Significant changes in pelagic fish stocks of *Clupeonella* spp. in the south Caspian Sea

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Abstract

The present study was carried out during 2006-2007 along the southern Caspian Sea. The species composition showed that the common kilka, *Clupeonella cultriventris caspia*, is dominant species with 89% and then anchovy, *C. engrauliformis*, has shown only 8.7% while it was already dominant species in the past decades. The overall results indicated that common kilka was replaced with anchovy kilka as previous dominant kilka species due to invasion of *Mnemiopsis leidyi* to the southern Caspian Sea. Anchovy suffered greatly from *M. leidyi* so that the total catch dropped from 95000 mt in 1999 to less than 20000 mt in 2007. In our survey, 1415 fish specimens were collected randomly, including 221 anchovy, 281 bigeye and 913 common kilka. The mean length of anchovy was 117.8 ± 0.27 mm, while it was about 93.0 mm during 1995 to 1998 before the invasion of *M. leidyi*. Analysis of age classes indicated the mean age of 4.5 ± 0.04 years for anchovy, 3.6 ± 0.03 for common kilka and 4.6 ± 0.08 for big eye *C. grimmi*. According to the age and the length structure of the specimens in this study, it could be concluded that in recent years, young fish population of anchovy has been decreased in comparison with the last decade. The results showed that some biological characteristics of kilka population were affected by *M. leidyi*. Recently fishing activities take place in shallow waters where schools of kilka are in suitable density for fishing. According to our results, ctenophore occupied the anchovy habitat where it was mainly more than 50 m depth. The fishing has moved to areas with depths less than 50 meters where it was the main reason to change in species composition.

Keywords: Age structure, Caspian Sea, *Clupeonella*, Species composition, *Mnemiopsis leidyi*

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Introduction

In the Caspian Sea, the main stock of pelagic fish consists of three species of clupeids, anchovy kilka *Clupeonella engrauliformis*, bigeye kilka *C. grimmi*, and common kilka *C. cultriventris caspia*. The kilka is a small pelagic species resident in different area of the sea. They play an important role in food chain of the ecosystem. During the past 30 years, the environment of the Caspian Sea has changed significantly. Invasion of the comb jelly *Mnemiopsis leidyi* to the Caspian Sea pelagic ecosystem is one of the main pressures in the past decade (Kasymov, 2001). *M. leidyi* came into the Caspian Sea through the ballast water from Azov-Black Sea basin. *M. leidyi* has damaged particularly the pelagic ecosystem of central and southern Caspian Sea. It influenced directly or indirectly all links of the food chain (Mamedov, 2006).

Anchovy kilka was the dominant species from 1955 to 1957 and constituted more than 80 percent of the catch. Large amount of kilka were caught during the year 1998 (85000 tonnes) and in 1999 (95000 tonnes). From 1999, catch was decreased sharply and since 2001, the stock has been virtually collapsed. Therefore, catch has declined to less than 30,000 tonnes per year and some of indicators such as catch per unit effort, CPUE also declined. In fact, the collapse of kilka stocks causing a change in the ecosystem.

Mnemiopsis leidyi had a similar devastating impact on ecosystem of the Black Sea and Azov Sea when it was accidentally introduced there in the same manner as for the Caspian Sea (Kideys, 1994, 2002; Niermann et al., 1994; Shiganova, 1998; Vinogradov et al., 1998; Shiganova and Bulgakeva, 2000; Volvik, 2000). There, the productivity of Azov Sea dropped, and within a few years during the 1990s, the annual catches of *Engraulis encrasicholus* and kilka fell from 165300 tonnes to around 21000 tonnes (Volvik, 2000).

Results of studies on anchovy kilka stocks have indicated significant changes in population size and age structure as well as a weak recruitment since 2001 (Kostyurn et al., 2005; Mamedov, 2006; Daskalov and Mamedov, 2007). Changes in age structure or growth rates could be used to detect environmental changes or ecological conditions influencing (Summerfelt and Hall, 1987; Hammers and Miranda, 1991).

The main aims of this study were 1) to describe the kilka fisheries in terms of changes in catch and effort to determine, if there were significant trends in catch rate and species composition over the years and 2) to assess the kilka stock in the Caspian Sea, using age structure, distribution and composition to provide some of the information needed to support management.

Materials and methods

The fishing activities in the southern Caspian Sea mainly took place in shallow coastal waters with depth less than 100 m and with the coastal line of approximately 900 km long. Most of the kilka fishing operations has been concentrated around the Anzali and Babolsar (Fazli et al., 2007) (Fig.1).

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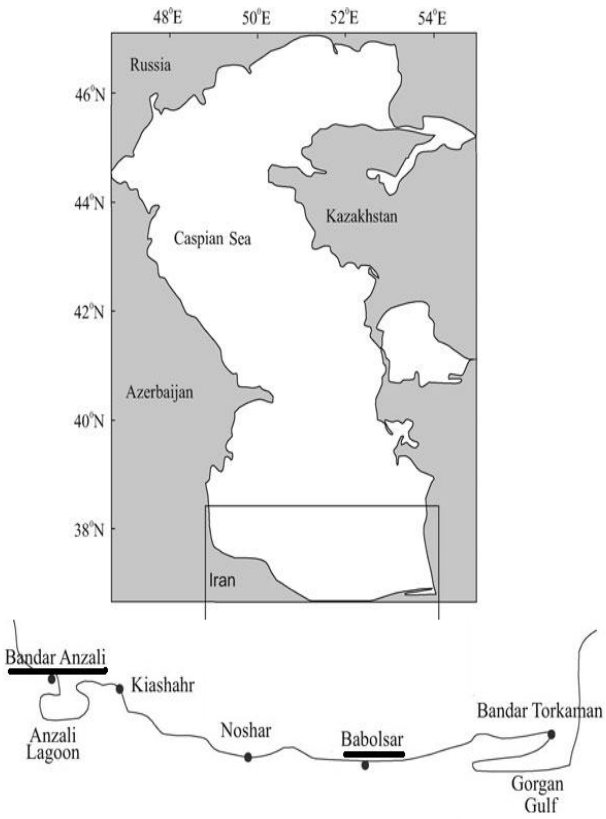


Figure 1: Map of south of Caspian Sea, showing the sampling stations (Anzali and Babolsar)

All of the fish were counted easily at the fishing ports, only a small amount of the catch will be unreported because of self consumption of fish by fishers. Kilka fishing were done at night, using a funnel net with a mesh size of 7-8mm and a lamp light (1000 – 1500 w) for attract the fish (Daskalov and Mamedov, 2007).

The present study has done based on surveys were conducted by fishing vessel equipped with 200 kHz echo sounder . The survey was carried out (10–12 h at night) four times in each months for estimation of abundance and composition of seasonal variability during 2006-2007.

Fish samples were identified to species by taxonomic level based on their morphological characteristics (Svetovidov, 1963; Kazancheev, 1982). Species composition was calculated to percentages of the total catch of all species from research samples. The relative abundance of each species (catch of the vessel per night) was assessed during this study for all three species (Sparre and Venema, 1998; King, 2007).

In the laboratory, some biological parameters were studied. Each fish was measured to the mm for fork length and weighed to the g for total body weight (King, 2007). Then, the sagitta otoliths were removed (Francis and Campana, 2004). Both otoliths cleaned and dried. The whole otoliths were fully immersed in glycerin for 12 h (Francis and Campana, 2004) and read under reflected light on a

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microscope at 10-40x magnification (Fig. 2). The age reading was based on 1415 specimens: 221 anchovy, 281 bigeye and 913 common kilka.

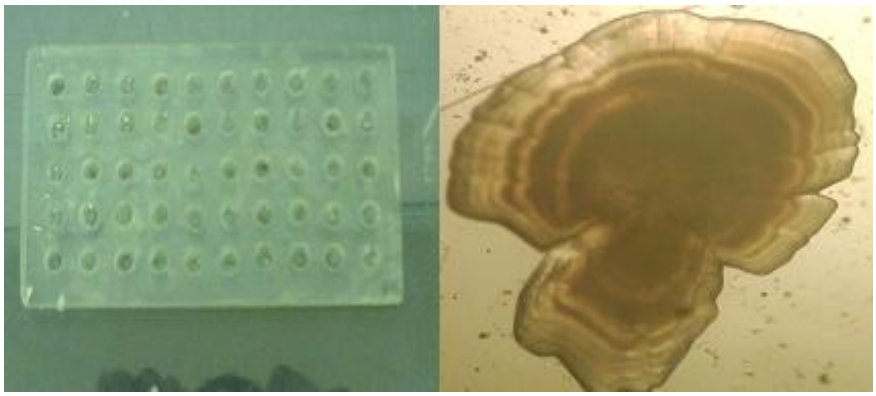


Figure 2: The whole otoliths immersed in glycerin for 12 h (left) and aging on a microscope at 10-40x magnification (right)

Results

Species composition

The kilka species were dominated by common kilka, accounting about 89.7% of the catch, followed by anchovy kilka at 8.7%. High proportion of common kilka is due to low rates of other species. Bigeye kilka has constituted just 1.6% of total kilka catch under the present condition. The fluctuations in catch trends for different species is a result in a shift in the species composition over the years.

Abundance and distribution

The annual catch was 22300 mt in 2006 and 15425 mt in 2007. Kilka fisheries showed a decrease of approximately 30.8% during this period. The contribution of common kilka in the total catch increased from 86.7% in 2006 to 91.5% in 2007, whereas the proportion of anchovy kilka decreased (Fig. 3).

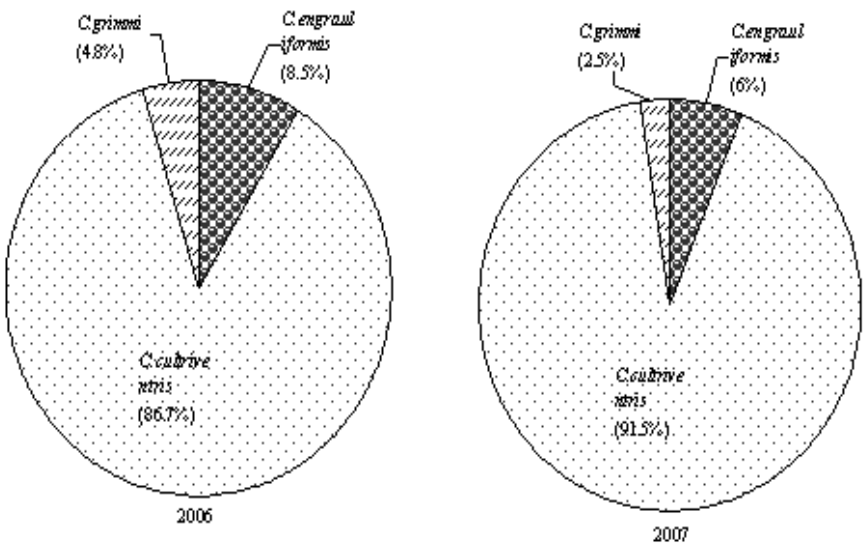


Figure 3: The contribution of the three species in total catch during 2006 and 2007.

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According to the echograms obtained from acoustic surveys, concentrated schools of kilka were observed in 30 to 40 m depth layer, while in the layers with depths more than 40 m they were not commonly found high densities schools of fish (Fig. 4).

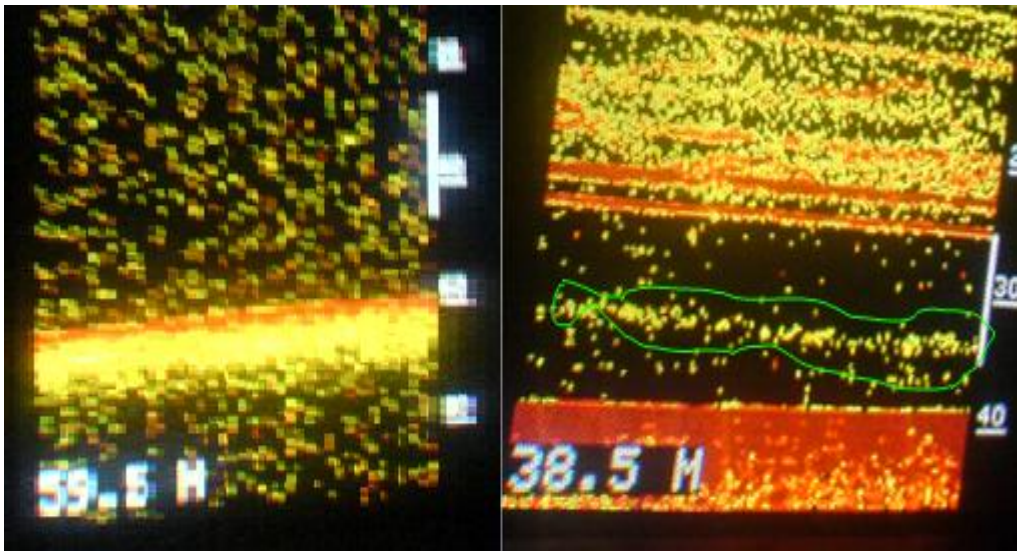


Figure 4: Echograms from the 59.5 and 38.5 m depths, showing scattering layers of kilka dispersed intensively over a depth layer between 32 and 37 m (right)

The mean catch per unit of effort (CPUE) values for the various species were given in Table 1. The CPUE was most value for common kilka, which was the most abundant species in the catches. In total, kilka had the higher CPUE in 2006 than 2007.

Table 1: Mean CPUE (mt per Vessel - Night) for different species of kilka during 2006 - 2007

Year	*Clupeonella engrauliformis*	*Clupeonella cultriventris caspia*	*Clupeonella grimmi*
2006	0.148	1.506	0.086
2007	0.099	1.514	0.041

Size and age

During the study period, the length of common kilka in the southern Caspian Sea varied between 56 and 144 mm, averaging 102.4 mm. The length of anchovy kilka ranged between 98 and 135 mm, with an average of 117.8 mm. Bigeye was scarce in the catch, but their length varied from 73 to 140 mm (average 119.9 mm) (Table 2).

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Table 2: The number (N), mean, minimum, maximum and standard error (S.E.) values of the fork length (mm) of three species of kilka in the Caspian Sea during 2006 - 2007

Species	Minimum	Maximum	Mean	S. E.	N
Clupeonella cultriventris caspia	56	144	102.4	0.23	1533
Clupeonella engrauliformis	98	135	117.8	0.27	546
Clupeonella grimmi	73	140	119.9	0.61	428

Analysis the age composition showed that common kilka were mainly 1–7 years old, but recently 3 – 4 years old have dominated (>73%). There have been few 1 year old. The average age of the population was 3.6 years. Anchovy kilka was aged between 2 and 8 years old, though more than 85% were 4 – 5 years old. Bigeye kilka was 1 – 8 years old, but more than 73% were between 4 and 6 years old (Tables 3 and 4).

Table 3: The number (N), mean, minimum, maximum and standard error (S.E.) values of the Age (year) of three species of kilka in the Caspian Sea during 2006 - 2007

Species	Min	Max	Mean	SE	N
Clupeonella cultriventris caspia	1	7	3.6	0.03	913
Clupeonella engrauliformis	2	8	4.5	0.04	221
Clupeonella grimmi	1	8	4.6	0.08	281

Seven age classes for common kilka and eight classes for anchovy kilka and bigeye kilka were observed. Only one specimen belonging to 8 years old for anchovy kilka and bigeye kilka were found. The mean lengths for the different age classes were shown in table 4.

Table 4: The mean length, standard error (SE) and number (N) values of age classes in three species of kilka in the Caspian Sea

Age (year)	*Clupeonella cultriventris caspia*			*Clupeonella engrauliformis*			*Clupeonella grimmi*		
	Mean length (mm)	SE	N	Mean length (mm)	SE	N	Mean length (mm)	SE	N
1^+	71.4	1.2	5	-	-	-	74.7	-	2
2^+	87.8	0.7	96	90.7	0.8	3	89.2	1.1	16
3^+	99.1	0.3	369	103.8	0.4	16	103.2	0.7	42
4^+	106.6	0.2	299	112.1	0.3	96	114.3	0.7	53
5^+	112.7	0.3	114	118.5	0.4	93	121.5	0.6	99
6^+	117.3	0.9	28	124.0	0.5	7	126.7	1.5	55
7^+	121.1	-	2	129.2	-	5	129.2	0.8	13
8^+	-	-	-	135.0	-	1	136.3	-	1

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Discussion

The total catch of kilka in the southern Caspian Sea, dropped from 95000 mt in 1999 to 15425 mt in 2007. It could be mentioned that two important effective factors, human and natural, had serious effects on kilka fish population especially on anchovy stock as already reported (Fazli et al., 2004; 2007 and Karimzadeh et al., 2010).

Decreasing process of anchovy kilka and bigeye kilka catch started from 1999 and continued strongly from 2006 to 2008. A similar decline observed in trends for the two other species. In 1999, the CPUE was 3.1 mt per night for anchovy kilka and 0.67 mt per effort for bigeye kilka. These values dropped to 0.099 and 0.041 mt per effort in 2007, respectively. In contrast, the CPUE for common kilka was only 0.6 mt per effort in 1999, which reached 1.514 mt per effort in 2007.

The contribution of common kilka increased from 13.7% in 1999 to more than 91.5% in 2007, whereas the proportion of anchovy kilka decreased from 71% to 6% during this period. The shift in catch composition was from an increase in the common kilka and a decrease anchovy ratio over the years. According to the results of the study on catch and CPUE amount, could be said relative abundance of common kilka population shows an increasing trend in relative abundance in recent years and as well as in comparison with other species.

Large amounts of kilka catches by the Soviet Union during 1978 to 1982 could be as an important factor. During these years, more than 300 thousand mt fish caught each year by Russia in the Caspian Sea (Ivanov, 2000). In addition, in the southern part of the Caspian Sea, fishing activities increased from 1991. The number of vessels was 18 in 1991, with an ascending trend to reach more than 200 vessels in 2001. Raising fishing effort accompanied by reduced catch per unit effort, as has been already reported (Karimzadeh et al., 2010). The CPUE was about 5mt per night for each vessel in 1991 but this index declined about 1.6mt in 2001.

Besides the effects of human activities should also note to the natural effects. The most likely negative influence on the kilka stocks was the invasion of the *M. leidyi* in the Caspian Sea. Anchovy kilka was the most abundant fish species in the Caspian Sea before the invasion of the *M. leidyi*, composed about 80% of the total catch of kilka. By 2001, *M. leidyi* became the dominant species in the pelagic ecosystem and extended throughout the whole Caspian Sea (Daskalov and Mamedov, 2007).

M. leidyi caused the biomass reduction of zooplankton, the main food resources of kilka. Anchovy kilka feeds on mainly from copepods. *Eurytemora grimmi* alone contributing 70% on average annually of anchovy kilka food (Prikhodko, 1975; Sedov and Paritskiy, 2001) which disappeared recently. *E. grimmi* dropped to about one eighth of its previous level in the central Caspian and was not found in the southern Caspian (Tinenkova and Petrenko, 2004). In 2000, the zooplankton biomass dropped 4 to 10 times compared with the situation in 1998 (Polyaninova et al., 2001). Currently the dominant

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zooplankton species in the southern and central area is *Acartia clausi* (Tinenkova and Petrenko, 2004), that consist of about 55% of the diet of kilka (Mamedov, 2006). Kilka feeds exclusively on zooplankton, mostly copepods, cladocera and meroplankton (Ivanov et al., 2000). *M. leidyi* is a macrophage capable of eating large prey (Main, 1928), so, it is probable that *M. leidyi* and anchovy kilka have a competition for food.

Of the three species, anchovy kilka spawns over the longest period; May - December in water temperature of 15 – 25^{oc} and salinity 8 – 13ppm (Mamedov, 2006; Daskalov and Manedov, 2007). However, some spawning takes place in May and June along the coast of Azerbaijan. This is a different spawning season from the south – east Caspian where, according to Sedov and Paritsky (2001), the most of anchovy kilka (80%) spawns between October and December (Mamedov, 2006). Parafkandeh (2009) and Fatemi et al. (2009) indicated anchovy spawning time has more extension than common kilka, fulfilled after this species and the spawning peak in the Iranian coast of southern part of Caspian Sea is in October and November, exactly when it is the time of *M. leidyi* bloom in this area (Roohi et al., 2003; Bagheri, 2005), it means juveniles of comb Jelly grazes zooplanktons. This coincidence supports the idea that the stock of anchovy kilka is unable to recover its recruitment collapse.

The results of our study show that the fork length of anchovy kilka ranged between 98 and 135mm, an average 117.8mm. Meanwhile, the mean fork length of anchovy kilka was stable approximately 93mm during 1995 to 1998. However, it has gradually increased to more than 100mm in 2003 and reached to 105mm in 2004 after the presence of *M. leidyi*. According to age structure in this study, young fish population has decreased in recent years in comparison with the previous decade. The average age of anchovy has increased whereas this catch amount has decreased during 1997 – 2008 (Mamedov, 2006; Parafkandeh, 2009).

Before *M. leidyi* invasion to the Caspian Sea, kilka fishing accomplished in depths more than 60 m where habitat of anchovy kilka (Prikhodko, 1981) is. Nowadays, fishing activities occur in depths less than 50 m where fishermen could find relatively high densities of fish schools for fishing (Fig. 4). Therefore, fishermen changed the area and depth of fishing in order to attain more catch. Common kilka lives in shallow zones and does not present in depths more than 50m (Aseinova, 1992). It seems that this ctenophore has penetrated to anchovy kilka habitat, which was mainly more than 50m (Prikhodko, 1981; Aseinova, 1992). Therefore, the damage of anchovy kilka stock occurred after entering *M. leidyi*. The fishing areas have moved to shallow zones, which is the main reason to change species composition.

Overall, changes in species composition and relative abundance of anchovy in comparison with the recent 10 years have been mainly due to sudden increase of fishing effort, unsuitable management on kilka stocks and the recruitment failure.

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