Influence of climate variability on marine ecosystems

Large variability in populations of small pelagic fish species have been observed in global oceans (Watanabe 2009). The flexibility in reproductive features of the spawning stock combined with environmental induced fluctuation in survival rate of offspring and overexploitation, can be the major reasons for such large variability in stocks of these species (Ganias 2009) and relation between large scale climate alteration and these fluctuation known as an important scientific and economic concern (Klyashtorin 2001). Hence over the last decades, since about 1980, recognizing the process by which variability in recruitment of small pelagic fish occur, became a main subject for international co-operation and researches (Alheit and Bakun 2009). However providing a reliable correlation between global climate conditions and long-term stock variability has been forgotten till that time (Klyashtorin 2001) and lack of scientific knowledge from the process which govern recruitment was widely identified in the 1980s (and still is) as the important scientific problem which hindering successful management of populations of small pelagic fish (Alheit and Bakun 2009). Main focuses of these co-operation in 1990s has been concentrated on the influence of climate variability on marine ecosystems, mainly on small pelagic species. To improve the understanding from such relations several efforts have been done to correlate regular anchovy and sardine stocks alteration with the global and regional climate indices (Klyashtorin 2001).

Synchronous outbursts alteration in populations of these two species, i. e. sardine and anchovy in North and South Hemispheres might shown the signature of same global climatic events in governing of the fish populations

and such alteration became the subject of several studies in this case (Lluch-Belda et al. 1989; Lluch-Belda et al. 1992; Kawasaki 1992a, 1992b; Schwartzlose et al. 1999).

In study which conducted by Kawasaki (1992a), has been shown that catches of Japanese sardine are related to climate alterations, explained as air and water surface temperature in hemispheric scale. In another study by Kawasaki (1994) concept of cyclic climate alteration has been applied to explain regular alteration in the Japanese sardine catches over previous 350 years. The same dependence to climate change has been suggested also for Californian sardine (Lluch-Belda et al. 1992). Beverton (1990) and Schwartzlose et al. (1999) in case of industrial fishery collapses of the sardine (Sardinops caerulea) fishery in the California current were thought environmental induced effects may play an important role. In another studies which conducted by Bakun (1990, 1996), correlation between the long-term variability of catch of abundant small pelagic fishes and the upwelling index has been investigated. In these studies author showed that the world climate changes come with significant alteration in the atmospheric movement, direction and acceleration of largest oceanic streams, and upwelling strength.

Therefore, regarding to this background, several detailed investigations have been conducted by FAO during the years 1994 to 2001 to investigate the condition and aspect of the world fisheries and tried to make a simulations from applying of new methods to have predictions from dynamics of fish stock. Hence in latest one, which has been conducted by Klyashtorin (2001), long term variability in catches of commercially valuable species and climate

alteration has been investigated. The author showd a close correlation between the climate alteration and long-term variability of the main commercial stocks, including the small pelagic species over Atlantic and Pacific oceans.

With regard to important of such topics several studies continue to investigate the climate induce effects on commercially important small pelagic species in recent years (e. g. Gröger et al. 2009; Watanabe 2009; Alheit et al. 2012; Alheit et al. 2014). Rising in the abundance of European anchovy in the North Sea in the late 1980s was connected to the signal and strength of the AMO (Alheit et al. 2012). Also, in another study by Alheit et al. (2014) the dynamics and migrations of small pelagic fish stocks in the eastern North and Central Atlantic in relation to AMO have been investigated. The authors believed that a complex ocean–atmosphere alteration which occurred in the mid-1990s lead to a “ regime shift” in the ecosystems of these area and the small pelagic clupeoid fish stocks have affected by this shift.

The autumn-spawning herring (Clupea harengus) stock in the North Sea can be another example of the commercially valuable North Sea herring. More recent evidence from a directional alteration occurrence in recruitment of this species has been reported by Payne et al. (2009) during the 2000s. In this study authors believed that recruitment is affected not only by parental-stock biomass, but it seems that the environmental induced alteration, also, may influence the recruitment of this species in North Sea and changes in such factors could be of equal, or even more important. Hence to understand better the reproductive failures of North Sea herring, Gröger et al. (2009)

also studied large-scale climate proxies in the North Atlantic Ocean, (i. e. NAO and AMO), and their potential influences on stock regeneration of this species.

Commercially important pelagic species, European anchovy, which support the main fisheries in the Black sea (Chashchin 1996; Daskalov 2003) also has shown significant variability during the last five decades (Güraslan et al. 2014). According by Niermann (2004) and Oguz (2005) several process including regional climate fluctuation, overexploitation, rising the input of anthropogenic induce nutrient from rivers, and, the ctenophore (comb jelly) M. leidyi and regime shift can be responsible for such variability. Evidence has shown that not only human related activities but also environmental fluctuation can play important role in controlling anchovy production in the Black sea and such hypothesis was investigated several studies (e. g. Niermann et al. 1999; Daskalov 2003; Oguz 2005; Oguz et al. 2006). These studies have been shown strong correlation between local climatic variations such as those derived by the NAO and fluctuations of anchovy population in this Sea.

Many anthropogenic induced pressure including pollution (e. g. domestic and industrial run-off, the development of vast oil and gas fields) and uncontrolled fish exploitation, also, altered significantly the Caspian sea environment during the last 3 decades. These alteration that has resulted in poor management can be caused in increasing “ environmental degradation” and damaged in coastlines and trophic base of the Caspian sea (Mamedov 2006).

Fisheries sector play an important role in the Caspian sea. Total annually catches for the commercially valuable fish in this sea, for instance beluga, sturgeon, and Caspian roach were around 500, 000 to 600, 000 tonnes, in the past decades. Such state in fisheries production was not changed till the early 1950s, then, thereafter small pelagic species fisheries has significantly increased in central and southern part of the Caspian sea to atone the decrease in catches of the aforementioned more important fish species. Total catch of kilka species has mainly maintained in level of 300, 000 and 400, 000 tonnes during the period between 1960 to 1980 (Barannik et al. 2004).

During the past three decades kilka species and some other commercial fisheries in the Caspian Sea were suffered from significant decreases. Such decreases has been observed in total catch of the major commercial species of kilka in the Caspian, anchovy kilka, which suffered significantly from alteration (decrease trend). The catch of kilka by Russia, Azerbaijan, and Iran dropped from 182, 700 t in 2000 to 74, 700 t in 2001 and maintained really low after this time (Mamedov 2006). Over the period 2000 to 2011 a continuous decline of catches has been observed, the stock dramatically collapsed in 2001 and reached to its historical minimum in 2011. Dramatic collapse in mainly fisheries resource of the Caspian sea and also failure of biodiversity and ecosystem persistence in this sea became a widespread concern in the regional and internationally scales.

With regard to the important role of the kilka fisheries as main source of income and protein for Iranian people in coastal area of the Caspian sea, such dramatic collapses might have unfavorable influences on economy and

local protein intake (Fazli 2007). Accordingly Bagheri et al. (2004) reported economic losses around US$15 million, from decrease of anchovy kilka catches off Iranian over period of 1998 to 2001. Hence, as elsewhere, sustainable management of small pelagic fish can be vital for the fisheries and the ecosystem health of the Caspian sea.

Several studies has been conducted in case of kilka species in the Caspian Sea which according by Mamedov (2006) this studies started in 1940s. The study of kilka species has been followed by others for instance Prikhod’ko (1975), Paritskiy (1989), Mamedov (2006) and Fazli (2007). Many studies has conducted in Iranian waters of the Caspian Sea. the most of these previous studies were subjected to biological characteristics, ecologic features, distribution and stock assessment of the kilka (e. g. Pourgholam et al. 1996; Fazli and Besharat 1998; Fazli 2007; Karimzadeh 2011; Aliasghari and Parafkandeh Haghighi 2013). However in previous studies several mechanisms have been proposed as reasons of aforementioned fluctuation of the kilka species in the Caspian Sea during the last decade (Mamedov 2006; Daskalov and Mamedov 2007; Fazli 2007; Kideys et al. 2008; Roohi et al. 2010; Fazli 2011). Accordingly the recent study on anchovy kilka by Daskalov and Mamedov (2007) reported several candidate mechanisms which may be responsible for such a decline of the kilka species. In this study authors believed that the major stress factor for the Caspian sea pelagic ecosystem in the past decades was the invasion of the ctenophore (comb jelly) M. leidyi. This invasion and spread of the ctenophore M. leidyi in the Caspian Sea has been introduced as the most possible primary cause of recruitment failure and the stock collapse of this specie, although other

factors, including overfishing, climate change and seismic activity suggested as factors may negatively influenced dynamics of this species.

Although in previous studies the effect of the climate and environmental variability on kilka species has been mentioned as one of the hypothesis that may be responsible for the fluctuation of the kilka species the detailed information about the role of climate and environmental variability on fluctuations of these commercially important species during the last decades was (still is) not clear. To our knowledge, however, only few long-term studies are currently available in relation to climate and environmental variability in the Caspian Sea (e. g. Nezlin 2005; Lougheed 2006; Moradi 2013; Fendereski et al. 2014) that mainly focused on the dynamics of Chl-a concentration, and also physical and chemical characteristics of the Caspian Sea. Despite the widely used hypothesis of the role of climate changes in fluctuations of small pelagic species there is still no detailed investigation on kilka species in the Caspian Sea during recent years. Hence, in this study the following objectives and hypothesis has been defined to illustrate the role of climate driven effects on the fluctuation of these kilka species.