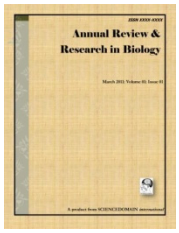

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Study of Natural and Fishing Mortality and Exploitation Rate of Common Kilka *Clupeonella cultriventris* in Southeast Part of the Caspian Sea (Babolsar)

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Research Article

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ABSTRACT

The objective of this study was to estimate natural, fishing and total mortality, survival and exploitation rates of *Clupeonella cultriventris* in the southern Caspian Sea. Survival rate and natural mortality were calculated using catch curve and Pauly methods, respectively. Natural and fishing mortality have been estimated up to 0.671yr^{-1} and 0.849 yr^{-1}, respectively. According to catch curve method, the annual survival rate of common kilka has been estimated up to 0.218 yr^{-1}. With owning this survival rate, the instantaneous coefficient of total mortality of common kilka has been estimated up to 1.52 yr^{-1}. The exploitation rate of common kilka has been estimated up to 0.55. It was revealed that common kilka has been dominant in the catch because of habitat expansion and the change in life depth. It was concluded that common kilka stock is under over-fishing now.

Keywords: Clupeonella Cultriventris; Caspian sea; natural mortality; fishing mortality; total mortality; survival rate; exploitation rate;

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1. INTRODUCTION

Three species of clupeids including anchovy kilka (*Clupeonella engrauliformis*, Svetovidov, 1941), bigeye kilka (*Clupeonella grimmi*, Kessler, 1877) and common kilka (*Clupeonella cultriventris caspia*, Bordin, 1904) exist in the Caspian Sea. These species live in pelagic waters and are one of the most abundant fishes in Caspian Sea catches. These species has important role in the diet of commercial important species such as sturgeons and salmon in the Caspian Sea. Common kilka inhabits in the coastal zone down to about 70 m (Abdoli and Naderi, 2009). *Clupeonella cultriventris* is a euryhaline species (from fresh water up to 36 ppt) with a wide distribution and can survive in high and low temperatures.

Kilka fisheries are an important source of income and protein for Iranians inhabiting in Caspian Sea coastal regions. The collapse of kilka fisheries had adverse effects on the economy of coastal communities in the region. Life history studies concerning *Clupeonella cultriventris* is restricted to distribution (Besharat & Khatib, 1993), stock assessment and biology (Fazli & Besharat, 1998; Pourgholam et al., 1996; Fazli, et al., 2007a; Fazli et al., 2007b). Quantitative assessments of fish population will assist in the development of management strategies and effective exploitation of *Clupeonella cultriventris* stock in the southern Caspian Sea. To assess the current statue of the population and variation over time, fishing mortality and biomass of past 10 years must also be taken into consideration. Thus the objective of this study was to determine natural, fishing and total mortality, survival and exploitation rates of *C. Cultriventris* in the southern Caspian Sea.

2. MATERIALS AND METHODS

Experimental fish were collected at monthly interval from the commercial catch (Babolsar, Iran) during the period from January to December 2008. CPUE was calculated by dividing total catch on fishing efforts. Fishing effort is the number of vessels per night (VN) which going to fishing. The fish were caught at the depths of 40 to 100 m by conical lift nets equipped with underwater electric lights. At each sampling time, about 150-200 specimens were randomly selected and transported to the laboratory. The samples were initially sorted into size bins of 5 mm fork length intervals and their weight (±0.1 g) and fork length (±1 mm) were recorded. The sex of the fish was determined by macroscopic examination of the gonads. Otoliths of 10% (363 specimens) of the total samples were used for age determination according to Newman et al. (2000).

Survival rate (S) was calculated using the catch curve method (Ricker, 1975). The instantaneous coefficient of total mortality (Z) was transformed from the survival rate as

$$Z = -\ln S.$$

The natural mortality coefficient (M) was estimated from tentative Pauly formula (Pauly, 1999):

$$\log(M) = -0.0066 - 0.279\log(L_\infty) + 0.6543\log(K) + 0.4634\log(T)$$

where T is the water average annual temperature of fish habitat. In this study, T was 12˚C.

Fishing mortality coefficient (F) was calculated using the below formula (Pauly, 1999):

$$Z = M + F$$

Exploitation rate was calculated using the formula (Sparre & Venema, 1992):

$$E = \frac{F}{F + M}$$

A biomass-based cohort analysis (Zhang and Sullivan, 1988) was used to estimate biomass and instantaneous fishing mortality at age.

$$B_t = \frac{C_t (F_t + M - G_t)}{F_t (1 - e^{-(F_t + M - G_t)})}$$

where B_t is the biomass of the last year and the last age-class, C_t is the catch in weight at last year and last age-class, F_t is the terminal fishing mortality.

3. RESULTS AND DISCUSSION

In the year 2008, total catch of three clupeid fishes (common, anchovy and bigeye kilka) and fishing effort were 10007.2 t and 5045 VN (vessel×night), respectively. Of total 2770 specimens collected during the time of this study, 2171 common kilka, 338 anchovy kilka and 261 bigeye kilka have been studied. The most abundant species was common kilka (87.38 percent) and bigeye kilka showed the least percentage (4.29 percent). Anchovy kilka abundance was 8.33 percent. Common kilka was dominant in catch all the year. It dominated the catch composition in January (91.67%) however the least composition was observed in February (75.68%) (Fig. 1).

During the year 2008, about 10007.2 t of clupeids were catched. The most amount of catch was for August (2027.3 t) and the least amount was for June (51.1 t). The highest fishing effort was in August (828 vessels per night = VN) and the lowest effort was in June (51 vessels per night). Maximum CPUE (Catch per Unit of Effort) amount for common kilka was in November up to 3.668 tons per vessel per night and its minimum was in April up to 0.561 tons per vessel per night. Overall, catch and CPUE amount for common kilka in studied zone in 2008 were 10007.2 and 1.983 tons per vessel per night, respectively (Table 1).

Average fork length of common kilka was 99.26±10.09 mm, ranged from 65 to 140 mm. About 67 percent of length abundance has belonged to 95-105 mm length classes. Average weight of this fish was 9.61±3.11 g. The minimum and maximum weight were 2.95 g and 25.14 g, respectively (N=2171) and about 80 percent of weight abundance has belonged to 5.6-11.2 g weight classes (Table 2).

Table 1. Monthly catch, effort and CPUE of common kilka in Mazandaran region of the Caspian Sea in 2008

Month	Catch (ton)	Effort	CPUE (ton)
Jan	357.5	327	1.093
Feb	1209.3	681	1.776
Mar	691.8	417	1.659
Apr	70.2	125	0.561
May	0	0	0
Jun	51.1	51	1.001
Jul	851.7	643	1.325
Aug	2027.3	828	2.448
Sep	785.5	453	1.734
Oct	274.1	218	1.257
Nov	1918.5	523	3.668
Dec	1770.3	779	2.273
Total	**10007.2**	**5045**	**1.983**

Table 2. Average fork length and weight of common kilka in the Caspian Sea in Mazandaran region in 2008

Average fork length and weight of common kilka	Value
Average weight ± SD (g)	9.61±3.11
Average length ± SD (mm)	99.26±10.09
N	**2171**

According to catch curve method, the annual survival rate of common kilka has been estimated up to 0.218 yr^{-1}. With owning this survival rate, the instantaneous coefficient of total mortality (Z) of common kilka has been estimated up to 1.52 yr^{-1}. The instantaneous coefficient of natural mortality (M) of common kilka which has been estimated from tentative Pauly method was 0.671yr^{-1}. The instantaneous coefficient of fishing mortality (F) was 0.849 yr^{-1}. Therefore, the exploitation rate (E) of common kilka has been estimated up to 0.55.

Dynamics of population parameters of common kilka fishes have been studied during 1997 to 2008. From 1997 to 2003, total biomass of common kilka has increased and reached from 23805.5 to 87038.1 tons.

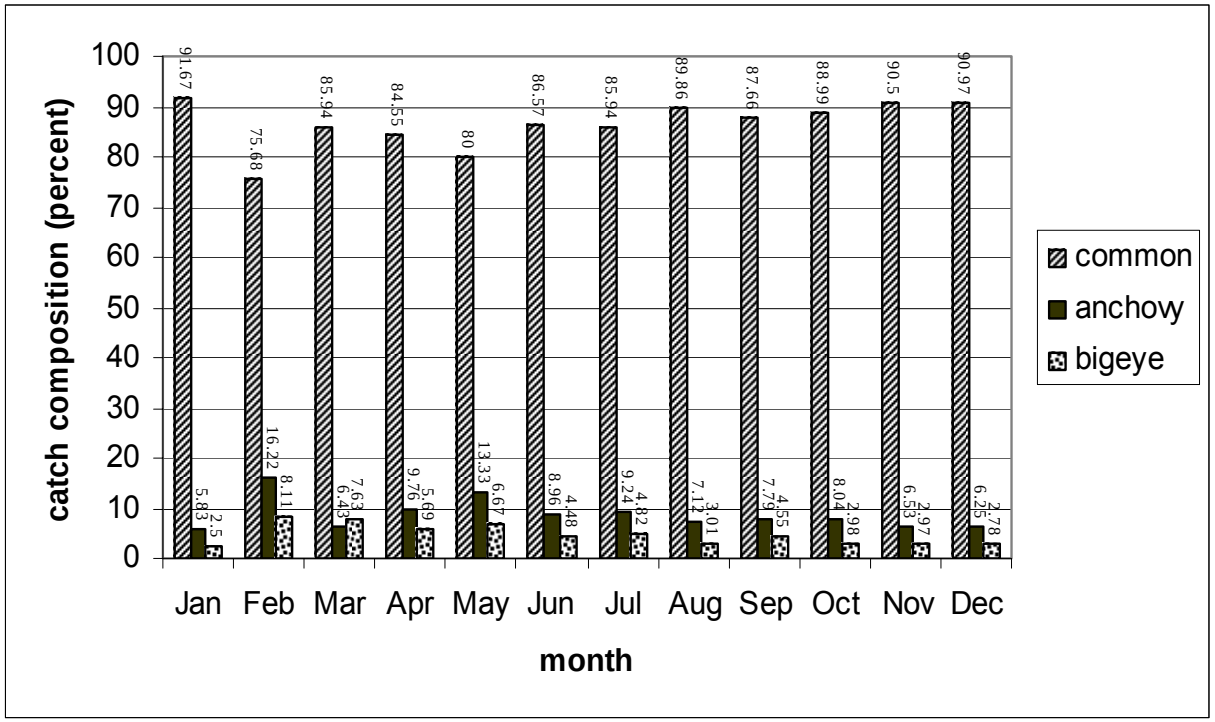

Fig. 1. Species composition of three kilka species in Mazandaran coastal waters in the Caspian Sea in the year 2008

The maximum total biomass of common kilka population were observed in 2002 - 2003 when its values fluctuated from 81680.3 to 87038.1 tons, afterwards a decrease of those values till 2008. In present study, common kilka total biomass in Mazandaran coastal waters of the Caspian Sea in the year 2008 has been estimated up to 42169.5 tons (Fig. 2). From 1997 to 2003, total numbers of common kilka has increased and the values of the numbers of common kilka population reached from 2868.1 to 16422.2 fish. Afterwards a significant decrease in population number was observed. In this study, total number of common kilka fishes in Mazandaran coastal waters of the Caspian Sea in the year 2008 has been estimated up to 4392.6 fish.

Age composition of common kilka was included of 6 age groups (from year 1 to 6). Age 3 was the largest age group and constituted 42.70% of the total catches (Fig. 3). Averages ages of females and males were 3.12±0.34 (ranged 2-6 years) and 2.85±0.59 (ranged 1-6 years) respectively. The average age of common kilka population in both sexes was 3.

In order to ensure constant exploitation and responsibly fishing management, the data on fish biology and population dynamics are needed. Population dynamics is related to continuous process of in time generation replacing and its production (growth and death).

General models can help to better prediction of the effect of fishing on the population and this is possible when various factors (ecology and exploitation) effects on population be clearely recognized (Biswas, 1993). Catch and biology studies aimed to recognize the effects of human and natural effective factors on fish population in order to ensure its profitableness continuity in a long time (Ball and Rao, 1984). The catch amounts of kilka in Mazandaran coastal waters decreased from 38 thousand tons in 1999 to 8.025 thousand tons in the year 2003 and then increased and reached up to 13.859 thousand tons in 2005 (Mazandaran fisheries statistic annals, 2005). According to the results of the study on catch and CPUE amount, it can be said that relative abundance of common kilka population has shown an increasing trend in the catch comparison compare to the last. This may be due to the increasing fishing effort and habitat expansion and changes in living depths. Compare to tha past years, the stocks of anchovy and bigeye kilka decreased. This can be due to overfishing and natural factors. Similar results was also found by Fazli et al. (2002, 2004, 2005 and 2007a, b) in for the stocks of clupeid species in southern Caspian Sea during the years 1995 to 2004. Average fork length of common kilka in southern Caspian Sea in the year 1997 was 103.5 mm. It has been decreased during the years 1998, 1999 and 2000 up to 80.8 mm. The mean fork length of common kilka increased again after the year 2001 (Fazli et al., 2007b) and reached to 99.26 mm in the year 2008. Average weight of common kilka in the year 1997 was 8.3 g. however the mean weight of catched fish was only 3.7 g during the years 1998, 1999 and 2000. After the year 2001, the mean fish weight increased (Fazli et al., 2007) and reached 9.61 g in the year 2008. Based on the results it is obvious that the population of common kilka was older during the years 2001-2008 than that of the years 1997-2001.

Experimental fish studied in the present study were between 1-6 years old. Fish of age 3 dominated in the catch (42.70%) Thus, it may be concluded that in recent years, the number of younger fish population has decreased in the commercial catch and older fish has gradually been dominant the catches. This can be due to the use of nets with standard mesh in recent years, overfishing during the past years and the habitat alternation.

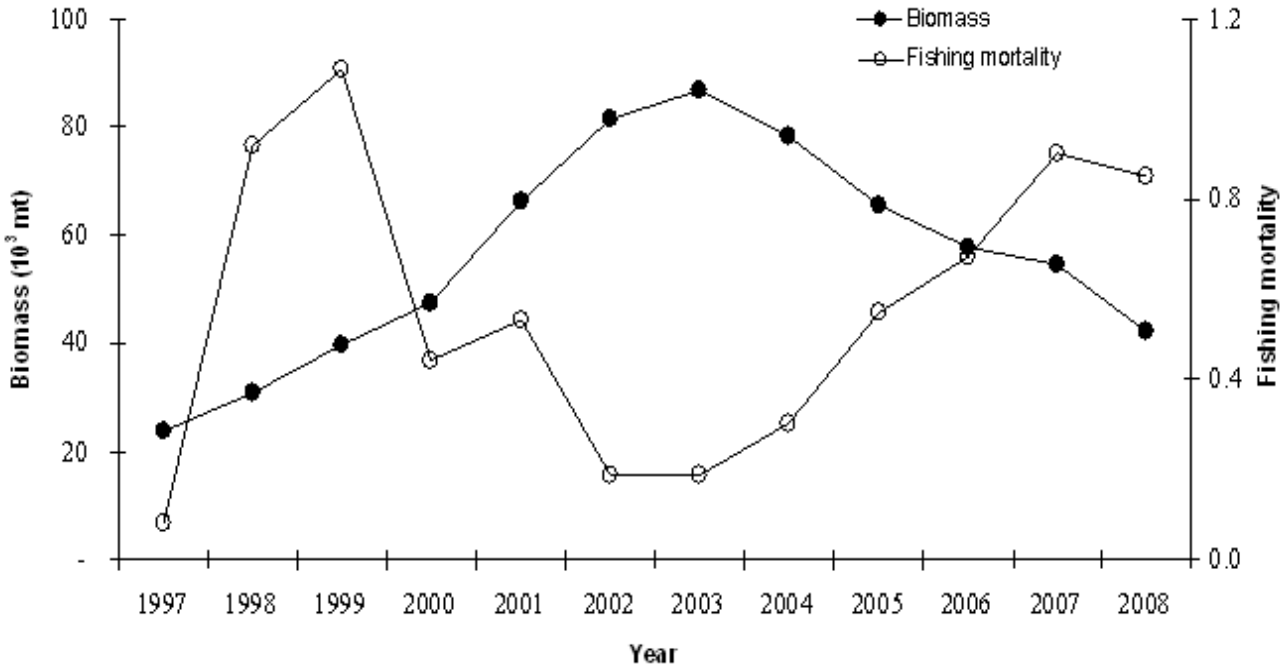

Fig. 2. Biomass (mt) and fishing mortality (yr^{-1}) of common kilka in Mazandaran coastal waters of the Caspian Sea from 1997 to 2008 (Fazli et al., 2007b)

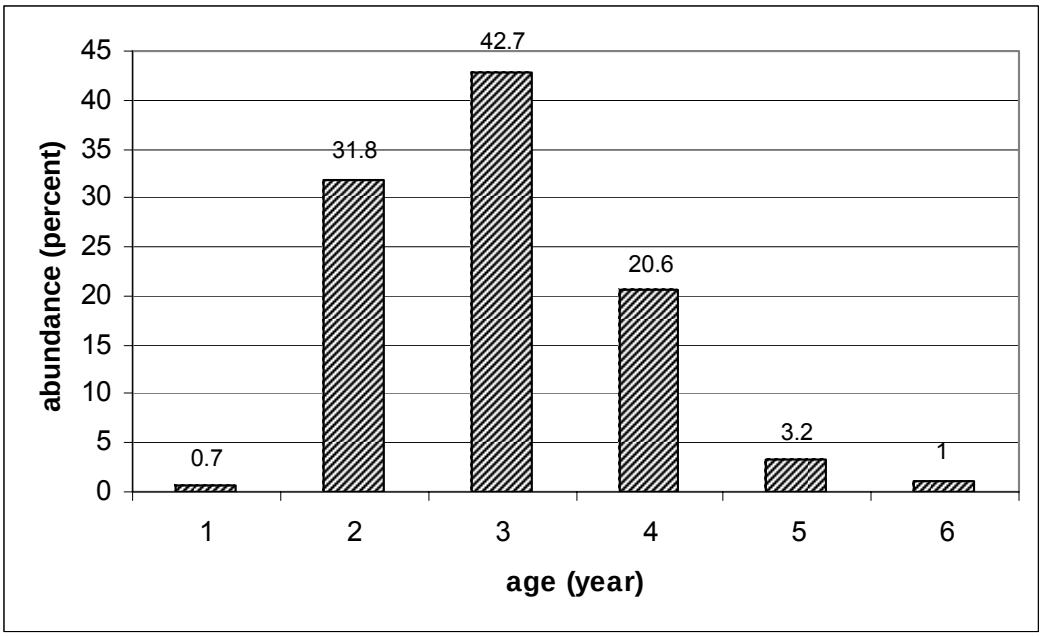

Fig. 3. Age frequency distribution of common kilka in Mazandaran coastal waters in the year 2008

Mnemiopsis leidyi is an alien ctenophore in the Caspian Sea, feeds mostly on zooplankton, fish eggs and larvae (Kideys and Moghim, 2003; Mutlu, 1993; Tsikhon-Lukanina et al., 1999) and competes with zoo-planktivorous fishes such as kilka (Kideys et al., 2001b). This may be one reason of the decline of pelagic fishes such as clupeid species in the Caspian Sea (Bagheri, and Sabkara, 2003). Before the invasion of *Mnemiopsis leidi*, common kilka was being catched during spring and summer; but after invading of this ctenophore, has been observed with a relative increasing abundance in the catch in all months of year (Valovik, 2000). Kilka fishing in cold seasons occurs in depths more than 60 m while common kilka lives in all parts of the Caspian Sea in depths 10 to 60 m (Pourgholam et al., 1996). Thus, it seems that this species has penetrated to anchovy kilka habitat, which lives mainly in depths more than 30-40 m and pushed this species to the deeper areas. Studies with funnel-shaped net and underwater light showed that CPUE and catch amount decreased severely in regions with high relative abundance of common kilka (Besharat and Khatib, 1993). Therefore, the damage of anchovy kilka stock occurred after *Mnemiopsis leidyi* invasion (Fazli et al., 2002). Moreover, common kilka presence in depths more than 60 m leads to anchovy kilka pushing and catch decreasing and replacing common kilka.

Dynamics of population parameters of common kilka fishes have been studied during the years 1997 to 2008. From the year 1997 to 2003, total biomass of common kilka increased from 23805.5 to 87038.1 t. The maximum total biomass of common kilka population was observed in 2002-2003 when the catch fluctuated from 81680.3 to 87038.1 t (Fazli et al., 2007). During the recent years, the biomass decreased but the catch of common kilka was more than the catch of two other species (anchovy and bigeye). It could be said that increasing of fishing effort, overfishing, human and natural factors are the main reasons for

decreasing kilka fishes in southern Caspian Sea in the Mazandaran coastal waters. Similar results reported by Fazli et al. (2004, 2005 and 2007a, b) and Karpuk et al. (2004).

In this study, the exploitation rate of common kilka has been estimated up to 0.55 which shows the desirable exploitation amount ($E \approx 0.5$). In 2008, the natural mortality of common kilka has been estimated up to 0.671yr^{-1} and the fishing mortality was 0.849 yr^{-1}. It was found that natural mortality was less than fishing mortality. This shows the less vulnerability of common kilka by natural antagonists and thus, the fishing role will be more visible in the catch fluctuations of this species. The current exploitation rate shows that common kilka has gradually become dominating in catches during the period from 1997 to 2008. Our results showed that common kilka stock is under over exploitation. Our results showed that exploitation rate was 0.55 in the year 2008. This amount is more than the rate 0.5 that offered by Gulland (1983). Similar results were reported by Fazli et al. (2002, 2004, 2005 and 2007).

4. CONCLUSION

Based on the results, human and natural factors that had serious effects on common kilka population, it was revealed that *Clupeonella cultriventris* stock is under over-fishing in the southern Caspian Sea.

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