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Full Length Research Paper

Distribution and size structure of comb jellyfish, *Mnemiopsis leidyi* (Ctenophora) in the southwestern Caspian Sea

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Temporal and vertical distributions of *Mnemiopsis leidyi* were studied along three transects namely Lisar, Anzali and Sephidrood in the southwestern Caspian Sea during 2001 to 2010. The maximum lengths of the ctenophore were 60 to 70 mm, and bulk of individuals (90.6%) were <5 mm in length. The means of abundance and biomass during the whole period were 3032 ind/m^2 and 293.54 g/m^2, respectively. The highest average abundance value (1017 ind/m^2) was measured in summer 2006 and the lowest abundance value (54 ind/m^2) was in spring 2010. The average biomass of *M. leidyi* ranged between 1175.40 and 0.85 g/m^2 in summer 2005 and winter 2008, respectively. The highest annual of abundance and biomass were obtained in 2005 and 2006. The dominant of *M. leidyi* bulk occurred above 20 m depth, whilst the ctenophore population sharply decreased below 20 m. The seasonal pattern of *M. leidyi* is related to water temperature, as evidenced from the positive correlation between the water temperature and *M. leidyi* population.

Key words: *Mnemiopsis leidyi*, abundance, biomass, size, Caspian Sea.

INTRODUCTION

The Caspian Sea is the largest inland water body on earth; it is located at the far end of southeastern Europe, bordering Asia (Kosarev and Yablonskaya, 1994). Approximately, 130 rivers with various sizes drain into the Caspian Sea. With an average annual input of about 300 km^3, the river Volga contributes up to 82% of the inflow (Dumont, 1998). The south of Caspian Sea receives more than 100 rivers, the Sephidrood is the largest river with 67,000 km^2 catchment area and discharge of 4,037 million m^3 (Lahijani et al., 2008; Bagheri et al., 2012a). The Caspian Sea is known for its traditional sturgeon fishery and in particular the caviar industries, it also supports a large scale pelagic fishery that is mainly made up of three small pelagic fish species of the kilka (*Clupeonella cultriventris*, *C. engrauliformis* and *C. grimmi*); the biological diversity of the Caspian Sea and its coastal zone makes the region one of the most valuable cosystems in the world (Shiganova, 2002). The native habitats of the ctenophore, *M*. *leidyi*, are temperate to subtropical estuaries along the Atlantic coast of North and South America. In the early 1980s, it was accidentally introduced in the Black Sea, where it flourished and expanded into the Azov, Marmara,Mediterranean seas (Purcell et al., 2001). The possibility of *M. leidyi* introduction into other sensitive, neighboring ecosystems, notably the Caspian Sea, had been mentioned during the GESAMP meeting in 1994. As expected, this ctenophore was reported to be present in the Caspian Sea by November 1999 (Esmaeili et al., 1999; Ivanov et al., 2000). Ivanov et al. (2000) suggested that this ctenophore was transported via ballast water

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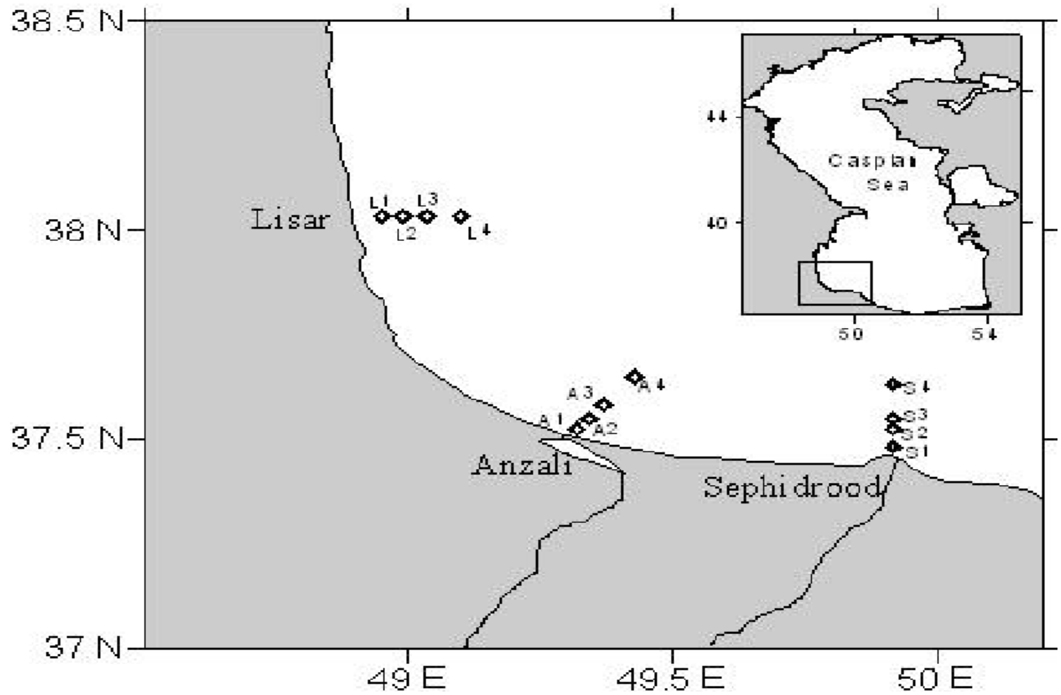

Figure 1. Sampling transects in the southwestern Caspian Sea during 2001 to 2010.

taken aboard either in the Black Sea or the Sea of Azov (where *M. leidyi* occurs in the warm months) and released after ballast-loaded ships passed through the Volga Don Canal and the shallow freshwater areas of the northern Caspian Sea into the saltier central or southern Caspian waters. This species invasion was the start of one of the most important anthropogenic problems the Caspian Sea ecosystem has ever experienced (Bagheri et al., 2012a).

Following the introduction, a few basin-wide surveys were undertaken to understand the distribution of *M. leidyi* in the Caspian Sea (Shiganova et al., 2001a; Kideys, 2002). Investigations of the new invader to the Caspian Sea in 2000 to 2001 showed that it was found almost everywhere, including the northwestern Caspian, where salinity exceeded 4 ppt (Shiganova et al., 2003).

There was an increasing trend in the abundance of *M*. *leidyi* in 2001 compared to 2000. The average and maximum biomass of *M*. *leidyi* over the entire middle and southern Caspian Sea were as high as 120 and 351 g wet weight (WW) m^{-2}, respectively, compared to a mean value of 60 g/m^2 in the summer of 2000 (Shiganova et al., 2001a; Kideys and Moghim, 2003). Furthermore, Roohi et al. (2008, 2010) documented the seasonal fluctuation of *M. leidyi* in the southern Caspian Sea from 2001 to 2006. The authors concluded that the total number and biomass of *M. leidyi* decreased to a certain extent in the years after 2003. Recently, Kideys et al. (2008) and Roohi et al. (2010) reported, the introduction *M. leidyi* have played important role in the variation of phytoplankton composition and decrease of zooplankton population after 2000.

Although a few *M. leidyi* studies have been conducted on the Caspian Sea in recent years (Ivanov et al., 2000; Shiganova et al., 2001a, b; Kideys and Moghim, 2003; Roohi et al., 2008, 2010), there is no adequate survey on the *M. leidyi* community in the southwestern Caspian Sea and at present, only a few publications on the *M. leidyi* are found (Bagheri and Kideys, 2003; Bagheri and Sabkara, 2003; Bagheri, 2006; Bagheri et al., 2010,2012a) for this region. This study intended to evaluate the distributions of *M. leidyi* abundance and biomass, and size structure in the southwestern Caspian Sea during July 2001 to October 2010, furthermore this study also intended to evaluate interactions between *M. leidyi* density, size structure and water parameters in the southwestern Caspian Sea.

MATERIALS AND METHODS

In this study, spatial and temporal distributions of *M. leidyi* were studied along three transects namely Lisar, Anzali and Sephidrood in the southwestern of Caspian Sea during 2001 to 2010; each transect had four stations located at depth 5 m (L1, A1 and S1), 10 m (L2, A2 and S2), 20 m (L3, A3 and S3) and 50 m (L4, A4 and S4) contours (Figure 1). The distance between stations differed among transects (Table 1).

Sample collections at all transects were accomplished on the same day using a speed boat. Sampling was planned at monthly intervals, however, due to certain metrological problems, no sampling could be done for some months during the period of 2001 to 2010, as shown in Table 2.

Table 1. Sampling region and stations in the southwestern Caspian Sea during 2001 to 2010.

Region	Station	Depth (m)	Latitude	Longitude	Distance from shore (km)
	L1	5	48° 51' 42"	38° 02' 21"	2
Lisar	L2	10	48° 58' 30"	38° 04' 51"	9
	L3	20	49° 04' 21"	38° 03' 40"	16
	L4	50	49° 11' 30"	37° 59' 34"	26
	A1	5	49° 29' 31"	37° 29' 00"	1
Anzali	A2	10	49° 28' 59"	37° 29' 20"	3
	A3	20	49° 29' 43"	37° 30' 30"	6
	A4	50	49° 28' 37"	37° 35' 07"	15
	S1	5	49° 56' 00"	37° 28' 08"	2
Sephidrood	S2	10	49° 55' 20"	37° 29' 42"	4
	S3	20	49° 54' 59"	37° 30' 31"	6
	S4	50	49° 55' 16"	37° 31' 29"	10

Table 2. Sampling frequency in the southwestern Caspian Sea during 2001-2010.

Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001							*	*	*	*	*	*
2002	*			*	*	*	*	*	*			
2003	*			*		*	*	*		*	*	*
2004		*		*	*		*		*	*	*	
2005		*			*		*	*	*		*	*
2006		*			*		*	*	*	*		*
2008		*			*		*				*	
2009							*				*	
2010	*		*							*		

Water samples were collected using a 1.71 L Nansen water sampler (Hydro–Bios, Germany; TPN; Transparent Plastic Nansen water sampler, No: 436201), and water temperature levels of the seawater at 5, 10, 20 and 50 m depth were measured *in situ* by using a reverse thermometer (Hydro–Bios, TPN). Salinity was estimated using a salinometer (Beckman; RS–7B, U.S. Patent, No: 2542057). At each station, water transparency was measured with a Secchi disk at each depth. *M. leidyi* populations were sampled using a 500 µm mesh sized closing plankton net having a diameter of 50 cm with a large cod-end (volume 1000 ml) suitable for the collection of ctenophores (Kideys et al., 2001). Samples were obtained via vertical towing from the bottom to the surface for all stations except the deepest stations.

At the deepest stations, due to the existence of thermocline, two vertical wings were carried out: from 50 m to 20 m and from 20 m to the surface. At the end of each tow, the net was washed from the exterior, and the cod end was passed into a container immediately to enumerate ctenophores by naked eye. The abundance of *M. leidyi* per unit area (that is, m^2) was calculated from the diameter of the net and the tow depth. The ctenophores were sorted based on their length groups of 0 to 5, 6 to 10, 11 to 15 mm and so on for determining the abundance of different size groups. A total of 179,000 individuals were measured and grouped in this way. Individual weighting of these animals was not practical at sea. Therefore, weights of these animals were calculated from an equation which was obtained from individual lengths (with lobe using a ruler) and weight measurements (using a digital balance with a sensitivity of 0.001 g) of 269 individuals obtained from the different depths in July 2001: $W = 0.0013 \times L^{2.33}$ where W is wet weight of *M. ledyi* in g and L is the length in mm (Bagheri and Kideys, 2003).

Statistical comparisons between months were made by using statistical (Statsoft) software SPSS version 15 for Windows. Analysis of variance comparisons (One-way ANOVA) for water parameters and nonparametric test (Kruskal–Wallis) for *M. leidyi* abundance and biomass were used to identify the importance of variables between different seasons and years. Spearman rank correlation coefficients (r) were calculated to evaluate the relationships between *M. leidyi* number biomass and water parameters.

RESULTS

No differences were noted in the spatial distribution of *M. leidyi* and water parameters among the three transects of Lisar, Anzali and Sephidrood during 2001 to 2010

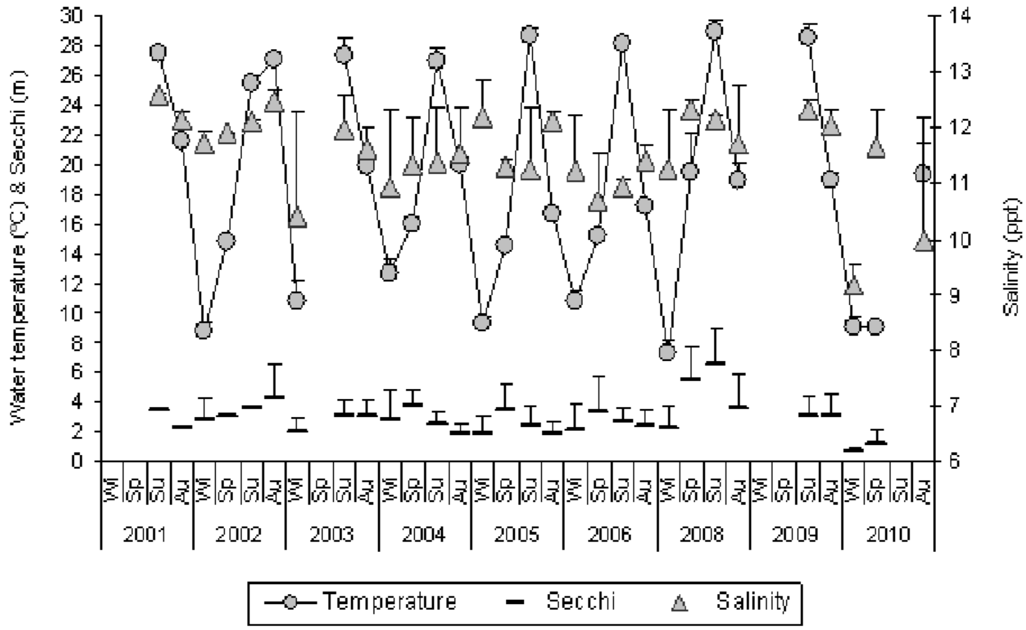

Figure 2. The average (±SD) surface water temperature, salinity and secchi depth at three transects and all stations in the southwestern Caspian Sea during 2001-2010. Wi, Winter; Sp, spring; Su, summer; Au, autumn.

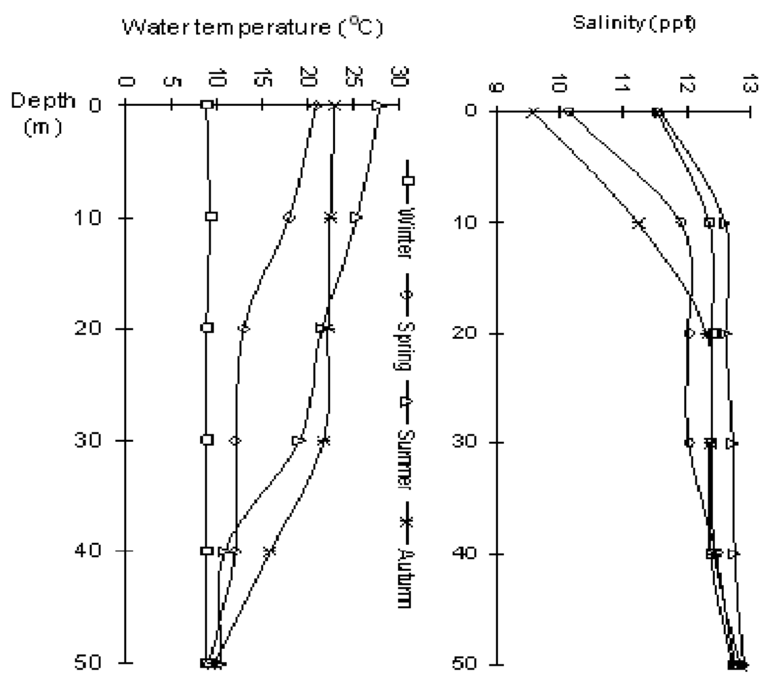

Figure 3. Vertical profiles of water temperature and salinity at Anzali transect (50 m depth) in the southwestern Caspian Sea in 2004.

(abundance: Df=2, p = 0. 285; biomass: Df= 2, p = 0.324. Therefore, the data of the three transects were combined per year and season. The sea-surface temperature distribution during the study period is showin Figure 2. The sea-surface temperature ranged between 7.4 and 29.0°C during 2001 to 2010. Differences in temperature variations among the years were not significant (p > 0.05) while there was a significant difference among seasons (p < 0.05). Seasonal stratification patterns were similar throughout the study period as shown in Figure 3. Here, different seasons in 2004 were chosen as representative (Figure 3).The thermocline started to form in summer and

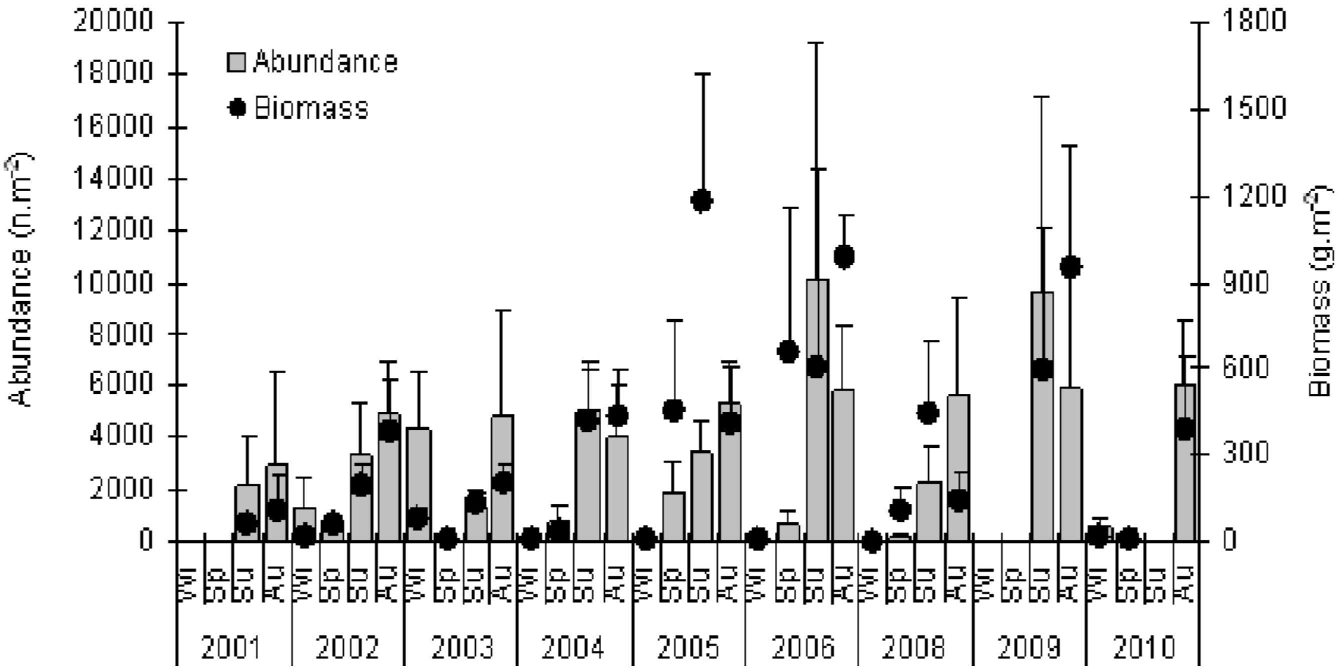

Figure 4. The average (±SD) of *M. leidyi* abundance and biomass at three transects and all stations in the southwestern Caspian Sea during 2001-2010. Wi, winter; Sp, spring; Su, summer; Au, autumn).

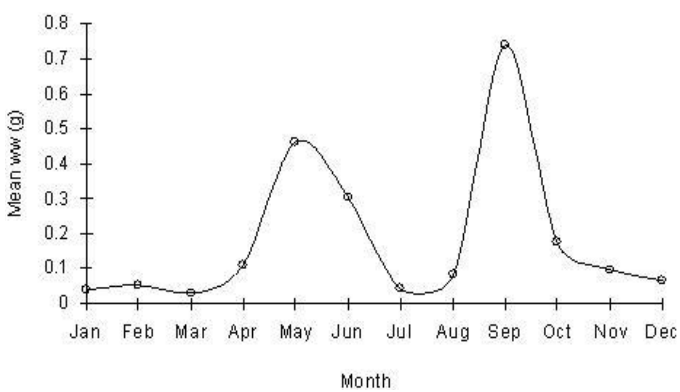

Figure 5. *M. leidyi* mean wet weight in the southwestern Caspian Sea during 2001-2010.

autumn at around 30 m depth. The sharpest thermocline was observed in summer. The halocline present all year round is sharpest in winter. The average salinity of all surface stations (10.68 ± 1.01 ppt) was lower than at 50 m depth (12.79 ± 0.07 ppt; Figure 3). There were increasing and decreasing trend in the average surface salinities from winter to spring (9.1 to 10.7 ppt) and summer to autumn (10.9 to 9.9 ppt), respectively (Figure 2). These variations could be related to fresh water input from rivers during different seasons. However, average salinities were not significantly different between seasons ($p > 0.05$), but there were meaningful difference between years ($p < 0.05$). The Secchi disk depth, being an indicator of water turbidity, changed from 0.7 to 6.6 m during the study period with an overall average of 2.9 ± 1.7 m. The Secchi disk depth has fluctuations during 2001 and 2010 (Figure 2), and was significantly different only between years ($p < 0.05$). *M. leidyi* was present at all regions, depths and seasons studied. There was a seasonal succession of ctenophore densities every year, with the maximum being observed in summer and the minimum density in winter. A positive correlation was found between water temperature and abundance (r = 0.86) and biomass (r = 0.80) of *M. leidyi* (p < 0.01). There was no significant correlation between the biomass of *M. leidyi* and salinity (r = -0.14, p > 0.05). Figure 4 shows changes in the abundance and biomass of *M. leidyi*. The highest values of abundance and biomass were obtained in 2006 and 2005, respectively.Statistical nonparametric test (Kruskal–Wallis) showed that *M. leidyi* abundance and biomass were not significantly different between the years ($p > 0.05$), however, the difference between abundance and biomass *M. leidyi* were significant among the sampling seasons ($p < 0.05$). The highest abundance value (10117 ind/m^2) was measured in summer 2006 and the lowest abundance value (54 ind/m^2) was in spring 2010 (Figure 4). The biomass of *M. leidyi* ranged between 0.85 and 1175.4 g/m^2 during the study period in the southwestern Caspian Sea (Figure 4). The abundance and biomass values of ctenophore were low during winter and early spring, and gradually increased during summer and autumn (Figure 4). The means of abundance and biomass during the whole study period were 3032 ind/m^2 and 293.54 g/m^2, respectively. Minimum mean weight of specimens in the population

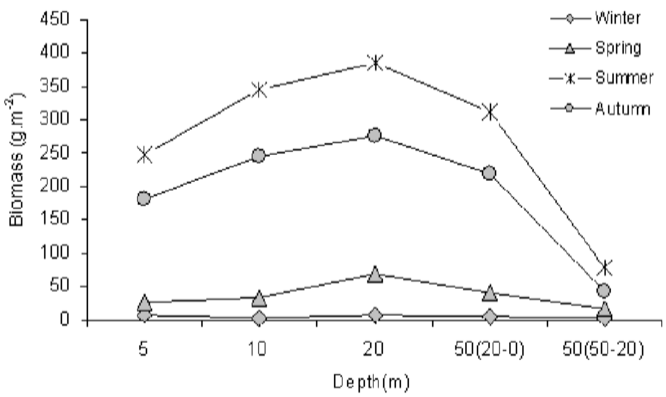

Figure 6. Temporal distribution of *M. leidyi* biomass in different seasons and depths in the southwestern Caspian Sea in 2004. Winter, spring, summer and autumn seasons were represented by February, May, July and November, respectively.

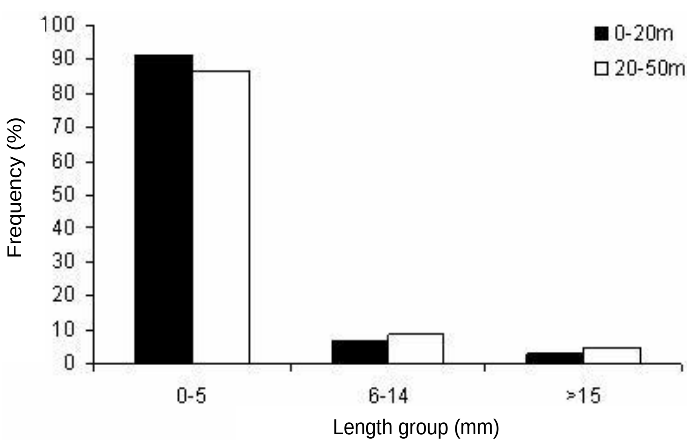

Figure 7. Comparison of size frequencies of the *M. leidyi* population from two layers in the southwestern Caspian Sea during 2001-2010.

was observed in March with a value of 0.03 g. There were two biomass increases after this period. Somatic growth appeared to take place from April to June and from August to September all years (Figure 5), when maximum increase in the weights of specimens were recorded (almost 15-fold). Seasonal stratification patterns were similar in all years and at all stations.Thus, year 2004 was chosen as representative to observe the vertical and seasonal distribution of *M. leidyi*.The highest *M. leidyi* biomass occurred at 20 m depth.The ctenophore population sharply decreased below 20 m depth. The lowest biomass values of *M. leidyi* were observed at the deeper layer (50 to 20 m depth) (Figure 6). *M. leidyi* biomass significantly varied vertically (p <0.05).

During the entire study period, a total of 179,000 specimens were sampled and individually measured for their body length. The length-frequency distribution displayed that whilst 90.6% of the population belonged to the 0 to 5 mm group, only 6.4% were from 6 to 14 mm length group (Figure 7). Thus, these larvae and juveniles made up 97% of the total population. The largest size that the ctenophore could attain in southwestern Caspian Sea was 60 to 70 mm, which was measured in September 2006. The length-frequency distributions of *M. leidyi* from 0 to 20 and 20 to 50 m depth are presented to understand the vertical distribution of ctenophores with respect to their size. In both layers, small ctenophores (< 5 mm) dominated the *M. leidyi* population (Figure 7), they comprised 91.16% (at 0 to 20 m depth) and 86.62% (at 20 to 50 m depth) of total abundance. However, ctenophores from the deeper layers had larger size compared to those from shallower depths. This indicates that mainly larger individuals penetrate through the thermocline to dwell in deeper waters. Despite the larger animals' ability to penetrate into deeper waters, the majority of ctenophores still remained at the surface waters. The larger specimens were observed more often during April to June (mid spring-early summer) compared to other months (Figure 8).

DISCUSSION

The variations in surface temperatures were between 7.4 and 29.0°C during 2001 to 2010 in the southwestern Caspian Sea (Figure 2). Dumont (1998), Kideys and Moghim (2003), Roohi et al. (2008), and Bagheri et al. (2010,2011,) reported that in the southern Caspian Sea, the maximum and minimum temperatures are 28 to 29 and 7 to 8°C in summer and winter, respectively. Kideys and Moghim (2003), Bagheri et al. (2012 a,b), and Zaker et al. (2007) noted that in the summer and autumn, thermocline was located between 20 and 40 m depths in the southern Caspian Sea; also they reported the depth of the mixed layer was not the same as in the Caspian. In this study, the thermocline started to form in summer and autumn at 30 m depth; the sharpest thermocline was observed in summer (Figure 3).

In additions, the variation of thermocline thickness could be related to meteorological monthly fluctuations during 2001 to 2010 in the southwestern Caspian Sea. Our findings are similar to Shiganova et al. (1998),Zaker et al. (2007) and Bagheri et al. (2012c) who reported stratification is dependent on weather conditions in the Black Sea and Caspian Sea.

There were increasing (winter-spring) and decreasing (summer-autumn) trends in the average surface salinities(Figure 2). This trend is related to fresh water inputs from rivers during seasons. Bagheri et al., (2010, 2011, 2012c) noted there was a strongly negative correlated between salinity and freshwater discharge via rivers in southwestern Caspian Sea. In additions, our findings are similar to the previous findings reported by Kosarev and Yablonskaya (1994), Dumont (1998), Purcell et al. (2001), Kideys and Moghim (2003), Zaker et al. (2007), and Roohi et al. (2008). The variations of fresh water input from Lisar and Sephidrood rivers as well as

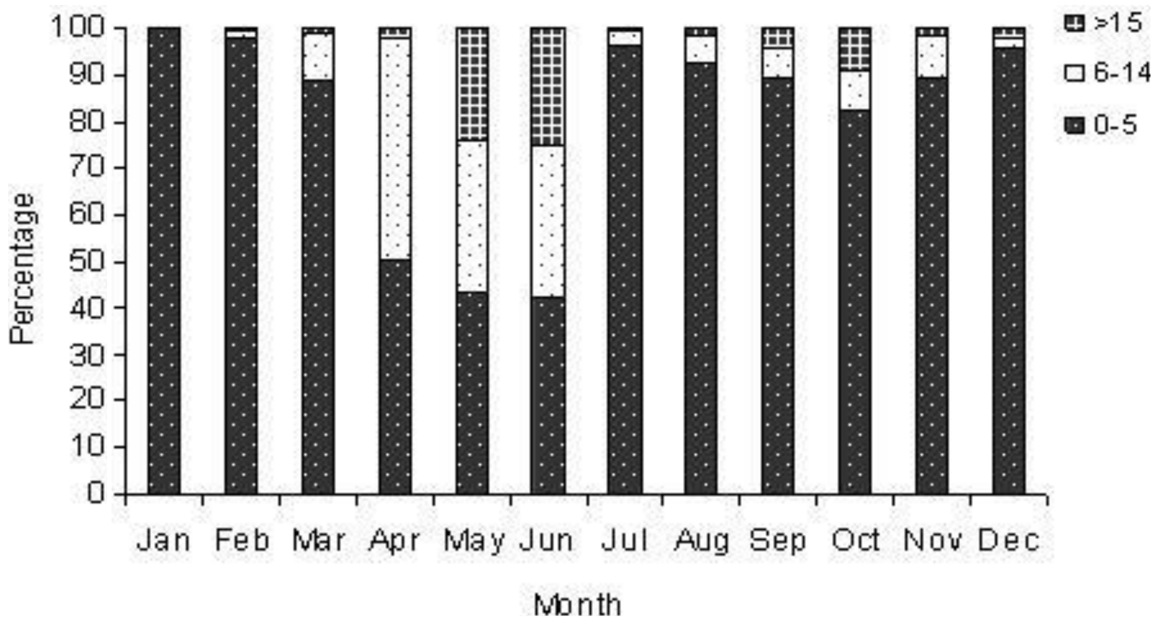

Figure 8. Percentage of *M. leidyi* size (mm) frequency in different months in the southwestern Caspian Sea during 2001-2010.

Anzali wetlands varied; the primary productivity in the southwestern Caspian, subsequently affected the Secchi depth readings in our study (Figure 2). Khodaparast (2006) and Bagheri et al. (2012b) reported that near the southwestern Caspian coasts, chlorophyll *a* levels increased from 0.56 to 1.34 µg/L in 1994 and 2.71 to 35.25 µg/L in 2006. Recently, Kideys et al. (2008) and Bagheri et al. (2012c) also noted that after 1999, satellite derived chlorophyll *a* levels gradually increased and reached extremely high levels of 9.26 µg/L in 2008.In the Black Sea, *M*. *leidyi* was usually found in the upper mixed layer, or in and above the seasonal thermocline, with only a few individuals found in deeper layers with low oxygen concentrations (Vinogradov et al., 1989; Bogdanova and Konsoulov, 1993; Mutlu, 1999; Kideys and Romanova, 2001). The reasons for the scarcity of ctenophores below the thermocline (of which the lower boundary is 25 to 50 m) in the Black Sea have been suggested to be low concentrations of food and temperature (Kideys and Romanova, 2001). Despite the fact that *M. leidyi* is known to display wide salinity and temperature tolerance (Kideys and Niermann, 1994). Bagheri and Kideys (2003), Kideys and Moghim (2003), Roohi et al. (2008) and Bagheri et al. (2012a) observed that *M. leidyi* is distributed generally above the thermocline in the Caspian Sea. *M*. *leidyi* inhabits mainly the surface layer from 0 to 15 to 25 m, and above seasonal thermocline (Purcell et al., 2001). The present study confirms that *M. leidyi* prefers surface waters or above the thermocline in the Caspian Sea (Figures 3 and 6).

In our study, the abundance and biomass values of *M. leidyi* were low during winter and spring, but gradually increased during summer and autumn. The maximum abundances and biomasses were observed in summer (Figure 4). There was a strong seasonality in the abundance of *M*. *leidyi* throughout the year; this is similar to the findings of Kideys and Moghim (2003), whilst up to 1200 specimens m^{-2} were recorded during the summer months; the population fell to very low levels of about 50 specimens m^{-2} during the colder period. This observation could be due to mass mortality during the colder months and renewal of the population in the following summer. So, the ctenophore population shrinks and expands again every year from small number of specimens. The seasonal pattern of *M*. *leidyi* is also related to water temperature, as evidenced from the positive correlation between the water temperature and abundance of *M*. *leidyi* (Figures 2 and 4), the ctenophore reached its highest abundances in summer when the water temperature was high, similar to the pattern observed by Shiganova (1998) and Finenko et al. (2006) in the Black Sea, Costello et al. (2006) in the Narrgansett Bay, Purcell (2005) in the Chesapeake Bay, and Javidpour et al. (2009) in the Baltic Sea.

The highest abundance and biomass were obtained in 2005 and 2006, respectively, showing the seasonal peaks of abundance and biomass of *M. leidyi* are very variable in the southwestern Caspian Sea from year to year (Figure 4). According to Roohi et al. (2008) during 2001 to 2006, the highest abundance and biomass of *M. leidyi* were observed during summer-autumn months coincident with warm temperatures. Besides, Bagheri and Kideys (2003) reported the biomass mean values of 164±79.8 g/m^2 in June, and 221±91 g/m^2 in October

2001, while Shiganova et al. (2001b) documented mean values of 372 g/m^2 in July and 556 g/m^2 in October 2001 from the basin wide surveys. Kideys and Moghim (2003) reported that the biomass of *M. leidyi* ranged between 3.5 and 351 g/m^2, with an average value of 120 g/m^2 from a basin-wide survey in August 2001. In additions, the highest *M. leidyi* population is showed during warm seasons in the Black Sea, Caspian Sea, Baltic Sea, Narragansett Bay and Chesapeake Bay (Purcell et al., 2001; Shiganova 2002; Kideys and Romanova, 2001; Bagheri and Kideys, 2003; Kideys et al., 2005; Purcell, 2005; Javidpour et al., 2009 ; Bagheri et al., 2012a).

Although there appears to be an increasing trend in the biomass of *M. leidyi* from 2001 to 2010 (Figure 4), the values are lower than the respective values for the Black Sea in the early 1990s. Despite the fact that the highest average biomass values for the Caspian Sea are, as yet, lower than those obtained in the Black Sea, the abundance of *M. leidyi* is much higher in the Caspian Sea due to the dominance of small sized (0 to 5 mm) animals in the population (Figure 8). Whilst maximum abundance of *M. leidyi* were 5976 ind/m^2 in October 2010, 9686 ind/m^2 in July 2009 and 10116 ind/m^2 in August 2006 in our study (Figure 4), respective values were 47 ind/m^2 in June 1991 and 408 ind/m^2 in August 1993 in the Black Sea (Mutlu, 1996). In all years, the mean of somatic growth appeared to take place from April to June and from August to September (Figure 5), when maximum weights of specimens were recorded. The mean weight of the ctenophore was 0.18 g in the southwestern Caspian Sea. Kideys and Moghim (2003) reported the average weight of *M. leidyi* as 0.24 g in the Caspian Sea for summer 2001, whereas for the Black Sea were 5.3 g in August 1993 and 4.2 g in July 1992. Based on the same sampling period, this denotes a 26-fold difference between the mean weight of *M. leidyi* from the two seas.

The size of surviving ctenophores and resulting population size increase with raise the water temperatures. From March to June,the biomass increased due to the intensive somatic growth of the animals that are wintering over; with the mean body weight of the ctenophores in the population been increased to 3.3 to 3.7 g, but the abundance remained low. In July, the abundance as well as the biomass increased due to the start of intensive reproduction; whilst the mean weight of animals in the population decreased by 0.26 g.

During that period, small ctenophores (< 5 mm) contributed 50 to 87% to the total population abundance. During subsequent months, the reproduction continued and the biomass decreased due to the elimination of the large animals that wintered over. The percentage of young animals remained was very high contributing 60 to 80% of the total abundance.

The mean wet weight of the animals in the population achieved its minimum in the first half of August as 0.05 g, when young animals <5 mm in size contributed 87% to the total abundance. *M. leidyi* from the Caspian Sea is smaller than that from the Black Sea. The maximal size of *M. leidyi* in the Caspian Sea (51 mm in Bagheri and Kideys (2003), 45 mm in Kideys and Moghim (2003), 65 mm in Finenko et al. (2006), and 70 mm in the present study) is also smaller than that recorded in the Black Sea, where this ctenophore could attain a length of 180 mm (Shiganova, 1997). The length-frequency distribution based on measurements of a total of 179,000 specimens, displayed that 90.6% of the population belonged to the 0 to 5 mm group and 6.4% were from 6 to 14 mm length group (Figure 7). A characteristic feature of the size composition of the *M*. *leidyi* population in shallow waters of the Caspian Sea (especially in the south) is the predominance of small ctenophores of <10 mm, similar to the results of Kideys and Moghim (2003), and Roohi et al. (2008), these small ctenophores made up 90% of the total abundance in summer. The low salinity in the Caspian Sea has been suggested to be the reason for the smaller size of ctenophores (Finenko et al., 2006) although Purcell et al. (2001) reported there was no significant relationship between salinity and ctenophore body size in the western Atlantic. In our study as well there was no significant correlation between population of *M*. *leidyi* and salinity (r = - 0.14).The largest length group dominated during April to June (in spring) and the smallest length group dominated other months (Figure 8). *M. leidyi* population sizes in temperate locations are small during cold winter temperatures, and increase with reproduction in the spring (Kremer, 1994). The greatest numbers of ctenophores in Chesapeake Bay occur in the spring (Purcell et al., 2001). In the southern Caspian (that is, Iranian waters), contribution of smaller specimens to the population was highest in summer, due to high water temperature (Figures 2 and 8).

Conclusions

This study documented the seasonal distribution and size structure of *M. leidyi* in the southwestern Caspian Sea during 2001 to 2010 and attempted to estimate fluctuations in abundance and biomass of *M. leidyi* in comparison with the previous literatures. This survey clearly showed that small individual up to 5 mm dominanted the *M. leidyi* population over the years and the abundance and biomass of M. leidyi has not changed much. We suggested, in future studies, the effects of climate change, shifte in meteorological regime and environmental degradation on plankton community in southwestern Caspia Sea should be undertaken.

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