Acoustical Estimation Of Relative Spatial And Vertical Distribution Of Southern Black Sea Zooplankton

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Abstract: The Black Sea is being subjected to severe ecological changes, mainly driven by human impacts. Consequently, zooplankton, which is an important link in the energy transfer between primary producers, and higher trophic levels, such as fish, were equally affected. Their species composition, abundance and even vertical distribution have changed, which in turn, influenced fish and fishery of the Black Sea.

In this study, an acoustical survey has been conducted in July 1996, which coincides with the spawning season of Black Sea anchovy and in September 1996. Spatial and vertical distribution of the zooplankton were assessed within Turkish EEZ. The relative abundance of the zooplankton obtained from analysis were extrapolated to southern Black Sea and presented in a distribution chart. At different regions, where peculiar vertical features were observed, daily migration patterns were studied and depicted in distribution diagrams.

Introduction

The Black Sea has been subjected to various human impacts for few decades and its oligotrophic character has progressively changed to mesotrophic and then eutrophic, and in some places even to dystrophic (Sorokin, 1983; Zaitsev, 1992; Caddy, 1993).

Increase in nutrients has elevated the rate of primary and secondary production. On the other hand, eutrophication brought about a change in species composition of phytoplankton, and due to this change, many zooplankton species populations, have become scarce or disappeared. Many large species of crustacean zooplankton replaced by smaller species and the omnivore species (Zaitsev, 1992).

As a consequence of increased zooplankton populations, the abundance of planktivorous fish species increased (Caddy, 1990; Gücü, 1997). The total catch raised gradually with small pelagic fishes like anchovy and sprat those made 30 % of the catch (GFCM, 1993). In 1980's the total catch of small pelagic fish doubled However, in 1989, a sharp decline occurred in fish stocks resulted in collapse of fishery. In the same period, *Mnemiopsis sp.*, an introduced ctenophore, spread out all over the Black Sea by a sudden increase reaching to 800 million tons of total biomass (Vinogradov et. al., 1989).

According to some authors, the reason for the collapse of fishery was due to possible predation of *Mnemiopsis sp.* on anchovy egg and larvae, while others were suggesting the sharp decline of fish stocks resulted from over-fishing. This debate is still unsolved, on the other hand, recent studies showed that anchovy egg and larvae constitute only a minor part of *Mnemiopsis* diet (Tsikhon-Lukanina et al., 1990;

Tsikhon-Lukanina and Reznichenko, 1991). Anchovy and *Mnemiopsis* both feed mainly on copepods, and compete for the same food source.

After the outbreak of *Mnemiopsis* sp. in the Black Sea, the vertical distribution of copepods also underwent significant changes. Since the *Mnemiopsis* inhabit above the thermocline, the copepod species that migrate vertically and spend at least a part of their life just above suboxic layer, has gained advantages over those inhabiting surface waters.

The aim of this study is to observe the spatial and vertical distribution and relative abundance of zooplankton with respect to fisheries in the Black Sea, by using acoustical methods that enables to search a large area and shortens the time needed.

Methods

The data were collected during June-July and September 1996 Black Sea cruises of R/V BILIM of Middle East Technical University Institute of Marine Sciences (METU-IMS). The cruises covered the southern part of the Black Sea - Turkish EEZ. The shipborne ADCP (Acoustic Doppler Current Profiler) recorded data throughout the cruises. ADCP transmits acoustic pulses and receive backscattered sound from plankton and small particles riding the water currents.

ADCP backscatter

The ADCP records routinely the values of echo intensity per ping (transmitted sound pulse). The ADCP was normally set up with 70 bins (depth ranges) each of 4 m. depth, 2 m blank after transmit, and a 10 min. averaging interval. The ADCP is at a depth of about 3 m. on R/V BILIM; therefore the first bin is from 5 to 9 m. below the surface. The bin nearest to the instrument was not included in the summation, since it is likely to be contaminated by flow noise and bubbles.

In order to process the backscattered signal strength, the following steps were followed:

The echo intensity given by ADCP output values are biased because; i) echo intensity contains ambient noise as well as sound reflected by the targets, ii) transmitted signal is reduced by radial spreading of the sound beam, iii) and acoustic energy is absorbed as it propagates through the water column.

To correct the echo intensity by eliminating the noise, the ambient noise threshold was estimated by examining echo intensities where they reach to a steady value at lower depths. Then noise (Ne) was subtracted from signal counts of each ping.

The range correction (Rc) was applied as follows:

$$TL = 20\,\mathrm{Log}(r) + 2ar - 10\,\mathrm{Log}(10^{-3}D)$$

Where TL is the two way transmission lost, r is the range in meters; a is the attenuation coefficient (0.06 dBm^{-1}; Urick 1983); D is the ensonified stratification size in meters.

Results

Although it is not possible to give absolute zooplankton values at this step, if acoustic units are compared, the average of overall southern Black Sea zooplankton was higher during June-July 1996 than September 1996 survey.

Spatial Distribution of zooplankton

June-July 1996

The relative distribution in southern Black Sea of the zooplankton are shown in Figure 1. The abundance is apparently higher in coastal waters as compared to offshore region. Other remarkable findings are the dense zooplankton aggregations i) around Bosphorus region, from western most end of the study area towards Kefken; ii) in front of Sakarya River; iii) at the central Black Sea, near to Sinop and iv) between Kızılırmak and Yeşilırmak Rivers. On the contrary, eastern part of the Black Sea, around Batumi region was conspicuously arid in terms of zooplankton biomass.

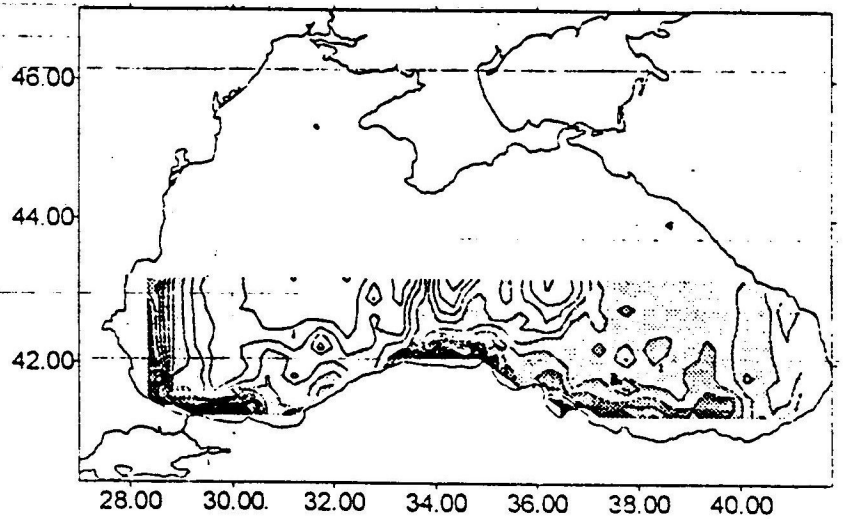

Figure 1. Spatial distribution of zooplankton in southern Black Sea during June-July 1996 survey

September 1996

Figure 2 consists noticeable features of relative distribution observed in June-July 1996 cruise. The only difference is that; the high abundance near to Sinop was not observed during September 1996 cruise.

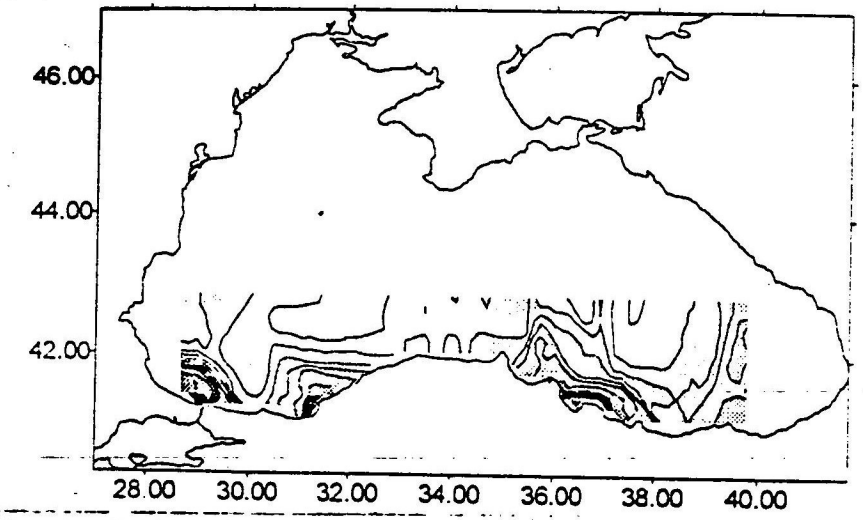

Figure 2. Spatial distribution of zooplankton in southern Black Sea during September 1996 survey

Vertical Distribution of the Zooplankton

June-July 1996

The vertical distribution of zooplankton during June-July 1996 cruise is shown in Figure 3. The highest abundance in surface waters was at 21:00 and lasted till 01:00, there with the zooplankton began to migrate downwards and remained there until 18:00. Later, they began to ascend through the surface again.

September 1996

The zooplankton performed a similar vertical distribution to previous cruise (Figure 4). They reach to the highest abundance in surface waters at nearly 18:00. The zooplankton descend downwards at 22:00 and remained there until 14:00.

Discussion And Conclusion

Considering the hydrography of the Black Sea, the results were in good agreement with the expectations.

In coastal waters, especially around Sakarya, Kızılırmak and Yeşilırmak Rivers' runoff areas, the relative abundance is higher because of nutrient input.

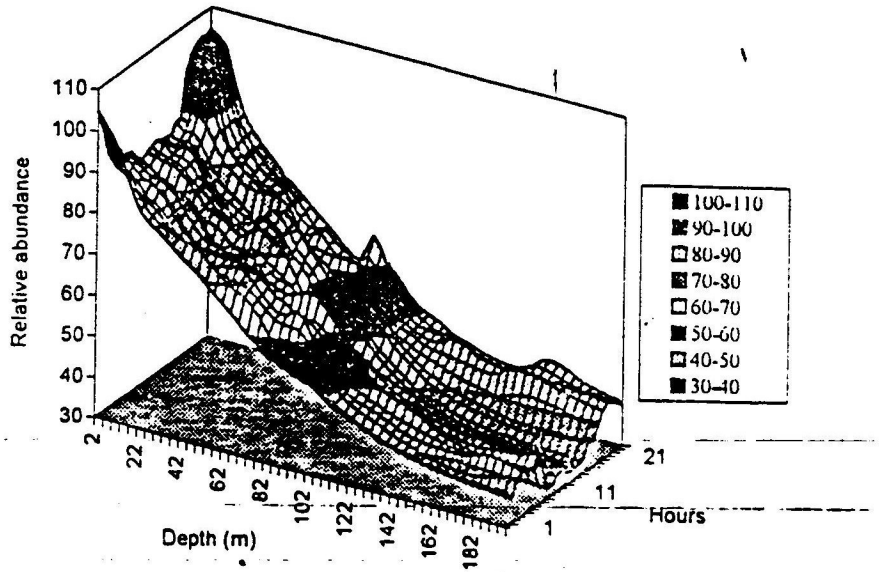

Figure 3. Vertical distribution of zooplankton in southern Black Sea during June-July 1996 survey

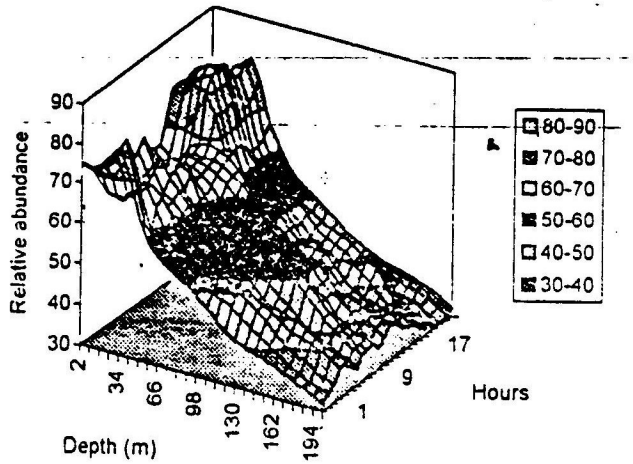

Figure 4. Vertical distribution of zooplankton in southern Black Sea during September 1996 survey

The rim current prevents the flow of this nutrient rich coastal waters to offshore so that the open waters is less abundant than coastal waters.

The significantly high abundance region along the north western towards Kefken is an evidence of the effect of Danube river runoff. The eutrophic waters of drainage area of Danube River flow southward as it was obstructed by rim current and it causes an increase in relative abundance of zooplankton.

The high abundance region near Sinop is a result of regional upwelling. This upwelling area was not observed during September cruise since it occurs seasonally, in early summer till early autumn. (Sur et. al., 1994).

Like Batumi anticyclonic gyre, the east and west cyclonic gyres are the arid areas of southern Black Sea. Although the cyclonic gyres are expected to be productive, since these gyres act as barriers to nutrient input from surround and the nutrient they have was utilised rapidly, they became arid.

In the vertical distribution diagram, one can see that the time where the zooplankton have the highest abundance in surface waters is shifted in September nearly two hours before than it was in June-July cruise. Since the day-time is shortened in September, the zooplankton begin to ascend through the surface earlier according to the sunset time.

Consequently, spatial distribution of zooplankton in the southern Black Sea coincides with the hydrographic features of the Black Sea. And also using ADCP in such a study is convenient since it shortens the time needed and reduces the effort. On the other hand, ADCP does not give absolute values. The ADCP data must be calibrated using the net sampling data to gain the absolute values by ADCP.

Acknowledgement

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