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RECENT CHANGES OF THE TURKISH ANCHOVY FISHERY IN THE BLACK SEA WITH SPECIAL REFERENCE TO CLIMATE CHANGE

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Abstract. The Black Sea ecosystem, suffering ecological deteriorations through long-term changes induced by natural and anthropogenic factors, needs to be continuously monitored for its environmental state and ecological processes. In this study we have analysed the changes of the sea temperature over the 25 years of period in the southern Black Sea to look at if there has been an effect of climate changes on the Turkish anchovy fishery. Conclusions derived through this present study, comparisons for assessing changes in the Black Sea ecosystem related to climate changes and Turkish anchovy fishery can be summarised as follows: It is clear that there has been an increase in temperature especially in the winter months in the southern Black Sea. Although the data set is not good enough for a complete analysis of the effect of global warming on anchovy fishery, together with ecological problems, pollution, over-fishing, oil prices and tendency in temperature increase over the years may be of the other reasons for anchovy crisis observed in the late 80's.

Keywords: the Black Sea, anchovy, climate change, ecology.

AIMS AND BACKGROUND

The Black Sea is of global interest on several levels, since the coastal and shelf zones of the Black Sea are a mosaic of complex, interacting ecosystems with immense economic significance, rich natural resources and ecological communities, and concentrated human activities. They contain biologically productive, diverse ecosystems that provide a vital habitat for many commercial and endangered species. Until recently, the Black Sea supported fisheries almost 5 times richer than those of the neighbouring Mediterranean[1].

The Black Sea ecosystem, suffering ecological deteriorations through long-term changes induced by natural and anthropogenic factors, needs to be continu-

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ously monitored for its environmental state and ecological processes. One of the most practical and appropriate parameter, which can be used for monitoring the marine ecosystems, is chlorophyll *a* concentration. Its level correlates well with primary production and it is widely accepted as an index of phytoplankton biomass. It has been monitored in the Black Sea for several decades and a large volume of data is available at present[2].

It is well known that environmental factors have an important role on reproduction, development and populations characteristics of fish and aquatic organisms. Each fish needs to a certain water temperature for survive and reproduction for example. Physical and chemical properties of seawater and oceanographic events such as current, tide, temperature and light have direct or indirect impact on fish behaviour and stocks. For example, currents carry fish eggs and juveniles from spawning to feeding areas. In the same way, fish demonstrate different behaviour via light influence[3]. If it is known that effect of environmental parameters and changing of these parameters, it is possible the amount of catch to be estimated[4]. Estimation of amount of catch has an important role for making a good plan and taking precaution in terms of fisheries management. When amount of catch is more than suggested, it is likely to have an overfishing problem. One of reasons for the crisis during the 80's is a good example in the Black Sea.

It is known that anchovy has more than 50% percent in fisheries sector in Turkey, when investigating anchovy catch values it is easily seen that values revealed continuous increase from 1975 to 1988. After 1988, a decrease in catching anchovy has been observed. The amount of anchovy was 295 000 metric t in 1988, while in 1989 and 1990 the amount of anchovy demonstrated a decrease, respectively, 97 000 and 66 000 metric t (Ref. 5). Fisheries sector was affected seriously by fluctuation of anchovy catching in the following years, which attracted attention and provoked debates[6].

These decreases result due to extreme catching operations[7,8] and appearance of uncontrolled changing in the Black Sea ecosystem[9,10]. When evaluated as productive ecosystem to mid-1970's, changing of water parameters and nutrient composition, entering exotic species and excessive catching caused unexpected changes. Pelagic populations firstly have replied these unexpected changes[11,12].

Excessive growing of Ctenophore *M. leidyi* which moving via ballast waters from USA with ships, caused considerable changes in the Black Sea ecosystem in the early of 1980's (Ref. 10). Icthyoplankton fauna extremely decreased in the Black Sea in the late 1980's and early 1990's (Refs 13 and 14). The decreasing of icthyoplankton fauna caused dramatically excessive decrease in economic fish species (Fig. 1). Figure 1 shows changing of long period anchovy catching values[15] and biomass of *M. leidyi* values[12] in the Black Sea.

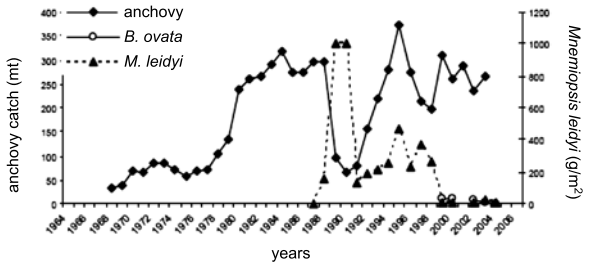

Fig. 1. Anchovy catching values (metric t) and biomass of *Mnemiopsis leidyi* by years

Water temperature is an important factor for reproduction and migration of anchovy. In the same way abundance of plankton related to temperature. It is known that anchovy eggs and larvae are generally distributed between 0–3 m in pelagic zone and pelagic zone is rich area in terms of plankton[16].

In this scope the present study aims to determine relation between sea level temperature, primary production and Turkish catching values by years in area.

EXPERIMENTAL

In the present study, the relation between sea surface temperature, primary production and anchovy catches was evaluated by years in the Black Sea. Sea surface temperatures of the last 13 years were obtained from Turkish State Meteorological Service. Chlorophyll *a* observations were provided from published sources including the data for the last five years from marine sciences laboratories at Karadeniz Technical University.

RESULTS AND DISCUSSION

Temperature. When changes of the sea surface temperature by years of eastern Black Sea were investigated, it was noticed that the mean sea surface temperature in November and August was gradually increased during the last 50 years (Fig. 2). It is known that anchovy generally form a 'school' in November. It is also well known that fluctuations in sea surface temperature are important parameters for schooling and for that particular fishery[17].

Catch. Anchovy are distributed along the north and middle East Atlantic region, Mediterranean and Black Sea in the world. Turkish anchovy fishery has high proportion in the total production. World anchovy production has a regularly increasing tendency from 1950 to 1984 as it was in Turkey (Fig. 3) except for the 70' when an economic crisis took place in Turkey.

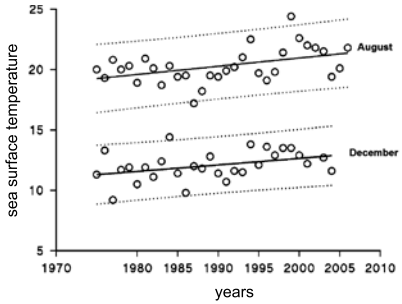

Fig. 2. Mean sea surface temperatures in the Black Sea by years

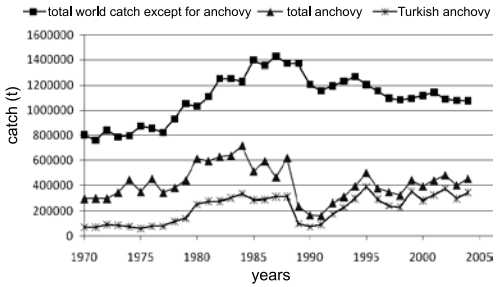

Fig. 3. European anchovy catch (metric t) by years

When the anchovy catches together with the other economic species by years were investigated (Fig. 3), a gradual increase in the catches was observed, in the late 80's, however, a rapid drop in anchovy fishery took place. This emphasised an ecological crisis since not only overfishing but ecological problems of the ecosystem caused by *M. leidyi* were blamed for[10]. After a clear recovery of the crisis from 1989 to1990 it was again increased up to the former same values. A number of researchers have indicated that there have been different reasons for the crisis including overfishing and ecological reasons[9,18]. Little has been said about environmental effects and the dramatic increases in the oil prices on the world oil market[8,19] (Fig. 4).

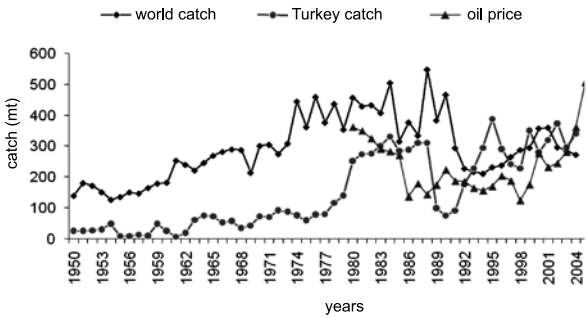

Fig. 4. Fluctuation of world catch, Turkey catch and oil prices by years

Primary productivity. The mean monthly distributions of chlorophyll *a* values derived from *in situ* (present study) and CZCS data are shown in Fig. 5. The distributions are quite variable in the western shelf region, south region and the whole basin. In the south eastern region, it is similar from April to October except for a small decrease. The distributions in the western shelf region differed significantly from south eastern and the whole basin. The western shelf, however, had a higher mean concentration than of other regions for all seasons. Chlorophyll *a* concentrations within the western shelf regions differ significantly especially for warm seasons, but in the south-east region its concentrations are low especially for warm seasons. The highest chlorophyll *a* concentration was observed in October in the south-eastern region. It is known that the Black Sea has two big blooms which occurred early spring and late autumn during the year. Our results also support this information.

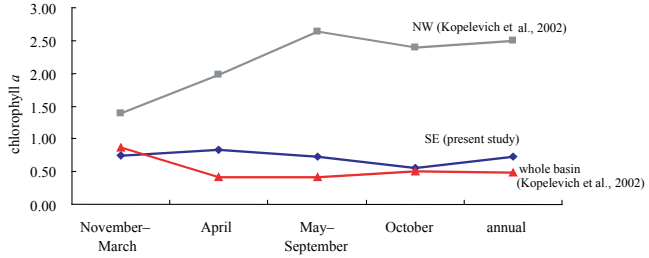

Fig. 5. Annual chlorophyll *a* concentrations

When annually chlorophyll *a* and primary production fluctuations have been compared, it is clearly seen that both chlorophyll *a* and primary production values gradually increase in the 4-year data sets (Fig. 6).

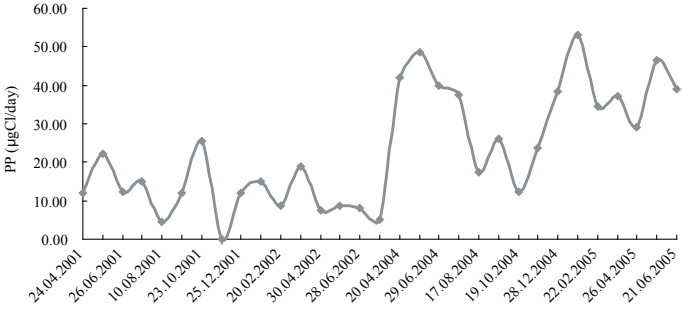

Fig. 6. Annual chlorophyll *a* and primary production fluctuations by years

In the 80's dramatic reductions have been reported not only for Turkish Black Sea fisheries, but also for the fisheries of other riparian countries[10]. However, some increase is noticed due to large introduction of new fishing technology and also

some important factors such as increased nutrients, particularly on the north-western shelf[20]. However, eutrophication (particularly in the shallow north-western region) in combination with overfishing and the recent appearance of the competing invader *M. leidyi* (Ctenophora) appears to be the reason for an abrupt decrease to 60 000 t in *E. encrasicolus* catches in the end of the 1980's.

In the present study we have analysed all the period again by following the changes of the sea temperature over the last 25 years in the south-eastern Black Sea, in order to decide whether the temperature has affected the Turkish anchovy fishery. The primary productivity over the years for which the data are available has been related with the catch values in the area and discussed with the information published. Over the years, the Black Sea ecosystem has been studied in details (Refs 4, 7, 8, 10–12, 14, 16, 21) as a result there is a great deal of information available related to anchovy fisheries in the Black Sea.

Relationships between recruitment, parental stock biomass and physical environment variables in four Black Sea species: sprat *Sprattus sprattus*, whiting *Merlangius merlangus*, anchovy *Engraulis encrasicolus* and horse mackerel *Trachurus mediterraneus*, were investigated by Daskalov[21]. Also sea surface temperature, wind speed, wind stress, wind mixing, sea level atmospheric pressure and river run-off data were used as indices of interannual variability of the Black Sea environment were investigated. In another study, composition of eggs and larvae of fish and macrogelatinious zooplankton in Sinop region (The central Black Sea) during 2002 was conducted by Satilmis et al.[11], this study was carried out in order to determine abundance and distribution of macrogelatinous organisms (*Aurelia aurita*, *Pleurobranchia pileus*, *Mnemiopsis leidyi* and *Beroe ovata*) with respect to fish egg and larvae in Sinop region in 2002. Also, the changes of the Black Sea ecosystem and its impact on anchovy fisheries were documented recently by Bat et al.[12]. In this study it was revealed that as a result of eutrophication caused by increased nutrient input via major northwestern rivers during the last few decades, the Black Sea ecosystem has been subject to extreme changes in the recent years. Abnormal changes due to altered nutrient balance were reflected in the qualitative and quantitative composition of phytoplankton and zooplankton. The increase observed in the quantity of plankton was probably responsible for the rise of Turkish anchovy catches observed over the last few decades. Apart from those mentioned above the other possible reasons for the decrease in *E. encrasicolus* stock in the Black Sea are extensive fishing, uncontrolled development, and pollution of the ecological system.

Sea surface temperature (SST) of the Black Sea evaluated by years in the present study revealed that there has been a slight increase in mean temperature values in October and November in the last 25 years period. In 1982, SST was 14.1°C in October, it reached to 16.5°C with a slight fluctuation in 2006. The same situation was also determined for November. In the mean time we have looked at

the average temperature of the 3 months: November, December and January, of all years from which data have become available and plotted against together with total anchovy catch (Fig. 7).

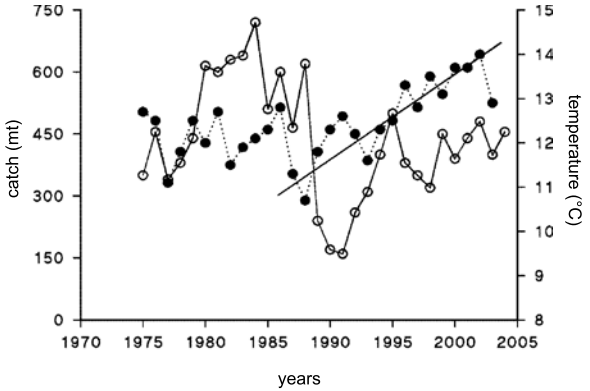

Fig. 7. Average temperature and anchovy catch by years (open dot indicates the annual anchovy catch, solid is temperature)

Temperature during the first period of data set which lasted from 1975 to 1985 has fluctuated a little but not changed very much, lateron it is clearly seen that an apparent increase in temperature in the late 1980's resulted in dramatic reduction in the anchovy catch. Similar trend was also observed in the overall SST in the Black Sea. The trend of increase in winter SST in the all area for last decade is in agreement with one we presented here (Fig. 8).

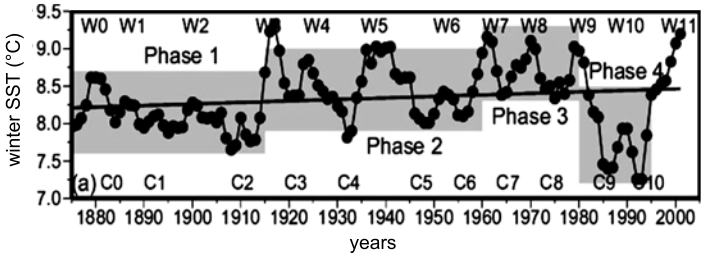

Fig. 8. Change of SST (°C) in the Black Sea over the last 13 decades[22]

Long-term data obtained since the 1960's have shown that primary production in the Black Sea generally displayed two phytoplankton maxima throughout the year: the major one occurred in early spring (mainly diatoms) while a secondary peak appeared in autumn (mainly coccolithophorids). More recently (after the mid 1990's till present), additional summer and more significant autumn blooms (dominated by dinoflagellates and coccolithophorids) have frequently been observed both in the coastal and open waters. Primary production ranged from 570 to 1200

mg C m^{-2} d^{-1} at the NW shelf, between 320 to 500 mg C m^{-2} d^{-1} in the regions of continental slope and between 100 to 370 mg C m^{-2} d^{-1} in the central deep sea regions during 1960–1991 period. Similar primary production rates (247–1925 mg C m^{-2} d^{-1} for spring and 405–687 mg C m^{-2} d^{-1} for summer/autumn periods) have been estimated for the southern Black Sea for 1995–1996 period[23].

When annual primary production (PP) is considered by years (Fig. 7), it shows a rise and fall by 2002. PP shows also an increasing tendency from 2002 to 2005. It can be easily realised from the data sets of Yilmaz et al.[23] in southern Black Sea coast PP that it is low when compared to northern coasts. In the present study, PP values show low, as a result of unit of PP as µg C/l day. Our PP results also support decrease in Turkish anchovy catch during crisis and after that.

CONCLUSIONS

Comparisons for assessing changes in the Black Sea ecosystem related to climate changes and Turkish anchovy fishery can be summarised as follows:

1. It is clear that there has been an increase in temperature especially in the winter months in the southern Black Sea.

2. Although the data set is not good enough for a complete analysis of the effect of global warming on anchovy fishery, ecological problems, pollution, over-fishing, oil prices and tendency in temperature increase over the years may be of the other reasons for anchovy crisis observed in the late 1980's.

3. At this stage we are not able to state clearly the effect of increase in temperature on anchovy fishery in the Turkish part of the Black Sea.

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