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Concentration of Chlorophyll-a in Coastal Waters of Rudsar

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Abstract: In the study, chlorophyll-a concentrations were examined using field observations by Ocean seven 316 profiler over the Southern continental shelf of the Caspian Sea near Iranian coasts. The data were collected at nine stations with a maximum depth of 117 m depth along three transects in perpendicular to the Southern coasts of the Caspian Sea, off Rudsar in Summer 2008. Amounts of the chlorophyll-a varied from 3.8 to 0.1 mg m^{-3} with the maximal levels at 15 m depth. The formation and destruction of seasonal thermocline affect the chlorophyll-a concentrations. Chlorophyll-a concentration sharply decreased with depth and reached around 0.1 mg m^{-3} near bottom.

Key words: Caspian Sea, chlorophyll-a concentration, vertical distribution, coastal waters

INTRODUCTION

The Caspian Sea, the largest closed water body in the world, with rich biological and petroleum resources plays important role in the region (Dumont, 1998; Kostianoy and Kosarev, 2005; Zonn, 2005a).

The Caspian Sea can be divided into the three major regions: North (shallow part), Middle and South (deep parts) Caspian (Kosarev, 2005). The shallow and deep parts of the Caspian have very differences in hydrological and ecological characteristics. Chlorophyll-a distributions of the Caspian Sea is under effects of some important factors such as sea surface highly influenced by several factors such as temperature, wind stress, Atlantic Oscillation Index, Volga and Ural Rivers (Nezlin, 2005).

Seasonal and interannual variability of phytoplankton biomass in the Northern Caspian Sea is under the influencing of freshwater discharges of the Volga Rivers. In the deep area of the middle and Southern Caspian Sea, vertical thermal structure and stratification of the water column adjust influence the concentrations of chlorophyll-a. Here, thus the sharp Summertime thermocline acts as a resulting in natural nutrient limitation for phytoplankton growth. The seasonal pattern of chlorophyll concentration (basis on Sea WiFS observations 1997-2004) shows maximum values in surface layer in August in the Southern Caspian Sea. During the months of the year, chlorophyll concentration in the northern Caspian Sea is higher than its concentration in the Southern and middle deep Caspian (Nezlin, 2005).

In recent decades, the Caspian environment due to extensive exploitation and discharge of large magnitudes of human wastes is under high stress (Zonn, 2005b; Korshenko and Gul, 2005). Discharge of great amounts of municipal domestic sewage waters, industrial and agricultural wastewater, that contain nutrients, pesticides and detergents that threat the

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Caspian ecosystems (Kostianoy and Kosarev, 2005; Zonn, 2005b; Korshenko and Gul, 2005). For example, a great scale Anomalous Algal Bloom (AAB) was observed for the first time in the Southern basin of the Caspian Sea during August-September 2005. The algal bloom was consequence of the highly increased concentration of phytoplankton as following increased nutrient input to the Caspian seawater (CEP, 2006).

In addition, maximum levels of chlorophyll-a concentration observed in the middle and Southern parts of the Caspian Sea in Summer 2001 (Kideys *et al*., 2008; Nezlin, 2005). This phenomenon was not related to the changes in physical conditions such as temperature or wind current. Some Scientists believe that maximum levels of chlorophyll was to the invasion of Jellyfish (Mnemiopsis Leidyi) which was observed in the middle and Southern Caspian Sea (Kideys *et al*., 2008; Kideys and Moghim, 2003; Nezlin, 2005).

On the other hand, chlorophyll-containing organisms are the first step in most food chains, the health and abundance of these primary producers will affect the integrity of the other trophic level. Therefore, very low and high concentrations of the chlorophyll-a can be harmful to marine biota.

Thus, measurement of chlorophyll concentration is one of the key indices in the study of the health status of any natural marine ecosystem. Variability of chlorophyll-a concentrations determines the ecological conditions of marine systems such as the changes in the physical and chemical characteristics of the environment. One of the fundamental interests of oceanographers is investigation on ecological characteristics of seawater. Recently, several studies on physical, chemical and biological oceanographic conditions of the Southern Caspian Sea waters in adjacent to Iranian coasts were made (Nasrollahzadeh *et al*., 2008; Zaker, 2007; Zaker *et al*., 2007).

In the previous studies, the monitoring of the chlorophyll-a concentrations in the Southern Caspian Sea is organized based on satellite data sets (Nezlin, 2005; Kideys *et al*., 2008). Vertical structure of chlorophyll-a concentrations and its variations in deeper layers of the Southern Caspian seawater were not well known (Kideys *et al*., 2008; Nezlin, 2005) and need more investigations. In this study, distribution of chlorophyll-a concentrations in the Southern Caspian Sea water near Rudsar in Summer 2008 was evaluated.

MATERIALS AND METHODS

Study Area in the Southern Caspian Sea

The Southern coast of the Caspian Sea has a warm and humid subtropical climate. The maximum and minimum air temperatures are in August and January, respectively. In the winter, air temperature ranges between 8 and 12°C and in Summer the mean monthly air temperature over the entire sea ranges from 24-26°C (Kosarev, 2005).

The study area is located in the West part of the Southern coasts of the Caspian Sea between N37° 9´ and N37° 22´ latitude and between E50°18´ and E50° 29´ longitude (Fig. 1). In the West and East parts of the Southern Caspian Sea, continental shelf width is in the range of 9-10 km and maximum depth of 50 m. The depth from the coast increases gently to about 50 m near the shelf break and after that reaches to 500 m depth in a distance of 18 km from the coastline (Zaker, 2007).

Data Collection

Chlorophyll-a is one of the most common type of chlorophyll in seawater. The chlorophyll-a exists as a primary photosynthetic pigment in all plant life. Marine plants use chlorophyll-a to capture sunlight in photosynthesis procedure. The analysis of vertical

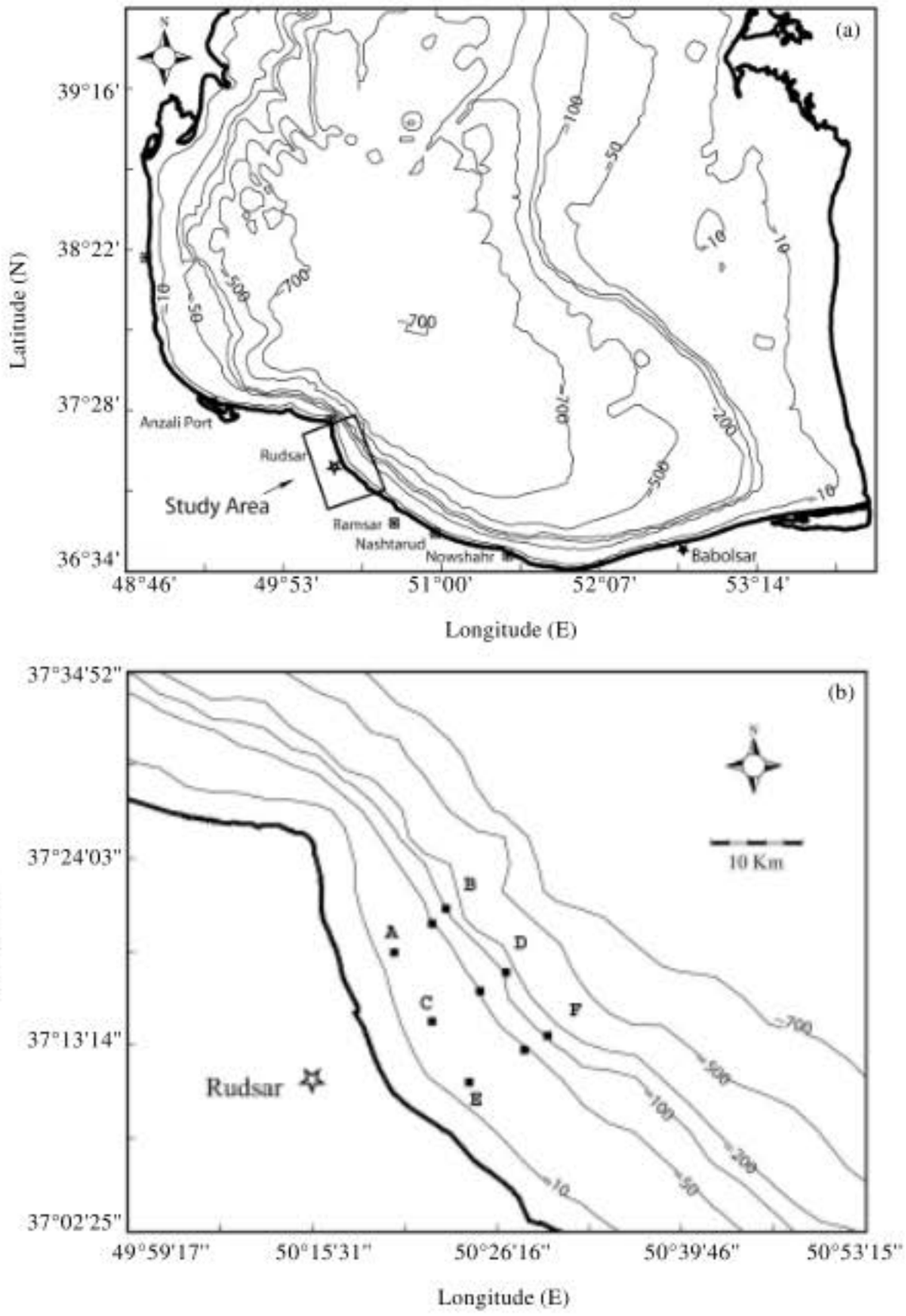

Fig. 1: (a) Study area in the Southern Caspian Sea, (b) Positions of CTD stations

variability of chlorophyll-a in the area was based on the field observations data. The data were collected over the Southern continental shelf of the Caspian Sea. Measurements were organized by Iranian National Center for Oceanography (INCO), in August 2008. The data sets were gathered by using a portable Ocean Seven 316 probe developed by IDRONAUT. Measurements were made using the Seapoint Chlorophyll Fluorometer probe. The instrument was calibrated in the Physical Oceanography Laboratory of INCO. Before the field measurements, the probe was set in Timed Data Acquisition mode and released into the seawater in the sampling stations. Maximum depth in the sampling stations was 117 m. Data collection was performed with profiler in free falling mode in every second with time interval of one meter per second. The CTD probe was used to measure seawater properties with time interval of one second. The observations were conducted at nine predetermined stations along three survey lines perpendicular to the coastline. There were three stations along each

transects and the distances between stations were 5 km. Global Positioning System (GPS) and admiralty topographic map were used for identifying the positions and depths of the stations.

RESULTS AND DISCUSSION

Chlorophyll-a is one of the vital requirements for marine ecosystems. The collected data present useful knowledge about distribution of chlorophyll-a concentration in the coastal waters of Rudsar in Summer 2008. Seawater properties are important factors in distribution and concentration of chlorophyll-a in the region. Thus, before analysis on vertical distribution of chlorophyll-a, variation and structure of seawater characteristics in the Southern coastal waters of the Caspian Sea were explained. Basis on our studies, thermal stratification through the water column is in the strongest situation in the Southern Caspian Sea in Summer season. On the other hand, due to low values of salinity in the Caspian seawater variation of density is in high agreement with changes of temperature (Zaker *et al*., 2007). Pycnocline is in the strongest condition in the Summer, too. Thus, pycnocline act as a natural boundary separating between deep layers with high levels of nutrients from the surface mixed layer where chlorophyll concentration is more. This wall limits the growth of phytoplankton (Nezlin, 2005).

Vertical profiles of temperature, salinity and chlorophyll-a were shown in Fig. 2. In the time of measurements, vertical variation of temperature was between 29°C at the sea surface and less than 8°C at 117 m depth. In the Southern coastal waters of the Caspian Sea, stratification of water column is in the strongest situation in mid Summer. A thermocline layer was located between 10 and 40 m depths with 18°C temperature gradient. Below the thermocline, temperature gradually decreased and reached < 8°C at 117 m depth. Three parts consist of surface mixed, thermocline and deep layers were observed in the vertical profile

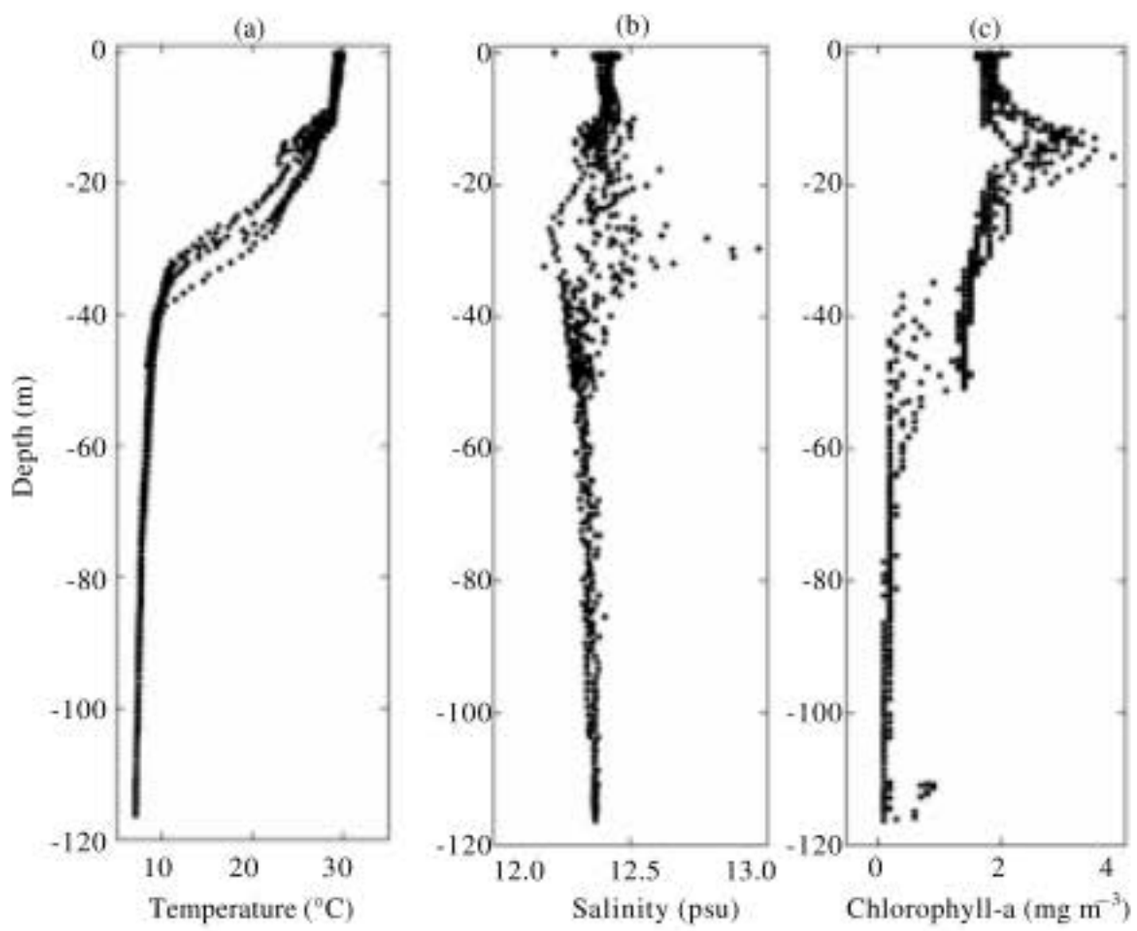

Fig. 2: Vertical profiles of (a) temperature (°C), (b) salinity (psu) and (c) chlorophyll-a (mg m^{-3})

of temperature (Fig. 2). Vertical and horizontal distributions of salinity were mainly between 12.18 and 13.1 psu.

Results of field observations on chlorophyll-a concentrations in water column were presented along survey lines from sea surface to the bottom. Vertical structure of chlorophyll-a in transects AB, CD, EF and BF was indicated in Fig. 3-6. Concentrations of chlorophyll-a were found to vary between 3.8 and 0.1 mg m^{-3} from near the sea surface to bottom in 117 m depth in August 2008. According to the climatological maps which were observed by Sea-viewing Wide Field-of-view Sensor (Sea WiFS) in the Southern Caspian Sea from 1997 to the end of 2004, chlorophyll-a concentrations at the surface layers near the study area were less than 4 mg m^{-3} in August (Nezlin, 2005).

Maximum concentrations of chlorophyll-a were observed at water layers between 10-20 m depths. Due to less light at depth of the sea, the highest chlorophyll-a concentrations were observed near the surface. In the study area, chlorophyll-a had maximum concentration about 3.8 mg m^{-3} below the surface at 15 m depth at transect lines CD and BF. Along the transects, horizontal gradient of chlorophyll-a over the continental shelf was minimal with contours being parallel to the seawater level. Over the continental shelf, seawater forms the surface mixed layer and thermocline. In the transect AB, chlorophyll-a values were between 1.7and 2.9 mg m^{-3} over the continental shelf. At the end of transects and in an area far from the coastline, chlorophyll-a concentrations had concentration of 3.3 mg m^{-3}. In the survey line of CD (Fig. 4), variation of chlorophyll-a was similar to that of transect AB (Fig. 3). At the end of transect CD, chlorophyll-a was in the range of 3.7-3.8 mg m^{-3}. In the transect EF, chlorophyll-a concentrations were between 2.5 and 2.9 mg m^{-3} 10 to 20 m depths within and outside the continental shelf (Fig. 5). The maximum value of chlorophyll-a in this transect was 2.9 mg m^{-3}. Average of chlorophyll-a concentrations in the middle transect (CD) was more than in other sections. Figure 6 showed the vertical variations of chlorophyll-a along section BF. In this transect chlorophyll-a concentrations were between 1.7 and 2.1 mg m^{-3} in the surface mixed layer. Across the thermocline, chlorophyll-a concentrations were between 2.1 and 3.8 mg m^{-3}. Below thermocline chlorophyll-a concentrations gradually reduced from 1.3 mg m^{-3} at 40 m depth to 0.5 mg m^{-3} at 60 m depth. Chlorophyll-a was 0.1 mg m^{-3} at 80 m depth and below.

Totally, in the time of measurements, the surface mixed layer had chlorophyll-a concentrations between 1.7 mg m^{-3} at the sea surface and 2.1 mg m^{-3} at 10 m depth. Across the thermocline, chlorophyll-a concentrations decreased from 2.1 to 1.3 mg m^{-3}. Chlorophyll-a concentrations declined below the thermocline and reached concentrations of 0.9 and 0.5 mg m^{-3} at 45 and 50 m depths, respectively. A sharp drop in chlorophyll-a concentrations was observed below 50 m. Concentrations of chlorophyll-a decreased to 0.1 mg m^{-3} at 80 m depth and below. It can be seen that below the thermocline and in deeper layers, concentrations of chlorophyll-a were considerably low. Near the seabed (depth of 117 m) chlorophyll-a concentrations were <0.1 mg m^{-3}. The data set indicated that chlorophyll-a variations over transects were similar and concentrations over the continental shelf were higher than outside shelf break. Statistic summary of seawater properties collected from surface to bottom (117 m depth) in the study area was presented in Table 1. At the time of measurements in the study area, variations of chlorophyll-a were in the range of 0.1-3.8 mg m^{-3}. Chlorophyll-a values were mainly around 1.7 mg m^{-3} at the sea surface.

In a previous study, chlorophyll-a concentrations were measured in east part of the Southern coasts of the Caspian Sea, off Babolsar from surface to bottom at 42 m depth. There, variations of chlorophyll-a values were between 1.3-4.2 mg m^{-3} with the maximal levels at the 15 m depth. There, concentrations of chlorophyll-a in the subsurface layers were more

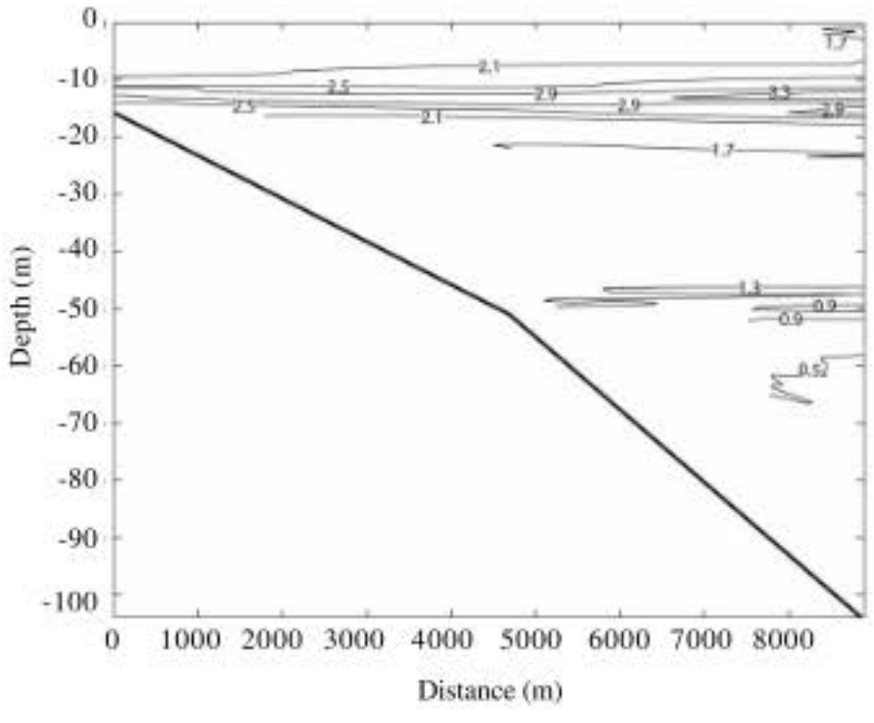

Fig. 3: Vertical structure of chlorophyll-a (mg m^{-3}) along transect AB

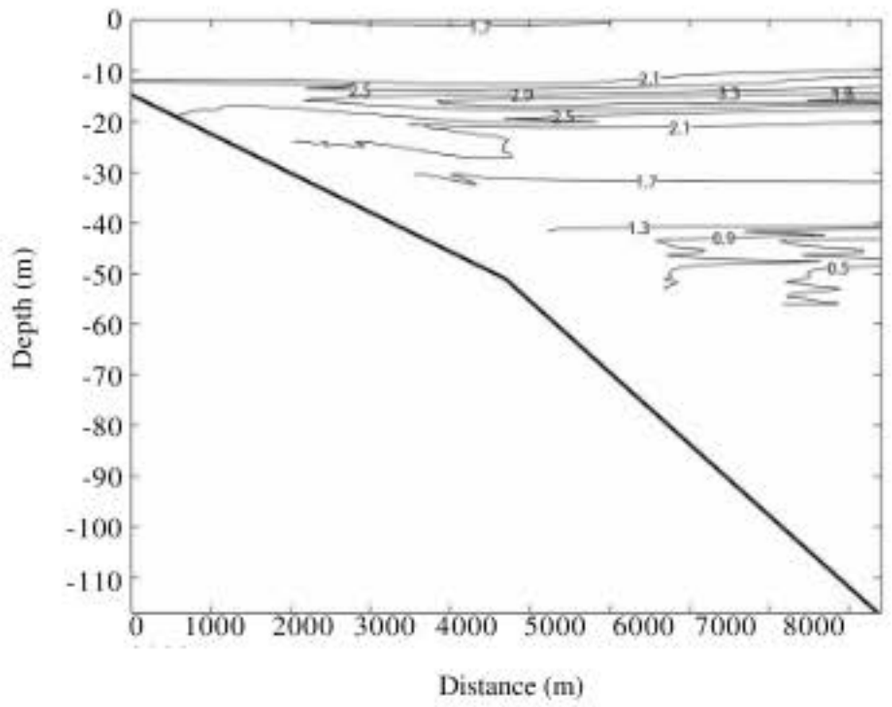

Fig. 4: Vertical structure of chlorophyll-a (mg m^{-3}) along transect CD

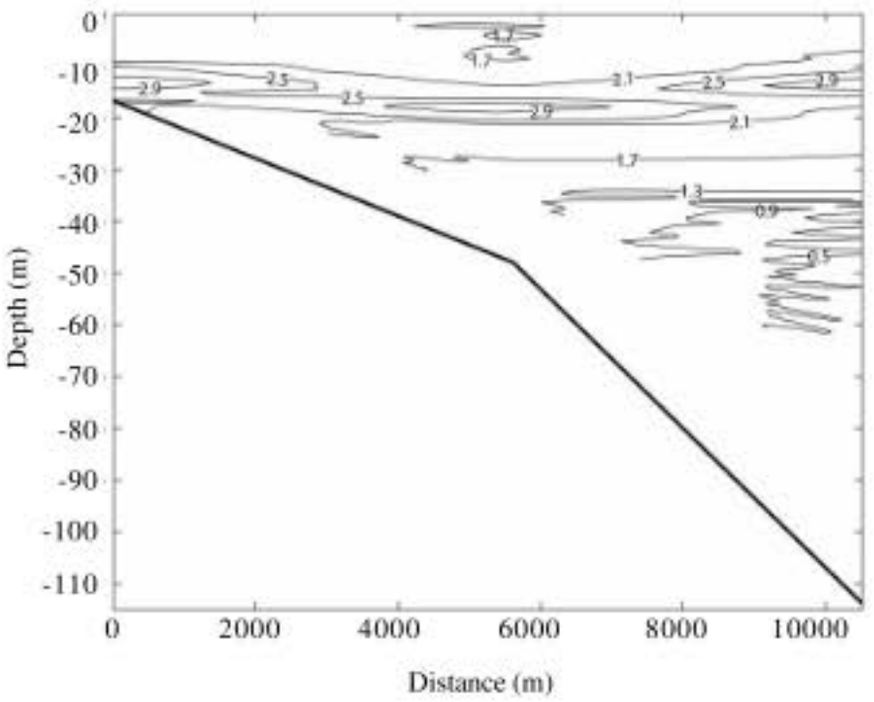

Fig. 5: Vertical structure of chlorophyll-a (mg m^{-3}) along transect EF

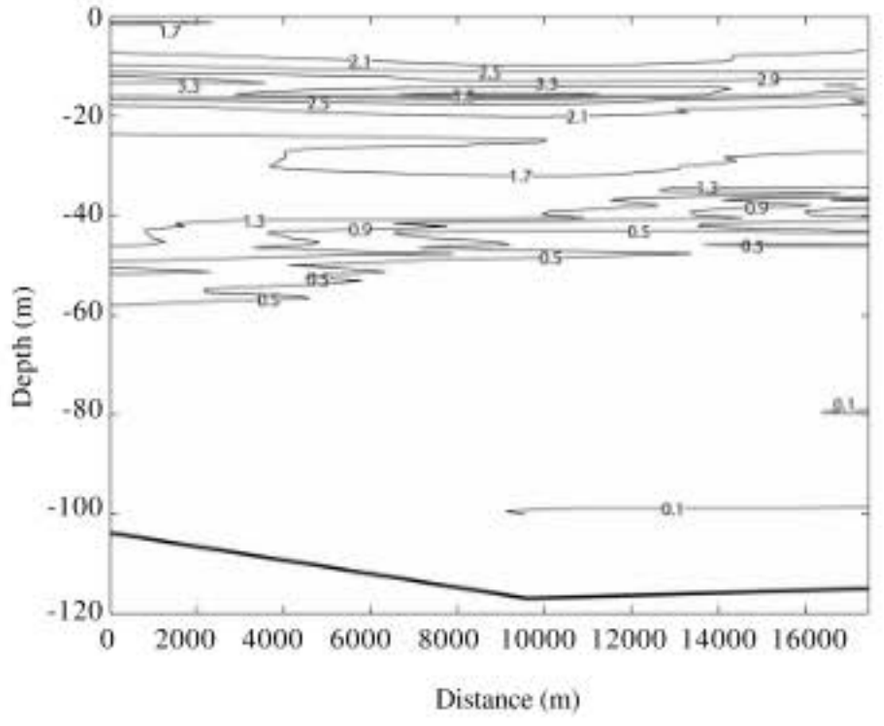

Fig. 6: Vertical structure of chlorophyll-a (mg m^{-3}) along section BF

Table 1: Statistic summary of seawater properties in the study area

Parameters	Minimum	Maximum	Average	SD	Median
Chl-α (mg m^{-3})	0.10	3.80	1.39	0.84	1.70
Temperature (C°)	7.10	29.97	18.26	9.54	18.89
Salinity (psu)	12.18	13.09	12.37	0.07	12.37
Sigma-t	5.58	10.45	8.30	1.99	8.71

than sea surface, too. The concentrations of chlorophyll-a were mainly recorded around 1.3 mg m^{-3} at the surface. Comparison between measured data sets in the coastal waters of Rudsar and coastal area of Babolsar port (Jamshidi *et al*., 2009) indicates that concentrations of chlorophyll-a at the surface in the West part of the Southern coastal waters of the Caspian Sea was higher than East part in Autumn.

In the periods of 1996-1997 and 2005, two phases of a field study were carried out at the sea surface waters of the Southern Caspian Sea near Iranian coast. The maximum chlorophyll-a concentration for two periods that was observed around 8.00 mg m^{-3}. Based the results, the mean chlorophyll-a concentration (2.14 mg m^{-3}) in 2005 was higher than chlorophyll-a concentration (1.44 mg m^{-3}) in period of 1996-1997. The observed data in 2005 had a minimum chlorophyll-a of 0.4 mg m^{-3} and during 1996-1997 showed a minimum value around 0.27 mg m^{-3} (Nasrollahzadeh *et al*., 2008).

In addition, seasonal pattern presented by Nezlin (2005) for chlorophyll-a concentrations at the sea surface in the Southern Caspian Sea were between 1997-2004 using SeaWiFS gives a range of chlorophyll-a values between 0 to less than 4 mg m^{-3}. Therefore, comparison between our measurements at the surface and the mentioned ranges of chlorophyll-a concentrations (Nezlin, 2005; Nasrollahzadeh *et al*., 2008; Jamshidi *et al*., 2009) showed that there are good agreements between data sets.

Occurrence of Anomalous Algal Bloom (AAB) in the Southern Caspian Sea during August-September 2005 (CEP, 2006) is a reason for existence unsuitable conditions in the sea and elevation of nutrient supply for plants. Furthermore, invasion of Mnemiopsis Leidyi (jellyfish) from the Black Sea to the Caspian Sea by ballast water is caused suppress on stocks of zooplankton and thus allow phytoplankton biomass to increase (Kideys *et al*., 2008). Due to entrance of pollutant, the environment of the Caspian is under pressure.

Therefore, it is needed to conduct permanent monitoring and serious efforts for decrease discharge of the pollutants into the Caspian Sea.

CONCLUSION

Presented data in this study provide a preliminary knowledge on vertical distribution of chlorophyll-a in Southern coastal waters of Caspian Sea in front of Rudsar in Summer. Vertical variations of the chlorophyll-a in the study area were considerable. The results showed that maximum concentrations of chlorophyll-a was at 15 m depth of water column. Below the thermocline, values of chlorophyll-a rapidly decreased and its concentrations were slight near the bottom.

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REFERENCES

CEP., 2006. Identification of the extent and causes of cyan bacterial bloom in September-October 2005 and development of the capacity for observation and prediction of HAB in the Southern Caspian sea using remote sensing technique. MHI, Ukraine. http://www.caspian.com/environment.org.

Dumont, H.J., 1998. The caspian lake: History, biota, structure and function. Limnol. Oceanogr., 43: 44-52.

Jamshidi, S., N. Abu Bakar and M. Yousefi, 2009. A study on concentrations of dissolved oxygen and chlorophyll-a in the coastal waters of Babolsar. Am. J. Applied Sci., 6: 1860-1867.

Kideys, E.A. and M. Moghim, 2003. Distribution of the alien ctenophore *Mnemiopsis leidyi* in the Caspian Sea in August 2001. Mar. Biol., 142: 163-171.

Kideys, A.E., A. Roohi, E. Eker-Develi, F. Melin and D. Beare, 2008. Increased chlorophyll levels in the Southern Caspian Sea following an invasion of Jellyfish. Res. Lett. Echol., 2008: 1-4.

Korshenko, A.N. and A.G. Gul, 2005. Pollution of the Caspian Sea. In: The Caspian Sea Environment, Kostianoy, A.G. and A.N. Kosarev (Eds.). Springer-Verlag, Germany, ISBN-10: 3540282815, pp: 109-142.

Kosarev, A.N., 2005. Physico-Geographical Conditions of the Caspian Sea. In: The Caspian Sea Environment, Kostianoy, A.G. and A.N. Kosarev (Eds.). Springer-Verlag, Germany, ISBN-10: 3540282815, pp: 5-31.

Kostianoy, A. and A. Kosarev, 2005. The Caspian Sea Environment, (Handbook of Environmental Chemistry). 1st Edn., Springer-Verlag, Germany, ISBN-10: 3540282815. pp: 271.

Nasrollahzadeh, H.S., Z.B. Din, S.Y. Foong and A. Makhloug, 2008. Trophic status of the Iranian Caspian Sea based on water quality parameters and phytoplankton diversity. Continental Shelf Res., 28: 1153-1165.

Nezlin, N.P., 2005. Pattern of Seasonal and Interannual Variability of Remote Sensed Chlorophyll. In: The Caspian Sea Environment, Kostianoy, A.G. and A.N. Kosarev (Eds.). Springer-Verlag, Germany, ISBN-10: 3540282815, pp: 143-1157.

Zaker, N.H., 2007. Characteristics and seasonal variations of dissolved oxygen. Int. J. Environ. Res., 1: 296-301.

Zaker, N.H., P. Ghaffari and S. Jamshidi, 2007. Physical study of the Southern coastal waters of the Caspian Sea, off Babolsar, Mazandaran in Iran. J. Coastal Res., 50: 564-569.

Zonn, I.S., 2005a. Economic and International Legal Dimensions. In: The Caspian Sea Environment, Kostianoy, A.G. and A.N. Kosarev (Eds.). Springer-Verlag, Germany, ISBN-10: 3540282815, pp: 243-256.

Zonn, I.S., 2005b. Environmental Issues of the Caspian. In: The Caspian Sea Environment, Kostianoy, A.G. and A.N. Kosarev (Eds.). Springer-Verlag, Germany, ISBN-10: 3540282815, pp: 223-242.