffy büyüme parametre değerleri şöyledir: L_∞= 339 mm; k = 0,55 yıl^{-1} ve t_0= -0,16 yıl. Anlık toplam ölüm oranına ait tahmini değer (z) av boy eğrisi yöntemine göre 2,07 yıl^{-1} olarak hesaplanmıştır. Büyüme parametreleri ve ortalama çevre sıcaklığına göre anlık doğal ölüm oranı, M 0,58 yıl^{-1} olarak hesaplanmıştır. Yıllık anlık avcılık ölüm oranı, F 1,49 yıl^{-1} olarak tahmin edilmiştir. Sömürme oranı, E 0,72 yıl^{-1} olarak hesaplanmış ve stoka katılan ürün başına yapılan analizin sonuçlarının gösterdiğine göre kaynak aşırı derecede sömürülmüştür. Basra Körfezinin kuzeyinde gümüş baltabaş balığı popülasyonunun korunması için bazı işletme önlemlerinin ivedilikle alınması gerekmektedir.

Anahtar Kelimeler: *Pampus argenteus*, ELEFAN, büyüme parametreleri, Basra Körfezi, balıkçılık yönetimi.

Introduction

The silver pomfret, *Pampus argenteus*, locally known as 'zobaidy' is a member of the Stromateidae family and is widely distributed throughout the Indo-West Pacific: from the Persian Gulf to Indonesia, Japan, West and Southwest of Korea and Eastern parts of China (Haedrich, 1984). Silver pomfret is one of the most commercially important fish in the Northern Persian Gulf and its stock is shared by Iran, Iraq and Kuwait (Al-Hussaini, 2003). Due to the high market demand and high value, commercial fisheries in the Persian Gulf usually target this species.

Information on the growth, mortality and population biology of this species are available from Korea (Lee and Kim, 1992; Lee *et al*., 1992), Kuwait (Morgan, 1985; Al-Hussaini, 2003; Al-Abdul-Elah *et al*., 2002), China (Liming and Yongsong, 2005; Lin *et al*., 2006), Bay of Bengal (Mustafa, 1993, 1999). Reports on the silver pomfret stock of the northern Persian Gulf is limited to the works by Ali (2001) and Mohamed *et al*. (2008) from the Iraqi waters and Salari (1996) and Parsamanesh *et al*. (2003) from the Iranian waters.

The catch statistics show that, in spite of increasing fishing effort, the total catches and catch rates in Iran and Kuwait decreased in recent years (Al-Hussaini, 2003) which subsequently led to economic losses for the fishing sector in the area. Many fish populations in the Persian Gulf have been heavily exploited and fishing effort may be above the optimum levels for some species (Samuel *et al*., 1987; Siddeek *et al*., 1999). The expansion of the fishing fleets of many Gulf countries and lack of appropriate data on most stocks (FAO, 1994) underscore the need of assessment of the region's fisheries resources.

In this context an attempt was made to investigate the present status of the stock and the impact of fishing. The specific objectives included the estimation of the growth parameters, mortality coefficients and length at first capture (Lc_{50}) and the evaluation of the yield and biomass-per-recruit to provide a preliminary assessment of the stock status of *P. argenteus* in the Northern Persian Gulf.

Materials and Methods

Fish samples were collected between April 2004 and March 2005 from the commercial catches landed in Hendijan (49°33' E - 30°04' N) and Abadan (48°35' E - 30°10' N), two major landing centres in the Khuzestan Province (Figure 1).

A total of 6789 fish were collected throughout the study period. Fork length (FL) of each individual fish was measured to the nearest mm by using a measurement board. The length frequency data were pooled into groups of 10 mm length intervals.

Growth was investigated by fitting the von Bertalanffy growth function (VBGF) to length frequency data (von Bertalanffy, 1938). The mathematical form of the length based von Bertalanffy growth model is given in Sparre and Venema (1998):

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

where, L_t is the length at age t, L_∞ is the asymptotic length, k is the growth coefficient, and t_0 is the hypothetical age when the size of fish is zero.

Length-frequency data were analyzed with the most recent version of FiSAT II (FAO ICLARM Stock Assessment Tools) version 1 software package (Gayanilo *et al*., 2003). The value for L_∞ was obtained by the Powell-Wetherall method (Sparre and Venema, 1992). The method used to estimate k was electronic length frequency analysis (ELEFAN I) (Pauly *et al*., 1984). Using the preliminary value of L_∞, values of k were scanned and the value that gave the highest Rn value (goodness of fit index value) was obtained (Gayanilo *et al*., 2003).

In order to compare the growth of *P. argenteus* from the study area with those from other studies, the growth performance index was calculated (Pauly and Munro, 1984).

$$\phi' = \log k + 2\log L_\infty$$

The estimate of theoretical age at length zero (t_0) was obtained by using Pauly's empirical equation (Pauly, 1980a):

$$\log(-t_0) = -0.3922 - 0.275 \log L_\infty - 1.038\, k$$

The annual instantaneous rate of total mortality (Z) was estimated using the length converted catch curve method (Pauly, 1983). Length frequency samples were converted into a relative age frequency distribution using the parameters of the von Bertalanffy growth function.

The annual instantaneous rate of natural mortality (M) was estimated by using Pauly's empirical formula (1980b):

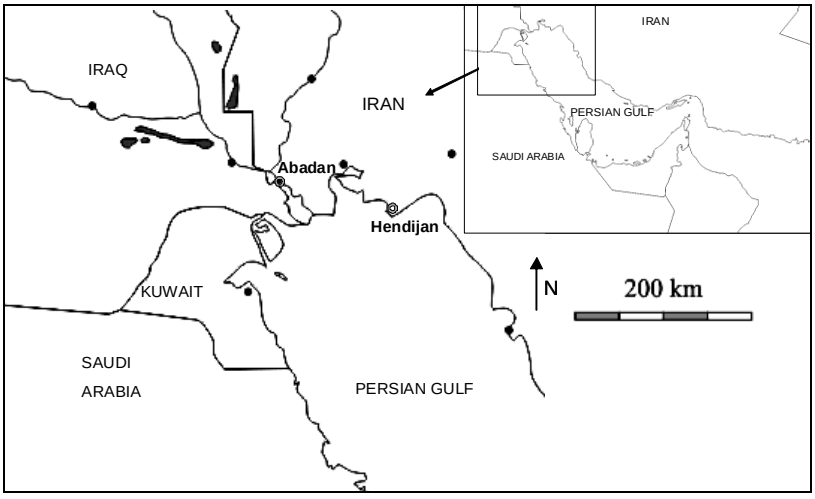

Figure 1. Location of study and landing areas for *P. argenteus* in the Northern Persian Gulf (2004-2005).

$ln\ M = -0.0152 - 0.279\ ln\ L_\infty + 0.6543\ ln\ k + 0.463\ ln\ T$

where T is the mean annual water temperature of the area (in °C), which is assumed to reflect the water surface temperature.

The annual instantaneous rate of fishing mortality (F) was obtained by subtracting the natural mortality rate (M) from the total mortality rate (Z) according to Beverton and Holt (1956). The exploitation rate (E) was calculated by the Beverton and Holt formula (1957), as the proportion of the fishing mortality relative to total mortality, E = F/Z.

The probability of capture was estimated by backwards extrapolation of the descending limb of the length converted catch curve. A selectivity curve was generated using linear regression fitted to the ascending data points from a plot of the probability of capture against length, which was used to derive values of the lengths at capture at probabilities of 0.25 (L_{25}), 0.5 (L_{50}), 0.75 (L_{75}) and 1 (L_{100}).

The relative yield-per-recruit (Y'/R) and relative biomass-per-recruit (B'/R) were estimated using the knife-edge method of Beverton and Holt model (1957):

$$Y'/R = EU^{M/k}[1-(3U/1+m)+(3U^2/1+2m)+(U^3/1+3m)]$$

where: $m = (1 - E)/(M/k) = k/Z$

$U = 1 - (Lc/ L_\infty)$

$E = F/Z$

$B'/R = (Y'/R)/F$

Results

The fork lengths of 6789 specimens were collected during the study period ranged from 95 mm to 312 mm.

Growth

The estimated von Bertalanffy growth parameters for *P. argenteus* population were L_∞=339 mm (FL), k= 0.55 $year^{-1}$ (the value of k-scan (Rn) was 0.24) and t_0= -0.16 year. The L_∞ value was estimated using the regression equation fitted to the Powell-Wetherall plot (y = -0.223x +75.59, r^2= 0.99) (Figure 2).

The raw data were restructured with ELEFAN I, plotting the curves from the growth parameters. The catch curves showed that fisheries operate upon 5 cohorts of the population (Figure 3).

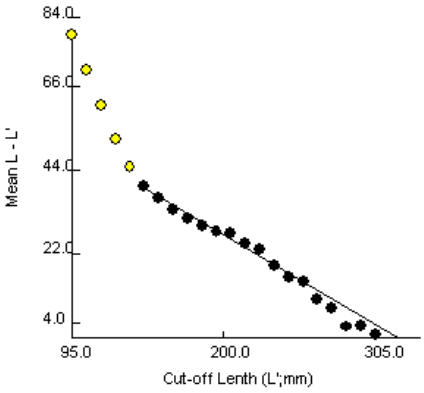

Figure 2. The Powell-Wetherall plot of *P. argenteus* in the Northern Persian Gulf (2004-2005).

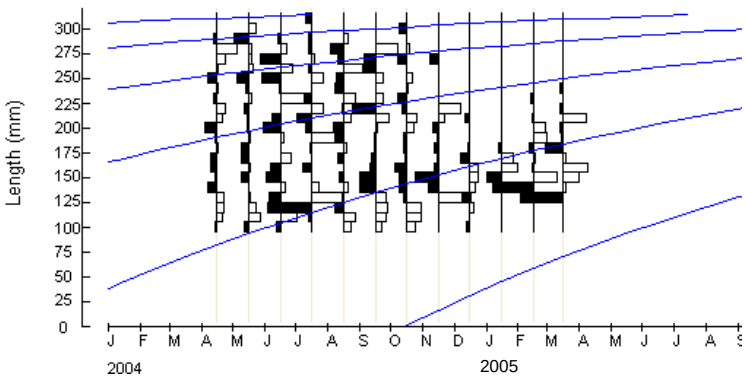

Figure 3. The length-frequency data and the growth curves estimated for *P. argenteus* (2004-2005).

The value of growth performance index, ϕ', estimated from the growth parameters was 2.8.

Mortality

The annual instantaneous rate of total mortality (Z) estimated from the length-frequency catch curve was 2.07 year^{-1} (Figure 4), The solid line show the regression equation fitted to data for length converted catch curve (y = -2.07x +11.5, r^2= 0.97). The annual instantaneous rate of natural mortality (M) derived from the Pauly's empirical formula (1980b) was 0.58 year^{-1}. The average water temperature for twelve months that was used in this study was 25°C. The calculated annual instantaneous rate of fishing mortality (F) was 1.49 year^{-1}. The exploitation rate (E) was estimated as 0.72 year^{-1}.

The mean lengths at first capture, L_c or L_{50}, was 101 mm (FL) and the lengths at capture at probabilities of 0.25 (L_{25}) and 0.75 (L_{75}) were 90 and 110 mm (FL), respectively. Fish were fully recruited to the fishery at a size of 150 mm (FL).

The relative yield-per-recruit (Y'/R) and biomass-per-recruit (B'/R) were determined as a function of L_{50}/L_∞ and M/K (Figure 5). The exploitation rate of population obtained in this study exceeded the maximum allowable limit based on yield-per-recruit calculation (E_{max}) which was 0.52 year^{-1}. E_{max} is the level of exploitation that leads to the maximum sustainable yield (MSY).

Discussions

The estimated growth parameters, L_∞ and k for *P. argenteus* population during the study period were 339 mm and 0.55 year^{-1}, respectively. The estimates of L_∞ for this species obtained from the studies in the Persian Gulf and other areas have a very wide range, from 280 to 424 mm (FL) (Table 1). The smallest estimated asymptotic length was from Bay of Bengal (Mustafa, 1993) and the highest value was from the Persian Gulf (Mohamed *et al*., 2008). The estimated k values were between 0.26 and 0.99. The L_∞ and k values obtained in this study are closer to the findings of Morgan (1985) in the Kuwaiti waters of the Persian Gulf (Table 1). Our estimates of k and L_∞ were lower than the earlier estimates reported from the same area (Salari, 1996; Parsamanesh *et al*., 2003). The reasons

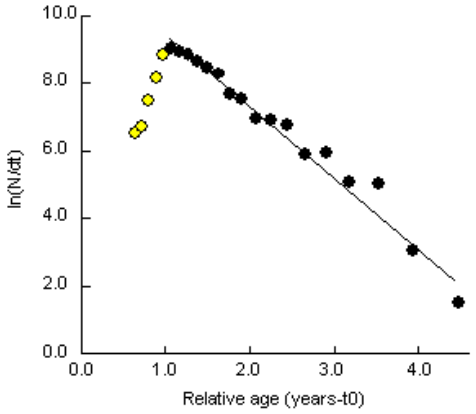

Figure 4. The length-converted catch curve for *P. argenteus* (2004-2005).

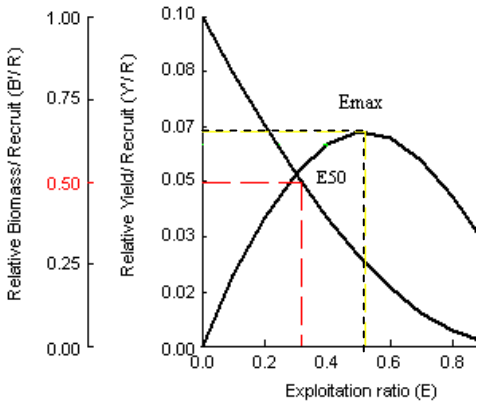

Figure 5. The relative yield and biomass per recruit plot of *P. argenteus* in the Northern Persian Gulf (2004-2005), yellow line: E_{max}, red line: E_{50}.

Table 1. The estimated growth parameters of *P. argenteus* from different regions

*L_∞ (mm)	k (year^{-1})	ϕ'	Area	Source
325	0.55	2.72	Persian Gulf (Kuwait)	Morgan (1985)
315	0.95	2.97	Java Sea	Dwiponggo *et al*. (1986)
336	0.26	2.47	Korean waters	Lee *et al*. (1992)
280	0.63	2.69	Bay of Bengal	Mustafa (1993)
298	0.53	2.67	Bay of Bengal	Mustafa (1999)
410	0.92	3.19	Persian Gulf (Iran)	Parsamanesh *et al*. (2003)
375	0.99	3.13	Musa estuary (Iran)	Salari (1996)
424	0.53	2.98	Persian Gulf (Iraq)	Mohamed (2008)
339	0.55	2.8	Persian Gulf (Iran)	Present study

*fork length

for the variation in these values in different regions may be due to the ecological differences, physiological conditions of fish, feeding variability, fishing pressure and sampling (Biswas, 1993).

The instantaneous total mortality coefficient (Z) estimated during the present study was 2.07 year^{-1} (Figure 4). This estimate compared well to that of Mohamed *et al*. (2008) for *P. argenteus* population (2.15 year^{-1}) in the Iraqi waters of the Persian Gulf. Our estimate was considerably lower than those of Parsamanesh *et al*. (2003) from the same area, which ranged from 2.6 to 10.2 year^{-1}. The present estimate of Z value is also close to that of Al-Hussaini (1994), 2.4 year^{-1}, reported from the Kuwaiti waters. The levels of total mortality, 1.62 year^{-1} from the Kuwaiti waters (Morgan, 1985) and Korean waters, 1.5 year^{-1} (Lee *et al*., 1990), were both much lower than the present result.

The instantaneous natural mortality coefficient (M) estimated using Pauly's equation (1980b) was 0.58 year^{-1} in the present study. This was less than the estimated values, 1.4-1.6 year^{-1} by Parsamanesh *et al*. (2003). Our result did not differ much from the instantaneous natural mortality coefficient estimated for the same species in the Korean waters, 0.5 year^{-1} (Lee *et al*., 1990). The estimate from the Iraqi waters of the Persian Gulf, 1.25 year^{-1} by Mohamed *et al*. (2008) was comparatively higher than the present result.

The value of the instantaneous fishing mortality coefficient (F) in the present study, 1.49 year^{-1}, was higher than that of Mohamed *et al*. (2008), which was 0.9 year^{-1}. However, our estimate was considerably lower than those of Parsamanesh *et al*. (2003) from the same area.

The exploitation ratio for population (E=0.72 year^{-1}) in the present study was high. Gulland (1969) suggested that in an optimally exploited stock, fishing mortality should be equal to natural mortality, resulting in an exploitation rate of 0.50 year^{-1}. The present estimate suggests that the population of silver pomfret in the Northern Persian Gulf is being exploited at a higher level than the optimum. Therefore, it may be claimed that the *Pampus argenteus* population in the Northern Persian Gulf is being overfished, and a better management policy is necessary in this area.

This assertion is also supported with the obtained relative yield-per-recruit (Y'/R) and relative biomass-per-recruit (B'/R) values. Both estimates indicated that the present level of exploitation rate (E=0.72 year^{-1}) exceeded the maximum allowable limit based on the yield-per-recruit calculation (E_{max}), which was calculated to be 0.52 year^{-1}. These findings imply that the exploitation of this stock has exceeded the maximum fishing level and thereby the present level of fishing mortality should be a great concern for the stock.

In order to maintain a population in equilibrium it is of great importance to give each fish the chance of reproducing at least once in its lifetime to recruit the stock, and therefore the length at first capture, L_c, should be bigger than L_m. Amrollahi *et al*. (2007) reported that the length at first maturity (L_m) for this species in the region was 192 mm (FL). However, 71% of total specimens sampled in the present study were smaller than 192 mm (FL). As a result, the current L_c (101 mm FL) for *P. argenteus* population in the Northern Persian Gulf was lower than the estimated Lm value. This situation, removal of pre-spawning fishes, may cause a greater reduction in the catch in near future In an investigation in the South China Sea, Liming and Yongsong (2005) suggested that L_c should be increased to 150 mm from 120 mm (Lm). Lin *et al*. (2006) suggested that for the East China Sea, L_c should be 170 mm to have a sustainable fishery. Morgan (1985) reported that the size at first maturity in the Kuwaiti waters was 200 mm, and for a sustainable fishery, the L_c must be equal to Lm. Therefore, for the *P. argenteus* population in the Northern Persian Gulf, some immediate management actions, such as size-limit regulation by gradually increasing mesh size of the gears and time-limit regulation by restricting fishing outside spawning season, are considered necessary.

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