Environmental Changes Due to a New Alien Comb Jelly, *Mnemiopsos Leidyin in* the Southern Caspian Sea

Aboulghasem Roohi[1*], Zulfigar Yasin[2], Ahmet E. Kideys[3], Aileen Tan Shau Hwai[2] and Elif Eker-Develi[3], Ali Ganjian Khenari[1] and Hassan Nasrollazadeh[1]

[1]Caspian Sea Research Institute in Ecology, P.O.Box961, Khazarabad Boolvar, Sari, Iran
[2]School of Biological Science, Universiti Sains Malaysia, 11800, Penang, Malaysia
[3]Institute of Marine Sciences, Middle East Technical University, Erdemli 33731, Mersin, Turkey
[*]Corresponding author. Phone: +60 17 447 8037
Email: Roohi_ark@yahoo.com

ABSTRACT

Results of a 6 years long survey on a new invasive ctenophore species, *Mnemiopsis leidyi*, which was introduced to the Caspian Sea in 1999 (Ivanov et al., 2000), showed that there were some relations among *M. leidyi* population, their main prey organism zooplankton and some environmental factors such as temperature, salinity and nutrient concentrations. In this study, fall and rise of this comb jelly abundance, biomass and some environmental parameters were studied in the Iranian coasts of the Caspian Sea during 2001-2006. The maximum *M. leidyi* abundance and biomass were noted in summer and autumn (August and September) and the minimum in winter with significant correlation with water temperatures ($P<0.005$). The maximum abundance and biomass of *M. leidyi* were found in 2001 with values of 6175 ± 6070 ind.m^{-2} and 482.99 ± 537.52 g.m^{-2}. Preliminary results showed that nutrient (both organic and inorganic) concentrations increased during 2003-2006 compared to a prior study performed in 1996 in spite of some seasonal fluctuations. Based on the stoichiometric molar ratio among inorganic nutrients silicate: nitrogen (nitrate, nitrite, and ammonium): phosphorus (phosphate) (~16:4:1), the major limiting factor was nitrogen.. Phytoplankton species composition changed from diatoms to cyanophytes or other phytoplankton groups related to decreased SiO_2 concentrations. The cyanophyte, *Nodolaria spp.* bloom was observed in the southern Caspian Sea in August-September 2005.

Key words: Caspian Sea, environmental changes, *Mnemiopsis leidyi,* nutrients, plankton.

1. INTRODUCTION

Comb jellies comprise a diverse phylum (Ctenophora) of delicate, gelatinous species living throughout the world's oceans. One species of this phylum, *Mnemiopsis leidyi* has spread from the Black Sea to the Seas of Azov, Marmara and eastern Mediterranean (Mutlu and Bingel 1999), and in 1999, it appeared for the first time in the Caspian Sea (Ivanov *et al*., 2000). The most drastic impacts of this new comb jelly species appeared to be in the southern Caspian, where the highest biomasses of *M. leidyi* have been observed (Roohi et al., 2001). Moreover, effects of *Mnemiopsis leidyi* in the Caspian Sea ecosystem expected to be greater than in the semi-enclosed Black Sea, as the former is a completely enclosed basin and hence, has a greater sensitivity to invasion stresses (Dumont 1995). Since *M. leidyi* is a voracious predator of zooplankton and thus competitor of planktivorous fish, a significant decline in the catches of main small pelagic fish (e.g. Kilka *Clupeonella spp*.) has already been reported for some riparian countries (Kideys et al., 2005). Within 2 years (2000 and 2001) an almost 50% decrease in Kilka catches of Iranian fishermen has occurred, with a minimum of 11 million US dollar loss of financial revenue (Kideys and Moghim 2003). *M. leidyi* is a hermaphrodite species capable of self-fertilization. Thus, under suitable conditions its abundance may increase rapidly, forming mass occurrences usually in the late summer and autumn (Shiganova et al., 2001). In this paper, we investigated the effects of the environmental factors (temperature, salinity and prey densities) on growth of *M. leidyi* population.

2. MATERIALS AND METHODS

Biological and environmental data used in this study were collected monthly by the R/V Guilan cruises conducted in 1996 and 2001-2006 along six transects (Nowshar, Babolsar Amirabad, Lisar, Anzali and Sepidroud) in the Iranian coast of the Caspian Sea. Each transect had four stations located at 5, 10, 20 and 50 m bottom depth contours with two deep stations having 100 m total depth off Anzali and Babolsar (Figure 1).

During the cruises, an Ocean Seven 316 multiparametric probe (Idronaut) and a Nansen water sampler were used to measure water temperature, salinity and pH and to take samples. Oxygen concentration was determined using the Winkler technique onboard immediately after the water sampling. Nutrient concentrations such as inorganic and organic nitrogen, phosphorus and silicon were determined using standard methods (Sapozhnikov 1991). Sampling data intervals have been integrated by season to facilitate comparison between the different years.

Phytoplankton samples were collected using Van Dorn water bottle from the surface, 5, 10, 20, 50 and 100m. Samples of phytoplankton were preserved using buffered formaldehyde to obtain a final concentration of 4% (Sourina 1978). Phytoplankton was identified down to genus and species level based on Senichkina (1986)) and enumerated using Sedgwick–Rafter counting chamber (Sourina 1978).

Zooplankton were taken using a Juday net with a mouth opening of 0.1 m^2 (mesh size of 100 μm) hauled from the bottom to the surface. Zooplankton samples were collected from the net and immediately fixed to have a final neutral formaldehyde solution of ~4-5%. Samples were sub-sampled using a 1 ml stemple pipette, which was transferred to Bogorov tray for counting at least ~100-150 individuals. (Postel *et al.*, 2000).

Comb jelly (*Mnemiopsis leidyi)* was collected with the METU net having a mouth opening of 0.2 m^2 (mesh size of 500 μm) same as the Juday net from the same depths (Kideys *et al*., 2001a). The body length of each individual with lobes was measured onboard and by the length-groups the density of *Mnemiopsis leidyi* (per m2) was calculated. Length measurements were converted to the weight for biomass (wet weight per m^2) measurement by using the appropriate equation (Kideys *et al*., 2001a).

The sampling used in this study is similar to the study performed by Hossieni *et al*. (1996) where both studies were conducted in the same regions using the same methodology.

3. RESULTS AND DISCUSSION

Overall plankton cycles for 1996 and 2001-2006 from spring through winter in the Southern Caspian Sea were shown in Figure 2. There was an opposite trend between phytoplankton and zooplankton abundances among the years. In 1996, phytoplankton abundance (Figure 2, A) was low but increased in 2001 and 2002. On the contrary, zooplankton abundance was much higher during 1996 decreased in 2001 and 2002. Although phytoplankton abundance decreased during 2003-2005 compared to the years 2001-2002, the abundance level of phytoplankton during 2001-2006 was generally higher than that in 1996 (Figure 2). Zooplankton abundance level was also low during 2001-2006 compared to that observed in 1996. The decrease in zooplankton abundance well corresponded to the increase of *M. leidyi* population in 2001-2002 (Figure 2, B). The increase in total phytoplankton abundance could be linked with the low abundance of their grazer zooplankton between 2001 and 2005. The variations among the years in terms of abundance and biomass of phytoplankton, zooplankton and *M. leidyi* were similar to each other except the years 2001-2002 for zooplankton. Zooplankton biomass decrease was more pronounced than the abundance decrease from 1996 to 2001-2002. Zooplankton biomass levels were more or less similar during 2001-2006 (<100 mg m^{-3}) while it was ~200-400 mg m^{-3} in 1996 as average. *M. leidyi* occurred in high abundance (12610±8078 ind.m^{-2}) and biomass (900.9±741.6 g.m^{-2}) in autumn 2001, in the southern Caspian Sea (Figure 2), simultaneous with the maximum phytoplankton abundance and biomass 234±32 million-cells.m^{-3} and 822.2±82.2 mg^{-3}. However, while high phytoplankton abundance persisted through the winter (5-7 folds higher than in 1996), *M. leidyi* abundance decreased in winter. The diatoms usually dominated all seasons constituting 43-90% of total abundance and 80-96% of total biomass (Figure 3) in 1996 (Hossieni *et al.* 1996) while in 2001-2002 the dominant phytoplankton group shifted from diatoms to cyanophytes (in abundance, 40%) and to dinoflagellates (in biomass, up to 64%). A sharp decrease in zooplankton associated with the associated with the slight decrease in silicon caused the summer cyanophytes, *Nodularia harveyana* bloom in 2005 (Data not shown in figure 2, CEP 2006). Zooplankton abundance was generally higher in winter period than in summer periods after the introduction of *M. leidyi* to the Caspian Sea, which was related to high *M. leidyi* abundance and higher predation pressure on zooplanktonin summer months. There was again an increase in phytoplankton abundance in 2006 when both zooplankton and *M. leidyi* was low. The highest abundance of phytoplankton and zooplankton were observed in winter at the depth layer <20m, while the highest *M. leidyi* abundance was observed in autumn for the same depth layer (not shown). The seasonal variations in abundances of phytoplankton and zooplankton were inversely related with the water temperature. Long-term hydro biological data from 1996 to 2006, shown water salinity decreased from 12.8±0.2 ppt in 1996 to 11.2±0.4 ppt (Fig. 4). In addition, the total nitrogen increased gradually from 424.8±263.5 μgL^{-1} in 1996 to 932.2±264.3 μgL^{-1}in 2006 (2 times higher compared to 1996). The total phosphorus increased also gradually from 21.0±1.4 μgL^{-1} in 1996 to 35.5±8.1 μgL^{-1}in 2006. A decrease of silicate (SiO_2) was observed from 288.5±137.6 to 191.9±67.2 from 1996 to 2006 (Fig. 4).

Invasions of exotic species have been an increasing concern in the global and coastal marine waters (Grosholz 2002) as a consequence of increasing anthropogenic pressures, such as overfishing and eutrophication. Non-indigenous gelatinous species have also negatively affected ecosystems throughout the world. A spectacular example of this phenomenon is the inadvertent introduction of the ctenophore *Mnemiopsis leidyi* into Black Sea and lately the Caspian Sea, presumably via ballast waters of ships. The resultant perturbation of the food web included devastation of the Black Sea and the Caspian Sea fisheries, which might have been also affected from overfishing in the previous periods (Kideys et al. 2005). This ctenophore species influenced the marine ecosystem down to the level of primary producers and marine elemental cycles in the Caspian Sea. (Roohi et al 2001). This voracious ctenophore consumed zooplankton rapidly especially in summer months and this led further decrease of zooplanktivorous pelagic fishes due to the starvation (Daskalov et al. 2007). In the Caspian Sea, *M. leidyi,* where small individuals were dominant indicating early reproduction, invaded almost the entire sea within less than a year (Ivanov et al. 2000). The rapid expansion of this invader have made a sharp decrease in zooplankton community, caused a rapid increase of phytoplankton. In the meantime, dominant phytoplankton groups changed from diatoms to cyanophytes and dinoflagellates during maximum *M. leidyi* abundance during summer-autumn of 2001-2002 in the Southern Caspian Sea (Figs. 2 and 3). There was an average of 75 % decrease in zooplankton abundance (63-86 %) and 86 % in biomass (81-90%) after *Mnemiopsis* invasion. In the meantime, there was almost a 65% increase in phytoplankton community in all seasons and 55 and 22 % decrease in summer and autumn phytoplankton biomass, which appeared to be an artifact since exceptionally long diatom chains were replaced by small cyanophyte and dinoflagellate species (Fig. 3). It is worth to mention that the toxic cyanophyte, *Nodularia harveyana* bloomed in 2005, which could be linked with slight decrease of silicon.

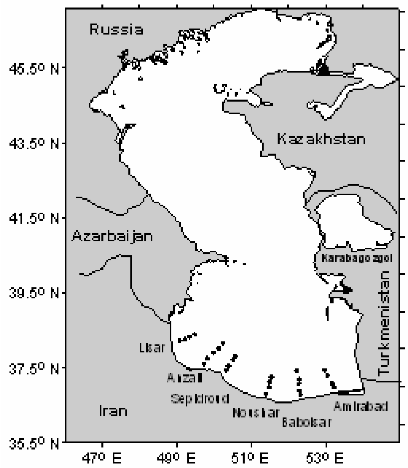

Figure 1 Distribution of sampling stations in the South Caspian Sea.

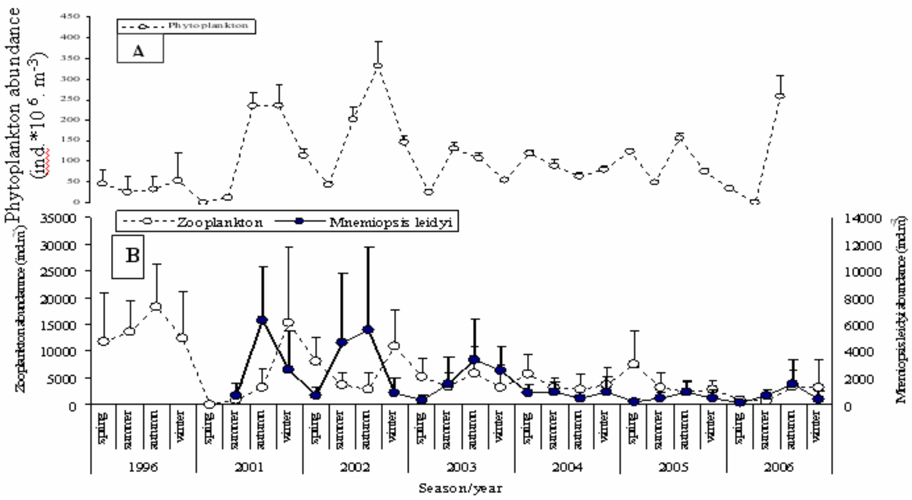

Figure 2 (A) The abundance of total phytoplankton and (B) Zooplankton and ctenophore *Mnemiopsis leidyi* Spring- winter of 1996 and 2001-2006 (including data from Hossieni *et al*. (1996).

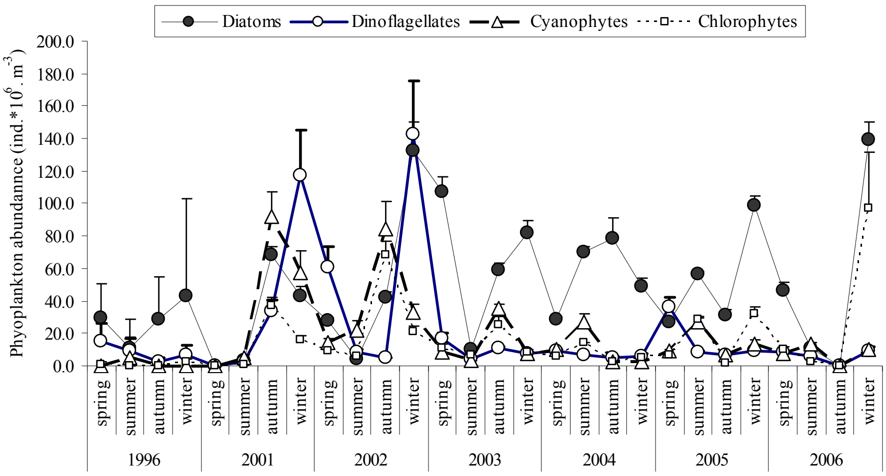

Figure 3 phytoplankton groups' abundance variation before and after *Mnemiopsis leidyi* invasion in the Southern Caspian Sea.

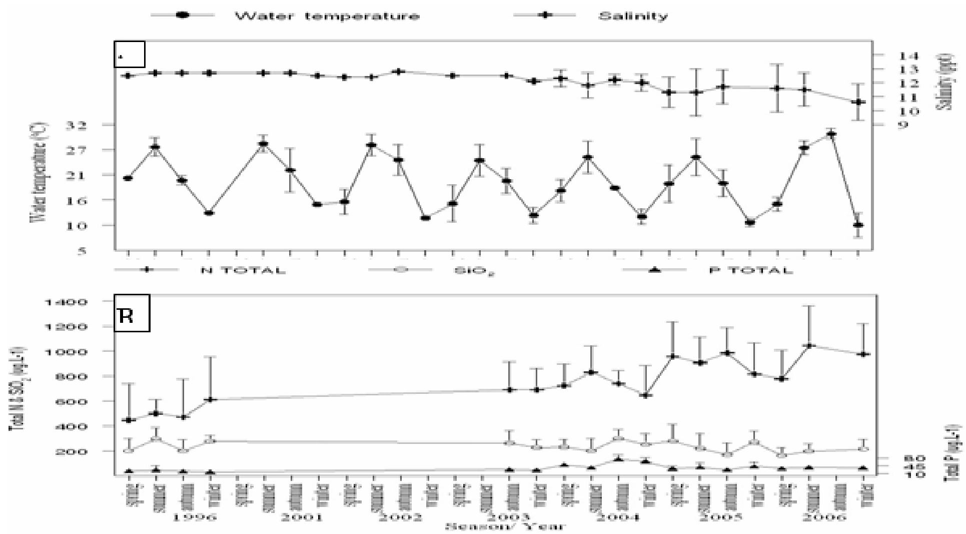

Figure 4 Mean of: A) water temperature and salinity in B) Nutrients (Total N, Total P and SiO_2) in the Southern Caspian Sea. (Averages of 0, 20, 50 and 100 m)

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