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Population dynamics and stock assessment of common kilka (*Clupeonella cultriventris caspia*) in Iranian waters of the Caspian Sea

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Abstract: This paper examines the changes in the population biology and biomass of common kilka (*Clupeonella cultriventris caspia*) in the Iranian waters of the Caspian Sea from 1995-2004. For most years during this 10-year period, we estimated the age structure of the catch, length-weight relationship, von Bertalanffy growth parameters, condition factor, sex ratios, maturity stages determined from ovarian analysis, natural and fishing mortality, age at first capture and biomass. Growth parameters were estimated as L_∞=132mm, K=0.259/yr, t_0=-1.285/yr. The instantaneous coefficient of natural mortality was estimated as 0.506/yr and the instantaneous coefficient of fishing mortality varied during the 10-year period between 0.125/yr to 1.487/yr. Biomass of the common kilka increased from about 16,000mt in 1995 to more than 41,000mt in year of 2002. This increase in common kilka was simultaneous with a sharp decline in anchovy kilka, changes in zooplankton abundance and composition, and especially increase in zooplankton species used by common kilka. We concluded that at the present time, the stock of common kilka is being over-fished.

Keywords: *Clupenella cultriventris caspia*, Growth, Maturity stages, Stock assessment, Caspian Sea

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Introduction

The most abundant fish of the Caspian Sea are three small clupeids known as "kilka", which are anchovy kilka (*Clupeonella engrauliformis*, Svetovidov, 1941), common kilka (*C. cultriventris caspia* Bordin, 1904), and bigeye kilka (*C. grimmi* Kessler, 1877)(Svetovidov, 1963). All three kilka species are caught in commercial fisheries by use of underwater electric lights with liftnet or fish pumps (Nikonorov, 1964). Common kilka inhabit the coastal area with depths shallower than 50-70m (Prikhod'ko, 1981; Poorgholam *et al.*, 1996; Fazli & Besharat, 1998). This euryhaline species is widely distributed and found in low and high water temperatures and both in freshwater and in high salinity up to $36^0/_{00}$. Common kilka spawns in spring (Prikhod'ko, 1981).

Previous studies on the population characteristics of the common kilka stock in the Iranian waters of the Caspian Sea were limited to the distribution (Besharat & Khatib, 1993) and stock assessment by hydroacoustic methods during 1994-96 (Poorgholam *et al.*, 1996; Fazli & Besharat, 1998). However, quantitative assessments are necessary for effective utilization and management of the stock. Despite the economic and ecological importance of the kilka as one of the major commercial and forage species in the Caspian Sea, no adequate information about sex, age, growth and mortality of kilkas in the Iranian waters has been published. Such information is especially important because of the ecological changes that are occurring in the sea at the present time. Further, the invasive comb-jelly, *Mnemiopsis leidyi*, that appeared in 1999 (Ivanov *et al.*, 2000), has affected all components of the ecosystem used by kilkas. The objective of the present study is to fill the information gaps on the population biology, estimate the biomass of common kilka and provide a basis for improved and effective management of common kilka fisheries in the Iranian waters.

Materials and Methods

Samples were collected from two fish landing sites of Amir-abad and Babolsar in Mazandaran Province and one landing site of Bandar-Anzali in Guilan Province (Fig. 1).

The samples examined in this study were caught at depths ranging from 40 to 100m by conical liftnets equipped with underwater electric lights.

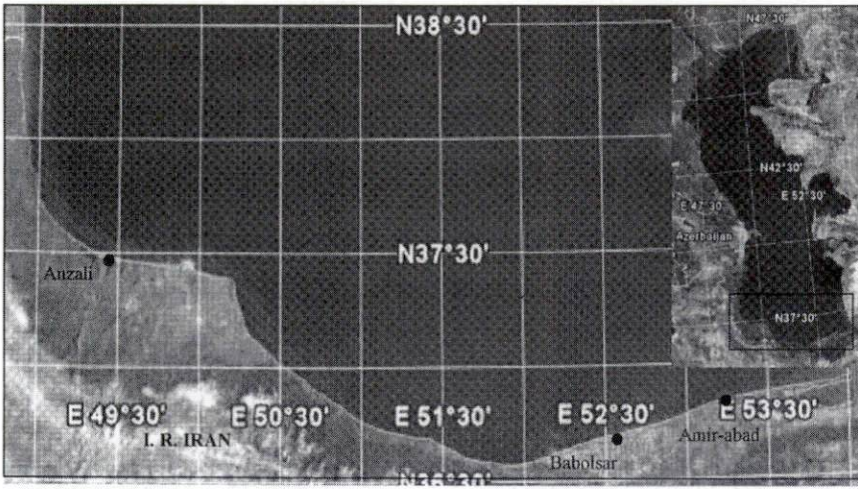

Figure 1: The Caspian Sea (insert) and three Iranian fishing regions of kilkas (Amir-abad, Babolsar harbors and Anzali port).
Source: http://earth.google.com/

Field sampling was conducted by staff of the Caspian Sea Ecology Research Center and Inland Waters Aquaculture Research Center from 1995 to 2004. After identification of the species, 50-200 specimens of common kilka were randomly selected in every fortnight in each province. The samples were moved to the laboratory for measurement. The samples were initially sorted into size bins according to 5mm (fork) length intervals. Then, the total weight (to the nearest 0.1g), sex and maturity stages of ovary were also determined. Maturity classification was carried out, based on six macroscopic stages in ovarian development (stage II is not ripe; stage III is almost ripe; stage IV is ripe; stage V is ripe and running and stage VI is spent) as defined by Biswas 1992.

The sagitta otoliths were removed from 1 to 83 sub-samples for each 5mm length interval up to a total of 735 otolith for common kilka during 1997-1999. To enhance contrast and to facilitate reading and interpretation of growth marks, the whole otolith was dipped in glycerol and observed under a stereo-microscope with reflected light against a dark background, so that alternating dark and white rings (hyaline and opaque, respectively) could be seen (Fig. 2).

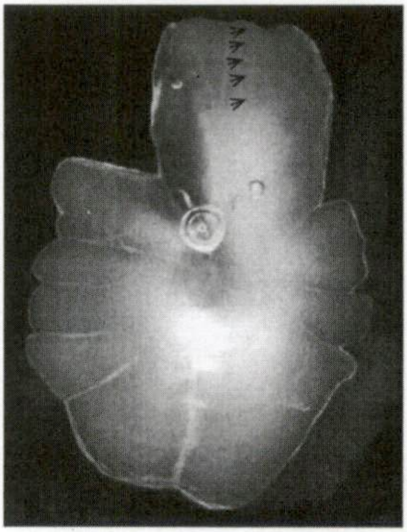

Figure 2: Whole embedded otolith of common kilka (98mm fork length). Arrows indicate opaque zones.

The length-weight relationship was calculated applying the exponential regression as the following equation:

$$W = aL^b \quad (1)$$

where W is the total weight (g) and L, the fork length (mm), and a and b are parameters to be estimated (Ricker, 1975). The condition factor (CF) of individuals was calculated from sub-samples following the equation (Bagenal, 1978):

$$CF = \frac{W}{L^b} \times 100 \quad (2)$$

Where W is the total weight (g), L is the fork length (cm) and b is the slope of length-weight relationship.

The von Bertalanffy growth curve (von Bertalanffy, 1938) was fitted to the observed length at age data for the resulting age-length key using the Ford-Walford method (Walford, 1946) as the following:

$$L_t = L_\infty (1 - e^{-K(t-t_0)}) \tag{3}$$

where L_t is the fork length at age t, L_∞ is the theoretical maximum length, K is a growth coefficient and t_0 is the hypothetical age for L_t=0.

For the estimation of the mean length at 50% maturity, a logistic function was fitted to the proportion of the mature individuals by size class using a non-linear regression. The function used was:

$$P = \frac{1}{1+e^{(-r(L-Lm))}} \tag{4}$$

where P is the mature proportion in each size class, r is a parameter controlling the shape of the curve and Lm is the size at 50% maturity (Saila *et al.*, 1988).

Survival rate (S) was calculated using the catch curve method to estimate terminal fishing mortalities. To estimate S, age compositions were derived from length composition data collected from the conical liftnet during 2000-2004, and age-length key in Iranian waters used as input data. These terminal mortalities were then used as input data for the biomass-based cohort analysis estimating biomass and fishing mortality. The instantaneous coefficient of total mortality (Z) was transformed from the survival rate as $Z=-\ln S$.

The instantaneous coefficient of natural mortality (M) was estimated using the ZM model (Zhang & Megrey, 2006) with von Bertalanffy growth parameters and a maximum age (t_{max}) of 7 for common kilka (Poorgholam *et al.*, 1996; Fazli & Besharat, 1998). The equation of ZM model is:

$$\hat{M} = \frac{\beta K}{e^{K(t_{mb}-t_0)} - 1} \tag{5}$$

where K is the growth coefficient, β the power parameter of the length-weight relationship, t_0 is the hypothetical age for L_t=0, and t_{mb} is the critical age, which can be estimated as: $t_{mb} = 0.302\, t_{max}$.

In general, age at first capture of a stock is estimated directly from fishing experiments, either by attaching a small-meshed net cover over the cod-end or from the size composition of the catches of nets of smaller meshes caught at the same time and place (Gulland, 1983). However, the Pauly method (1984), a length-converted catch curve, was used in this study.

A biomass-based cohort analysis (Zhang & Sullivan, 1988) was used to estimate biomass and instantaneous fishing mortality at age and by year according to the following model equations, assuming that catch is taken instantaneously at mid-year,

$$B_{ij} = B_{i+1,j+1} e^{(M-G_j)} + C_{ij} e^{(M-G_j)/2} \tag{6}$$

$$F_{ij} = \ln\left(\frac{B_{ij}}{B_{i+1,j+1}}\right) - M + G_j \tag{7}$$

where B_{ij} and $B_{i+1,j+1}$ are the biomass at age j and j+1 in year i and i+1, C_{ij} is the catch in weight at age j in year i, F_{ij} is the instantaneous coefficient of fishing mortality at age j in year i, M is the instantaneous coefficient of natural mortality, and G_j is the instantaneous coefficient of growth at age j. The catch in weight at age for the years 1995-2004, an instantaneous coefficient of growth at age, an instantaneous coefficient of natural mortality, and a terminal fishing mortality were used as input data. The instantaneous coefficient of growth at age (G_j) is calculated as the following equation:

$$G_j = \ln\left(\frac{W_{j+1}}{W_j}\right) \tag{8}$$

where, W_j and W_{j+1} are the body weight at age j and j+1, respectively.
The exploitation ratio (E) was estimated as the following equation:

$$E = \frac{F}{Z}(1 - e^{-Z}) \tag{9}$$

where F is the instantaneous coefficient of fishing mortality and Z is the instantaneous coefficient of total mortality (King, 1996).

Results

During the years 1995-2004 the fork length and weight of common kilka ranged from 40 to 125 mm and from 0.8 to 16.0g with averages of 91.7±10.16mm and 6.1±1.86g, respectively (Table 1). Based on otolith analysis, ages of common kilka were determined. Age compositions of catch were derived from the length composition data and age-length keys. The ages of common kilka ranged from 1 to 7 years. In the age compositions, age 3 was the largest age group during the years 1995-1998 and accounted for 31.5-41.3% of catches (Fig. 3). Age 2 was the largest age group during 1999-2000 and represented 40.2 and 46.0% of catches, respectively. During the years 2001-2002, age 3 was the largest age group and represented 39.0 and 37.1% of catches, respectively. In 2003 and 2004 the age 4 predominated, representing 31.5 and 41.35% of catches, respectively.

Table 1: Mean fork lengths (mm) and weight (g) of common kilka sampled in Iranian water of the Caspian Sea during the years 1995-2004

Year	N	Fork length (mm)		Weight (g)	
		Mean±SD	Min-Max	Mean±SD	Min-Max
1995	5,181	94.6±8.87	55-125	6.4±1.52	1.4-15.8
1996	7,953	98.6±6.42	45-125	7.5±1.20	1.0-16.0
1997	1,759	103.7±6.60	65-125	8.4±1.24	3.1-13.6
1998	970	87.3±12.38	55-125	4.9±1.76	1.4-10.2
1999	1,921	82.5±8.48	40-110	4.2±1.17	0.8-8.0
2000	1,440	81.5±6.77	55-110	3.8±0.84	1.5-7.5
2001	8,073	89.0±7.45	55-125	5.2±1.12	1.7-11.5
2002	4,359	87.0±9.07	45-115	5.2±1.17	0.9-10.0
2003	3,091	85.0±12.24	50-125	5.3±1.90	1.3-9.9
2004	4,776	93.8±8.19	65-115	7.4±1.87	0.8-16.0
Total	**39,523**	**91.7±10.16**	**40-125**	**6.1±1.86**	**0.8-16.0**

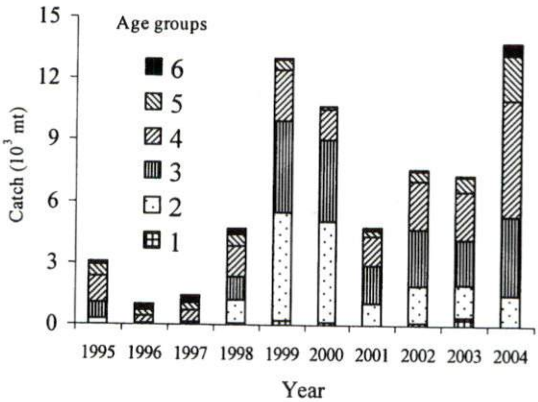

Figure 3: Age of common kilka in the Iranian commercial catches during 1995-2004.

The von Bertalanffy growth equation was estimated as (Fig. 4; Table 2):

$$L_t = 132(1 - e^{-0.259(t+1.285)})$$

The fork length and weight regression from all of the samples was:
W=0.000023$FL^{2.755}$ (R^2= 0.90, standard error of b=0.004);
W=0.000024$FL^{2.749}$ (R^2= 0.86, standard error of b=0.007) for female
W=0.000031$FL^{2.692}$ (R^2= 0.85, standard error of b=0.011) for male.

The slopes (b values) of the length-weight regressions were significantly different between sexes (t-test, t =159.8, P<0.001). The values of "b" for females was 2.749 and males was 2.692 (with 95% confidence of interval 2.735-2.763 and 2.670-2.714, respectively) were significantly different from 3.0 (t-test for males, t =1088.4, P<0.001 and for females, t =1113.5, P<0.001), indicating an allometric growth.

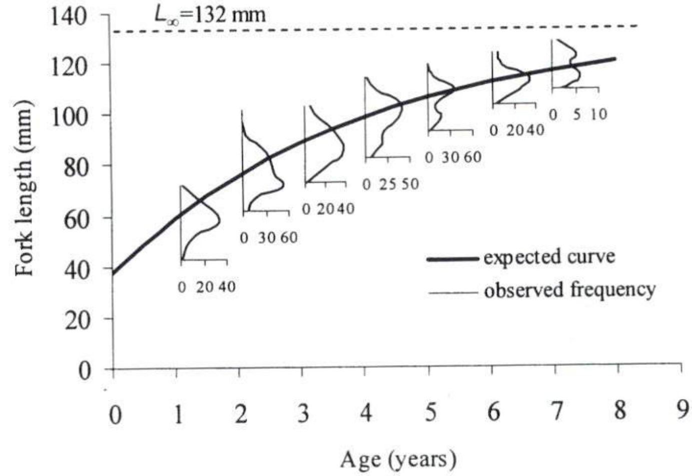

Figure 4: Theoretical growth curve for fork length of common kilka in the Caspian Sea

Table 2: Mean fork length and standard deviation and mean weight of common kilka in the Iranian waters of the Caspian Sea.

Size (mm)	Age group (year)							Total
	1	2	3	4	5	6	7	
n	95	183	145	140	76	78	18	735
$\overline{FL}$ (mm)	59.3	77.5	87.4	97.2	104.5	111.9	116.8	
S.D.	6.75	6.79	6.65	6.89	5.54	4.59	5.75	
$\overline{W}$ (g)	1.9	3.8	5.2	7.0	8.5	10.2	11.5	

Sex ratios varied among season. The sex ratio (male:female) was 0.47:1, for adult common kilka (n=30,984), which was significantly different from the expected 1:1 (χ^2=4039.8, P<0.001, Table 3). Female were more abundant in all months (except, in April male predominated; χ^2=29.9, P<0.001). Female compromised from 43.8 percent (April) to 91.3 percent (November) of the total samples. Female were most abundant in the all size classes (Fig. 5; P<0.001), except in the size class between 120-125 mm there was not significantly different (χ^2=2.7, P>0.102).

Table 3: Chi-square test for common kilka sex ratio comparisons by month in the Iranian waters of the Caspian Sea: samples were pooled for all years

Month	Males		Females		Total	χ^2	P
	No.	%	No.	%			
Jan	375	20.4	1465	79.6	1840	645.7	0.001
Feb	394	29.1	962	70.9	1356	237.9	0.001
Mar	884	32.0	1881	68.0	2765	359.5	0.001
Apr	1108	56.2	865	43.8	1973	29.9	0.001
May	915	35.5	1665	64.5	2580	218.0	0.001
Jun	2152	36.0	3825	64.0	5799	468.3	0.001
Jul	1717	38.8	2710	61.2	4427	222.7	0.001
Aug	1286	33.3	2571	66.7	3857	428.1	0.001
Sep	306	12.4	2171	87.6	2477	1404.2	0.001
Oct	62	9.3	604	90.7	666	441.1	0.001
Nov	51	8.7	533	91.3	584	397.8	0.001
Dec	648	26.1	1834	73.9	2482	566.7	0.001
Total	**9898**	**31.9**	**21086**	**68.1**	**30984**	**4039.8**	**0.001**

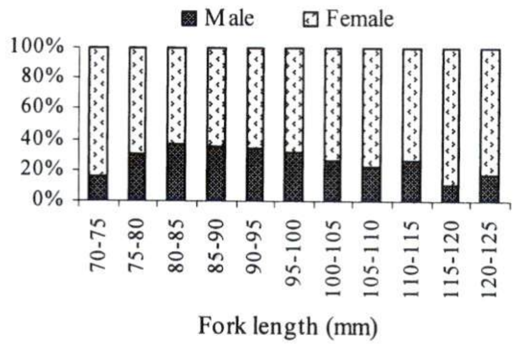

Figure 5: Sex structure of common kilka in the Iranian waters of the Caspian Sea

Condition factors of common kilka increased from 1995 to 1996, but declined to the lowest levels in 2000, and then increased from 2000 to 2004 (Fig. 6). Condition factors differed significantly among years ($P<0.001$). Condition factors also changed by month within years, declining to the lowest levels in July, and then increasing in November (Fig. 7).

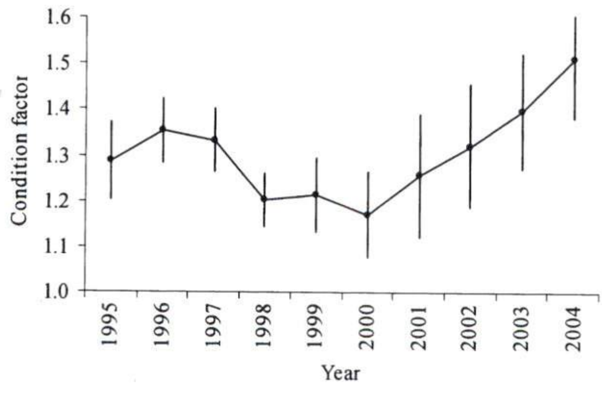

Figure 6: Condition factor (mean±SD) of common kilka in the Iranian waters of the Caspian Sea, during 1995-2004 (samples polled for all months).

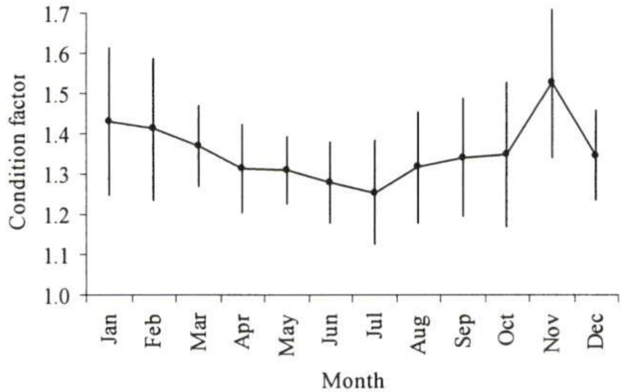

Figure 7: Monthly condition factor (mean±SD) of common kilka in the Iranian waters of the Caspian Sea (samples polled for years 1995-2004).

Monthly variation of ovarian maturity stages of common kilka showed that the proportion of the specimens with maturing but unripe ovaries exceeded 95 percent from September to January (Fig. 8a), but the proportion declined to less than 14 percent in May, and lowest values of immature fish occurred in this month. These analyses showed that reproduction of common kilka started in March and peaked in May (Fig. 8a) and finished at the end of August. Fig. 8b shows the size class variation of ovarian maturity stages in May. The maturity ogive for female of common kilka showed that 50% of samples were sexually matured at a fork length of 84.3mm (Fig. 9).

Based on catch curve method, the annual survival rate (S) of common kilka was estimated to be 0.200/year. Given this survival rates, the instantaneous coefficient of total mortality (Z) of common kilka was calculated to be 1.62/year. Estimates of the instantaneous coefficient of natural mortality for common kilka obtained from the ZM method (Zhang & Megrey, 2006) was 0.506/year.

The age at first capture (t_c) of common was estimated to be 2.80 years from the length converted catch curve of the Pauly (1984) method (Fig. 10).

We calculated biomass and recruitment of common kilka from the biomass-based cohort analysis (Fig. 11). The total biomass started to increase from about 16,000mt in 1995 to more than 41,000mt in 2002 and declined to less than 28,000mt in 2004. During this period, the average biomass of age 2 represented the highest proportion of total biomass at 30.95% (9,361mt), followed by the age 1 biomass (26.66%) and age 3 biomass (23.28%). Annual changes in the instantaneous coefficient of fishing mortality had a high C.V. (Coefficient of Variation) of 0.63 during 1995-2004. During the years 1995-2004 the exploitation rate of common kilka varied between 0.092 to 0.644 (Table 4).

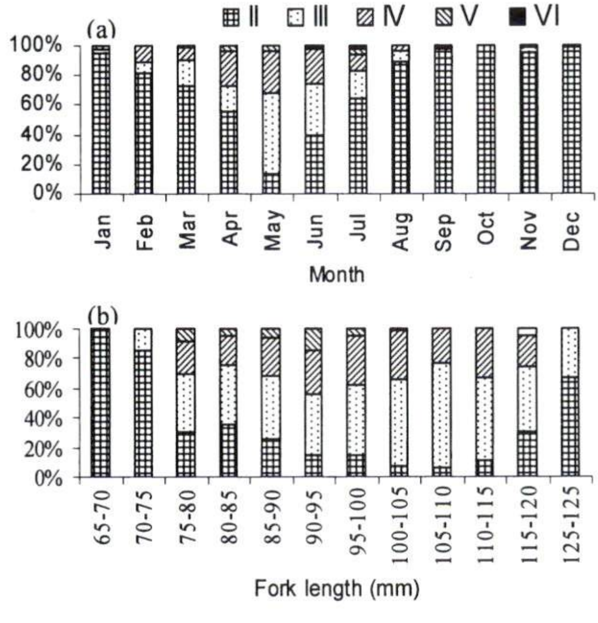

Figure 8: Monthly (a) and size class (b) variation of ovary stages of common kilka in the Iranian waters of the Caspian Sea (stage II is not ripe; stage III is almost ripe; stage IV is ripe; stage V is ripe and running and stage VI is spent) during 1995-2004.

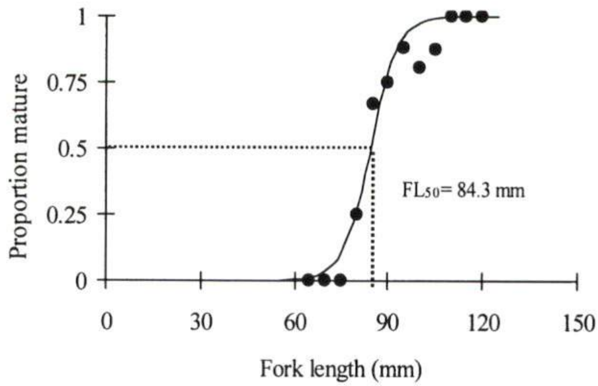

Figure 9: Maturity ogive showing length maturity of common kilka from the Caspian Sea

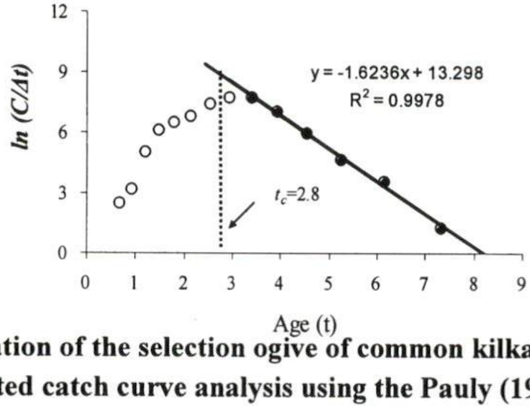

Figure 10: Estimation of the selection ogive of common kilka from length-converted catch curve analysis using the Pauly (1984) method

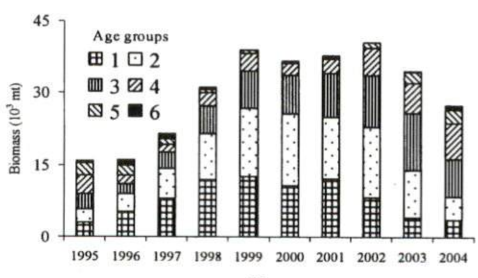

Figure 11: Biomass at age of common kilka in the Iranian commercial catches during 1995-2004

Table 4: Estimated instantaneous fishing mortality and exploitation rate of common kilka in the Caspian Sea during 1995-2004

Parameters		Year									
		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	1	0.004	0.000	0.000	0.008	0.015	0.015	0.000	0.012	0.087	0.056
	2	0.112	0.003	0.002	0.124	0.484	0.484	0.089	0.135	0.180	0.382
F_{ij}	3	0.328	0.042	0.042	0.253	0.984	0.984	0.258	0.339	0.233	0.778
	4	0.446	0.256	0.455	1.050	1.599	1.599	0.763	0.625	0.557	1.737
	5	0.301	0.183	0.634	2.111	3.141	3.141	1.629	1.023	0.461	2.517
	6	0.786	0.263	0.464	1.421	2.696	2.696	1.248	1.013	1.230	1.094
Mean F		0.330	0.125	0.226	0.828	1.487	0.711	0.664	0.524	0.458	1.094
E		**0.223**	**0.092**	**0.186**	**0.457**	**0.644**	**0.411**	**0.392**	**0.327**	**0.294**	**0.546**

Discussion

Age composition of common kilka has been estimated by scales and otoliths. Our analysis of age composition of common kilka using otoliths showed seven age groups from 1 to 7. Besharat and Khatib (1993) examined age readings using scales. They found that common kilka captured with commercial fishing gear varied from ages 1^+ to 5^+. A problem using scales of common kilka is their loss during handling (personal observations). However, there may be other problems with age determination using scales of older common kilka because the intra-annulus size increment is small, and can be missed, resulting in an under-estimate of age in older fish. Poorgholam *et al.* (1996) and Fazli and Besharat (1998) reported that common kilka (captured by mid-water trawl) consisted of seven age groups (from 1 to 7). Our results are consistent with these earlier observations. Before forming the hyaline zone, there may be some false annuli, which are weak or incompletely formed. With increasing age, common kilka deposits relatively little calcium on the posterior edge of the otolith, although there is adequate deposition for clear annulus detection on the rostrum. Therefore, otoliths from older fish may exhibit fewer visible annuli on the posterior edge relative to the rostrum. Alternatively, annuli may be so closely spaced on this part of the otolith that it is difficult to distinguish among them.

There are no pervious estimates on growth rates and instantaneous natural mortality of common kilka. The present study showed that the growth rate of common kilka was high for the first year of life and then gradually decreased (Table 2). The estimated value of $L\infty$ for common kilka was higher than observed L_{max}, and in agreement with a formula which suggested by Taylor (1960); Mathews and Samuel (1990) that: $L_{max} \approx 0.95\ L\infty$. The instantaneous coefficient of natural mortality obtained from the ZM method (Zhang and Megrey, 2006) was 0.506/year. The exponent of the length-weight relationship (pooled data: b=2.755) showed that growth allometric. This value is close to that found by Besharat and Khatib (1993).

The overall ratio of males to females (male:female) was 0.47:1, which was significantly different from 1:1, and there was a seasonal difference in sex ratios of the catches. This value was close to the ratio of 0.37:1 found by Besharat and Khatib (1993) who collected samples from 1990-91 using conical liftnet with underwater electric light. Fazli and Besharat (1998) reporting on samples collected by mid-water trawl, found that sex ratios varied from 0.18:1 to 0.65:1 (Table 5). These results confirm that the behaviour of females change with respect to underwater electric lights during the year. Between-sex differences in seasonal attraction to light may explain some of the intra-annual variation in our analysis. Ben-Yami (1976) reported that there were different responding behaviours of fish to light. A key hypothesis is that fish are attracted to light to feed. It is well-known that artificial light attracts many aquatic organisms (Maëda, 1951) and perhaps the motivation for attraction is related to increased prey density within the lighted area. With the development of the gonads, females appear to be less attracted to light. As they approach spawning time, they cease feeding and disappear from the catches. In the case of males, they continue to feed during spawning and it seems that their response to light remains unchanged (Ben-Yami, 1976). Therefore, some spatial segregation occurs between the sexes. In contrast, the Caspian Sea Biodiversity Database (CSBD; www.caspianenvironment.org, cited March 2006) reported that the proportion of males in the North Caspian population was high (69.5%) in all age groups. The CSBD also stated that the long-term sex ratio in the South Caspian population was close to 1:1. The CSBD did not describe details on methods of capture, and we have no explanation for the differences between our results and those presented in the CSBD.

Table 5: Sex composition of common kilka collected from 1996 to 1997 by mid water trawl in the Iranian coastal zone of the Caspian Sea

Month	N	Sex		Male:Famale ratio
		Male (%)	Female (%)	
July-August 1996	1895	39.3	60.7	0.65:1
December 1996	1554	30.2	69.8	0.43:1
February-March 1997	1923	28.5	71.5	0.39:1
April-May 1997	1135	15.0	85.0	0.18:1

During the spawning season, the monthly average condition factor of common kilka was lowest in April-July. After spawning, in the middle of summer and autumn, the condition factor increased (Fig. 7). Mean condition factor declined after 1996 reaching its lowest level in 2000. After 2000, condition factor increased (Fig. 6). These changes occurred as an invasive species, the ctenophora *Mnemiopsis* entered the Caspian Sea (Ivanov *et al.*, 2001). It feeds aggressively on zooplankton, fish eggs and fish larvae (Tsikhon-Lukanina *et al.*, 1993; Mutlu, 1999). Kideys *et al.* (2001a and 2001b); Kideys and Moghim (2003); Kideys *et al.* (2005) reported that because *Mnemiopsis* is a voracious predator on zooplankton, the availability of food for zooplanktivorous kilka species (*Clupeonella spp*) declined significantly in 2001. They further suggested that the reduction in zooplankton was responsible for the apparent decline in kilkas. Our analyses, however, indicated that the explanation for the decline of kilka species is more complex. For instance we found that condition factor of common kilka increased after 2000, after *Mnemiopsis* entered the Caspian Sea, and especially during 2003-2004 (Fig. 6).

Our analyses showed that reproduction of common kilka started in March and peaked in May (Fig. 8a). Abtahi *et al.* (2002) reported a similar result with peak spawning in Iranian waters of the Mazandaran Province in April-May. As has been found in other studies (Badalov, 1972; Prikhod'ko, 1979), the main spawning of common kilka occurs in depths less than 10m, away from the main fishing ground. Because of this phenomena, the abundance of female common kilka at ovarian maturity stages of ripe-running and spent was very low (Fig. 8).

Our analyses showed that during 1995-1997 the biomass of common kilka ranged from 16 to 22 thousand mt. During investigations to estimate the biomass of kilkas by hydro-acoustic methods, conducted in 1995 (Poorgholam *et al.*, 1996) and during 1996-1997 (Fazli & Besharat, 1998), the annual biomass of common kilka was estimated to be about 48 and 23 thousand mt in Iranian waters of the Caspian Sea, respectively. Subsequently the biomass of common kilka increased to about 41 thousand mt in 2002 (Fig. 11). Karpyuk *et al.* (2004) reported that after the *Mnemiopsis* impact on the Caspian Sea, only the stock of common kilka remained stable. Reproduction of common kilka occurs in the Northern Caspian Sea, outside the area of development of *Mnemiopsis*, although the survey area explained by Karpyuk *et al.* (2004) was different and they did not describe their assessment method.

The changes in the abundance of common kilka could be explained as follows. Three species of kilkas feed on zooplankton but there are substantial differences in their food composition. The food of common kilka is the most diverse which is consistent with the heterogeneous zooplankton composition of the coastal zone (Prikhod'ko, 1981). When *Mnemiopsis* appeared in the Caspian Sea, the species composition of meso- and macrozooplankton in the middle and southern areas declined drastically and *Eurytemora* and other copepods, was replaced by another copepod, *Acartia* sp (Karpyuk *et al.*, 2004; Rowshantabari & Roohi, 2004). Therefore, it seems that there are two probable explanations for the increases in condition factor and biomass of common kilka. First, the *Mnemiopsis* did not have a direct impact on the main food of common kilka. Second, after the *Mnemiopsis* appeared in the Caspian Sea, the biomass of anchovy kilka which was accounted for about 70% of total biomass of kilkas in the Caspian Sea (Poorgholam *et al.*, 1996; Sedov *et al.*, 1997; Fazli & Besharat, 1998), but soon decreased by a factor of about 10 (Karpyuk *et al.*, 2004; Fazli *et al.*, 2006). Therefore a decline in density-dependent, intra-specific composition among kilka species is another explanation.

Our results showed that, during the years 1995-2004 the exploitation ratio was <0.5 (except, in 1999 and 2004 it was 0.644 and 0.546, respectively). This is lower than rate of 0.5, suggested by Gulland (1983), as the theoretical exploitation rate that could maximize harvest. In most instances, this theoretical rate has proved to be high, and not sustainable. We concluded that the stock of common kilka was being over-fished during the last year (2004) of our study.

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