A comparative study on reproduction of kilka species (Clupeidae) in southeastern parts of the Caspian Sea

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Abstract

The aim of the present study was to investigate the reproduction of three species of kilka, including common, anchovy and bigeye kilka in the southeastern waters of Caspian Sea. This study was conducted during 2010 and 6476 specimens were fortnightly collected from fishing landing site. Body weight and fork length were measured. The samples were dissected and female gonads were weighed. Sexual maturity classification was carried out based on six stages in ovarian development. Age was determined using sagitta otoliths. Results were compared with the previous years. Male: Female ratio in common, anchovy and bigeye kilka were 1: 0.779, 0.569: 1 and 0.656: 1, respectively. Study of sexual maturity stages and GSI showed that common kilka spawning began in March and ended in July with the peak in May. Spawning period of anchovy kilka was more extensive than common kilka and take place from April to November with a peak in November. Bigeye kilka spawned during the year entirely. Its spawning occurred intensively during the autumn with a peak in October. Our results showed that M: F ratio differs during the year which is related to their reproduction. The reproduction scheduling of kilka species comparing with the previous years had some changes but has not significantly been affected by the Caspian Sea pelagic changes.

Keywords: *Clupeonella cultriventris caspia*, *C. engrauliformis*, *C. grimmi*, GSI, Maturity stages, Caspian Sea

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Introduction

Kilka fishes have an important role in the neighboring countries and ecosystem perpetuity of the Caspian Sea; so their exploitation should be conducted attentively (Pourgholam et al., 1996). These fishes belong to the family Clupeidae. In the Caspian Sea, two species including anchovy kilka (*Clupeonella engrauliformis* Svetovidov, 1941) and bigeye kilka (*C. grimmi* Kessler, 1877) and one subspecies named common kilka (*C. cultriventris caspia* Borodin, 1904) are found and all of them exist in catch composition of Iran and other countries and are important indices in ecological health of the Caspian Sea basin (Fazli, 1990; Razavi Sayyad, 1993; Karimzadeh et al., 2010).

Anchovy and bigeye kilka are endemic species in the Caspian Sea and common kilka is a subspecies from the Black Sea (Pourgholam et al., 1996; Melinkov, 2000). They are a main part of food chain in the Caspian Sea (Mamedov, 2006). Kilka fishing is done nightly using under water light and funnel-shaped nets (Yermalchev and Sedov, 1990; Fazli and Rouhi, 2002). During the recent years, catch composition of kilka fishes has changed (Aliasghari and Vatandoust, 2010). Entering the ctenophore *Mnemiopsis leidyi* into the Caspian Sea (Ivanov et al., 2000) can be one of the effective factors on ecosystem and kilka stock changes (Fazli et al., 2004; Aliasghari, 2009).

Kilka fishes are pelagic fishes which live in gregarious and are one of the most abundant fishes in the Caspian Sea (Karimzadeh et al., 2010). Common kilka inhabits in the coastal zone with depth less than 70 m and its high density was observed in depths less than 50 m (Prikhodko, 1981). This euryhaline species (Svetovidov, 1963) spends a wintering period in southern Caspian and afterwards, mainly has a northward spring migration (Kazanchev, 1963; Kaspnirkh, 1978) for spawning (Prikhodko, 1981).

Anchovy kilka is stenohaline and inhabits in the middle and southern Caspian Sea mainly in depth more than 20 m. This fish spends winter in southern Caspian (Svetovidov, 1963; Kaspnirkh, 1978; Rychagova, 1989). From the end spring, it begins a southward migration for spawning. Anchovy kilka spawns from spring to autumn in southern Caspian Sea (Berg, 1948; Kaspnirkh, 1978; Sedov and Rychagova, 1984).

Bigeye kilka lives substantially in depths more than 50-70 m and tolerates salinity and temperature changes less than two other kilka species (Prikhodko, 1981). It migrates from south to middle Caspian in spring (Kazanchev, 1963; Kaspnirkh, 1978) and comes back to southern Caspian in autumn for wintering (Lovetskaya, 1951). Bigeye kilka spawning is longer than two others and spawns intensely during spring and autumn.

Cognition of fish biological characteristics and life cycle is necessary for constant exploitation of their stock (Hoseinzadeh et al., 2001; Igdari, 2002). Fishing without the sufficient knowledge about fish reproduction can be harmful for its population (Khorashadizadeh et al., 2006). Some researches were conducted to investigate the kilka reproduction in the Caspian Sea (Krasnova, 1947; Kazanchev,

1963; Paritetski, 1976; Kaspnirkh, 1978; Naderi et al., 1997; Salmanov, 1999; Abtahi et al., 2002; Khorashadizadeh et al., 2006). This study investigated the reproduction of three kilka species using macroscopic features and compares them in southeastern waters of the Caspian Sea. The aim of the present study was to fill the gaps in our knowledge on kilka species reproduction season and to create a base for optimum management of kilka fishing in the southeastern Caspian Sea.

Materials and methods

Fish samples were collected from Babolsar station (52° 55" E and 36° 51"N) in Mazandaran province from January to December 2010. This research was conducted during a one-year period from January to December 2010. From the total 6476 samples, common, anchovy and bigeye kilka number were 3774, 1659 and 1043, respectively. These samples were caught at depths ranging from 25 to 100 m by funnel nets equipped with underwater electric lights. In the laboratory, fork length measured by biometry ruler (to the nearest 1 mm) and body weight measured using digital balance (to the nearest 0.1 g).

Age of fish determined by using sagitta otoliths which were provided from all fish in each biometry stage. Otoliths were put in glycerin for 12 h and age determined using stereomicroscope with a light from top and a black background (Chilton and Beamish, 1982).

The samples were dissected and female gonads were weighed. Sexual maturity classification was carried out based on six macroscopic stages in ovarian development (Biswas, 1993):

In order to reproduction time determination, GSI was calculated with equation as (Bagenal, 1978):

$$GSI = \frac{w}{W} \times 100$$

Where, w is gonad weight (g) and W is body weight (g).

Data showed as Mean±SE. Software Microsoft Office Excel 2003 and SPSS 10.0 were used for analyzing.

Results

Average fork length and weight of common, anchovy and bigeye kilka females and males were calculated and in all cases, the amount of females mean length and weight was more than the males. Bigeye kilka had higher average length and weight than two other species (Table1). Average age of females and males were calculated and showed that in all three kilka fishes, mean age of females was more than males. Anchovy kilka had higher average age than two others (Table1).

Table 1: Average fork length, weight and age for females and males of common, anchovy and bigeye kilka species in southeastern Caspian Sea in 2010

species	Common kilka		Anchovy kilka		Bigeye kilka	
sex	Female	Male	Female	Male	Female	Male
FL±SD (mm)	102.09±8.37	95.86±12.24	119.02±14.58	111.98±18.97	121.08±12.32	117.72±12.54
W±SD (g)	9.49±2.25	8.05±2.59	13.19±3.87	11.38±4.57	15.87±5.17	14.11±5.21
Age±SD(yr)	3.56±0.78	3.03±0.99	4.57±1.43	3.86±1.62	4.09±1.25	3.61±1.45
N	2121	1653	1057	602	630	413

Among 3774 common kilka samples, 56% (n=1653) were male and 44% (n=2121) were female. The sex ratio of M: F was 1: 0.779. Monthly abundance of sex ratio showed that females were dominant in October (51%), November (69%) and December (58%) (Table 2).

Amongst 1659 anchovy kilka, 36% (n=602) were male and 64% (n=1057) were female. The sex ratio was M:F= 0.569: 1 and females were dominant. Monthly abundance of sex ratio showed that males were dominant in June (54%) and September (53%) (Table 2).

Among 1043 bigeye kilka, 40% (n=413) were male and 60% (n=630) were female. The sex ratio was M:F= 0.656: 1 and females were dominant. Monthly abundance of sex ratio showed that males were dominant in December (67%). In July, females and males were equal (Table 2).

Table 2: Sex ratio (%) of common, anchovy and bigeye kilka species in the southeastern Caspian Sea in 2010

Month	Common kilka		Anchovy kilka		Bigeye kilka	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**
Jan	48	52	53	47	68	32
Feb	41	59	76	24	63	37
Mar	38	62	80	20	58	42
Apr	40	60	75	25	57	43
May	21	79	64	36	71	29
Jun	28	72	46	54	53	47
Jul	45	55	58	42	50	50
Aug	42	58	68	32	66	34
Sep	44	56	47	53	60	40
Oct	51	49	57	43	55	45
Nov	69	31	76	24	62	38
Dec	58	42	68	32	33	67

Study of common kilka sexual maturity stages showed that the abundance of fourth and fifth sexual maturity stages increased from February and reached to its maximum level in April and May. Spawning extended to July and completed in August. Afterwards, relative abundance of second maturity stage was almost more than 80% till early winter (Fig.1). The highest GSI (9.99±0.02) was calculated in May (Fig. 2).

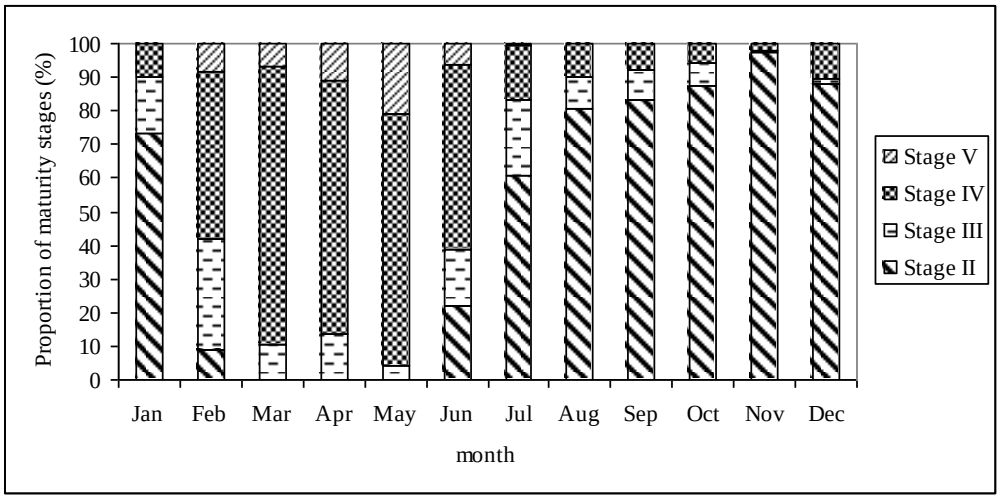

Figure 1: Monthly proportion (%) of maturity stages of common kilka in the southeastern Caspian Sea in 2010

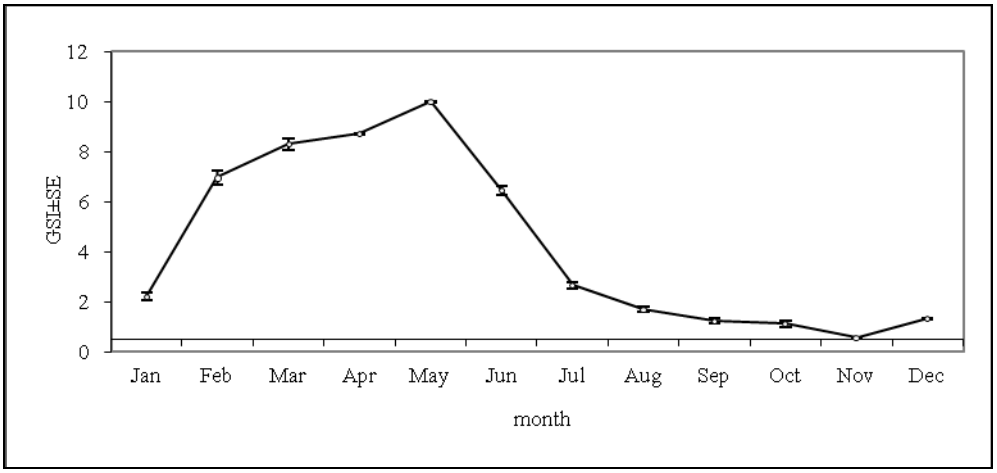

Figure 2: Monthly GSI mean (±SE) of common kilka in the southeastern Caspian Sea in 2010

In anchovy kilka, the abundance of fourth and fifth sexual maturity stages increased from April and reached to its maximum level in late autumn (October and November). Spawning completed in December; so, relative abundance of second maturity stage increased in January and February and was 45-50% (Fig. 3). The highest amount of GSI (7.12±0.41) was calculated in November (Fig. 4).

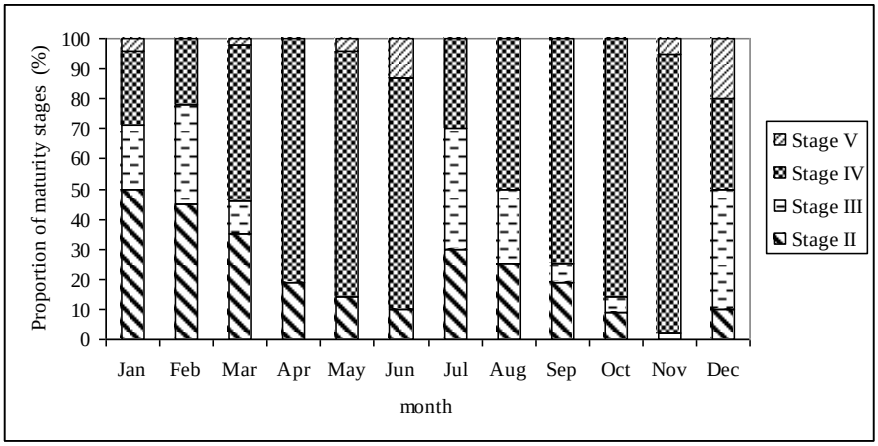

Figure 3: Monthly proportion (%) of maturity stages of anchovy kilka in the southeastern Caspian Sea in 2010

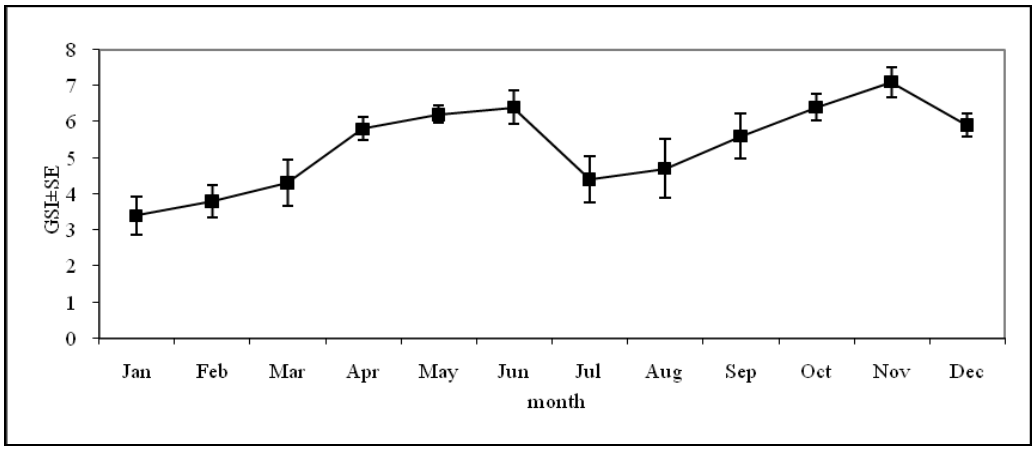

Figure 4: Monthly GSI mean (± SE) of anchovy kilka in the southeastern Caspian Sea in 2010

Bigeye kilka had high abundance of fourth maturity stage in many months as well as GSI amount. So, Bigeye kilka spawned during the year entirely. Its spawning occurred intensively during the autumn with a peak in October (Fig. 5). The highest amount of GSI (10.16±0.84) was in October (Fig. 6).

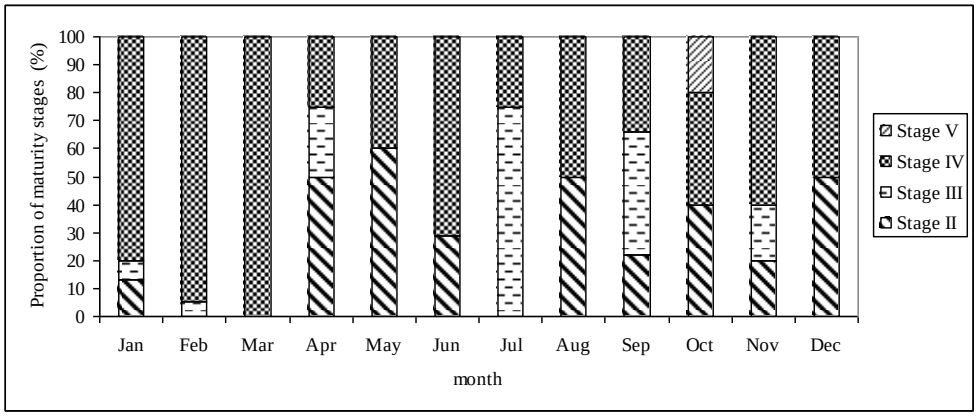

Figure 5: Monthly proportion (%) of maturity stages of bigeye kilka in the southeastern Caspian Sea in 2010

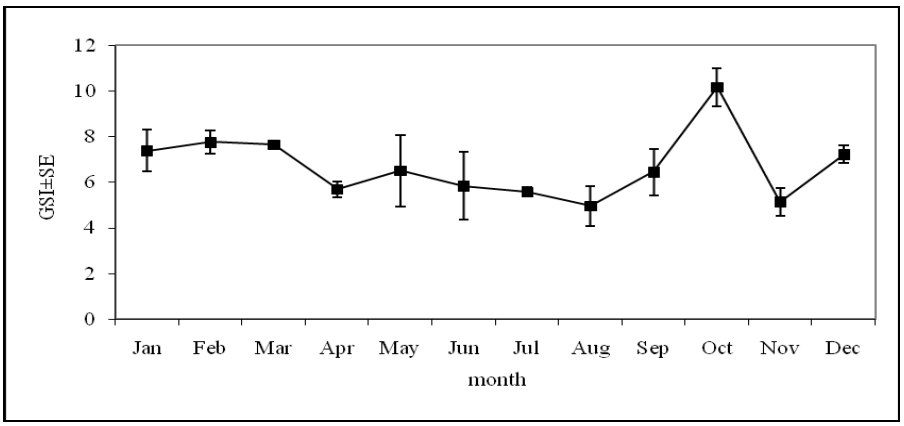

Figure 6: Monthly GSI mean (± SE) of bigeye kilka in the southeastern Caspian Sea in 2010

Discussion

Our knowledge about length, weight and age structure helps us to understand the status of the fish population and the potential of reproduction. Mean length and weight of common kilka in southeastern waters of the Caspian Sea decreased from 1997 to 2000 and increased after 2001 (Fazli et al., 2007) till 2008 (Karimzadeh et al., 2010) but decreased again in the present study. The mean length and weight of anchovy kilka decreased during 1997 to 2000 and increased from 2001 (Fazli et al., 2006a) till now. In bigeye kilka, the mean length and weight increased continuously during 1997 to 2001 (Fazli et al., 2006b) till now. Average age of common kilka decreased from 1997 to 2000 and increased after 2001 to 2005 (Fazli et al., 2007) but decreased again in 2008 (Karimzadeh et al., 2010) till now. The mean age of anchovy kilka decreased during 1997 to 2000, afterwards increased (Fazli et al., 2006a) till now. In bigeye kilka, average age has increased continuously since 1997 (Fazli et al., 2006b) as well as the present study. Study of length, weight and age suggesting that the population of common kilka has been younger but anchovy and bigeye kilka population has been older in recent years. In the present study, weight, length and age study showed that females were older than males perhaps related to their population structure or behavior to the light (Ben-Yami, 1976).

The M:F ratio of common kilka was 1: 0.779. This ratio was also estimated during 1997-2005 (Fazli et al., 2007) and 2008 (Karimzadeh et al., 2010) which females were dominant in all of these years with a relatively high abundance and were formed about 70-80% of the catch population.

Anchovy kilka sex ratio was M:F= 0.569:1 and females were dominant. During 1997-2004; males were dominant and then females formed about 55-70% of population during 1998-2003. In 2004, males were dominant with proportion 55% (Fazli et al., 2006a) and then in 2008, females were dominant with ratio 0.508: 1 (Karimzadeh et al., 2010).

M:F ratio in bigeye kilka was 0.656:1 and females were dominant. During 1997-2000, males have constituted about 60-90

% of catch and were dominant. Male ratio decreased in 2001 and females were dominant with 54 percent proportion (Fazli et al., 2006b). In 2008, this ratio was 0.434: 1 and females were dominant (Karimzadeh et al., 2010).

Monthly study of male: female ratio showed that this ratio varies in all of three kilka species during the year; i.e. females are dominant in some months and males in other months. These results confirm that the behavior of females changes toward the underwater electric lights during the year. There are different responding behaviors of fish to light (Ben-Yami, 1976). A key hypothesis is that fish are attracted to light to feed. It is well-known that artificial light attracts many aquatic organisms (Maeda, 1951) and perhaps the motivation for attraction is related to prey density increase within the light area. Sexual maturity stage effects on fish attraction toward the light in all seasons (Sayyad Bourani, 1997). With development of gonads, females appear to be less attracted to light. As they approach spawning time, they cease feeding and their proportion decreases in the catch. In contrast, males continue to feed during spawning and it seems that their response to light remains unchanged (Ben-Yami, 1976). Thus, using electric underwater light for fishing, some spatial segregation can occur between males and females at the spawning time.

The biomass of a fish population depends on its reproduction (Wootton, 1990). So, knowledge about the fish spawning time is very important for optimum management and constant fishing program.

Common kilka spawns in spring (Krasnovoa, 1947). In the northern Caspian Sea, their spawning accomplishes in April and extensively in May. In the southern Caspian, the spawning begins sooner and accomplishes in January-February and gregariously in March and April (Prikhodko, 1981). In the present study, common kilka spawning started from February and reached to its maximum level in May. Similar results were reported by other researchers (Prikhodko, 1981; Abtahi et al., 2002; Fazli et al., 2007) that showed the maximum spawning in April and May. In this study, spawning extended to June and completed in July.

Anchovy kilka spawning is more extensive than common kilka and also occurs after it. Previous studies showed that from May to October, anchovy kilka exists in depths 50-200 m gregariously in southern parts of Caspian Sea during the autumn (Berg, 1948; Kaspnirkh, 1978; Sedov and Rychagova, 1984). In present study, anchovy kilka spawning began from April and reached to its maximum level in late autumn (October and November). Spawning completed in January and February.

Bigeye kilka spawning time is longer than two other species and occurs intensively during spring and autumn (Kazanchev, 1963; Kaspnirkh, 1978). This fish spawns in deeper waters than two other species. In the present study, the reproduction of bigeye kilka occurred throughout the year. Its spawning occurred intensively during the autumn with a peak in October. This species has a spawning peak in spring but lower than the autumn.

Similar results were reported in a previous study (Karimzadeh et al., 2010) that bigeye kilka had two spawning peaks one in spring during April and May and another in autumn was in September and October.

Results showed that common kilka spawns intensively during April and May. Intensive spawning of anchovy and bigeye kilka is in October and November. Regarding to the biologic and economic importance of kilka stock in the Caspian Sea, more fishing limitations or even interdiction are necessary at these times for stock reconstruction. So, an attentive surveillance process should be exerted on kilka catch program.

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