3D SPATIO-TEMPORAL VERTICAL DISTRIBUTION OF ZOOPLANKTON AS ACOUSTICALLY INFERRED IN THE TURKISH SEAS

Erhan Mutlu

Institute of Marine Sciences, Middle East Technical University, Erdemli, Turkey - mutlu@ims.metu.edu.tr

Abstract

Sagitta setosa and *Calanus euxinus* showed spatio-temporal distribution in the Black Sea thereafter they were acoustically identified. *C. euxinus* overwintered from March to May, August. *S. setosa* were completely adult during January-June whereas their juveniles predominated in warm seasons. Their generation's time was July and September. Zooplankton community was restricted in upper water above the interface in Marmara Sea. *Aurelia aurita* aggregated just above the interface (evening), were dispersed towards the surface (midnight) to form community during the daylight. The Mediterranean zooplankton was composed of two scattering layers: one migrated between surface and thermocline and other below thermocline.

Keywords: Zooplankton, distribution, bioacoustics, Black Sea

About 150 zooplankton species are reported for the Black Sea, including numerous brackish-water and freshwater organisms restricted to coastal areas. Only about half of the Black Sea species occur in the Mediterranean. All taxonomic groups of planktonic animals are presented in the Eastern Mediterranean (EMED), but few have penetrated into in the Black Sea. This seems to be mainly due to differences in salinity between the two basins. Typical stenohaline organisms such as radiolarians, siphonophores, pteropods, and salps, common in the Mediterranean, do not occur in the Black Sea. Abundant groups, such as copepods, chaetognaths, and medusae, are present in much reduced numbers in the EMED. Appendicularia, Chaetognatha, Cladocera, Copepoda, Polychaeta, Gastropoda and Bivalvia larvae, Scyphozoa, and Ctenophora were found in the Sea of Marmara (1-6).

Monthly acoustical data from different years were collected with a scientific echosounder and Acoustic-Doppler-Current-Profiler.

Sagitta setosa was acoustically identified by looking at their diel migratory pattern in different months in the Black Sea. In cold-water season when population consisted of adults, they concentration layer coexisted with *Calanus euxinus* in Oxygen-Minimum-Zone (OMZ). In warm-water season when juveniles comprised more 60% of the population, they stayed in the oxycline. In July and September, individuals of new generation did not migrate and stayed in subsurface water. *S. setosa* speeded up in well-oxygenated subsurface water. *S. setosa* completed migration within 4 hrs at 0.38 cm s^{-1} (7).

C. euxinus were acoustically discriminated with respect to vertical migration and swimming speed, according to dissolved oxygen (DO) concentration and timing of migrations. Species became torpid in water with DO values <0.5 mg l^{-1}. Time spent swimming under DO conditions between 2 and 5 mg l^{-1} was insignificant, and varied from the 10% to 25% of total time spent swimming (5 h) under normoxic conditions (5–10 mg l^{-1}). *C. euxinus* formed a concentration layer in the water of 1–3 m thickness. Upward migration was completed in about 3.5 h, starting 2.5 h before and ending 1 h after sunset (average rate: 0.95 cm s^{-1}) in summer. Species ascended discretely from the suboxic to the lower boundary of cold intermediate layer (CIL) at 0.82 cm s^{-1}, and passed up the CIL and thermocline fast (2.3 cm s^{-1}). Downward migration took less time (2 h), starting ~1 h before and ending ~1 h after sunrise. Swimming speed within the thermocline and CIL was 2.7 cm s^{-1}; copepods subsequently returned to daylight depth at 0.57 cm s^{-1} (8).

The noise was 4 dB higher in the Sea of Marmara than in the other two Seas. This could have changed the "hardness" of the interface due to the biological variations as Korneliussen (9) suggested that bottom variations. Hardness of the interface could be associated with density of jellyfish, *Aurelia aurita*. Their swimming rhythms showed that they could be jellyfish (10). A variation of about 10-15 dB and occurrence of a peak every 25-30 s due to swimming of the jellyfish were observed in individual scatterers rising from the interface. 200 kHz data showed significant correlation between measured and calculated volume backscattering (Sv), and density of the taxa. Large-sized copepods and chaetognaths in the Black Sea, *Aurelia*, *Beroe* and chaetognaths and large sized and abundant appedicularians in Sea of Marmara and fish larvae in the Mediterranean Sea contributed most to the Sv. Biological scattering was vertically distributed between surface and suboxic zone in the Black Sea, whereas it was confined between surface and interface formed between waters of the Black Sea and Mediterranean Sea in the Sea of Marmara. The Mediterranean Sea was very different in terms of the volume backscattering due to absence of shallow interface. Acoustical scattering was layered in and above the suboxic zone during the daytime in offshore waters of the Black Sea, while it was aggregated in the mixed layer at night hours. As the bottom depth was shoaled, the volume backscattering strength became homogenous. In the Sea of Marmara, the scattering was much intensified and layered just above the interface during the daytime, whereas it was homogenously distributed within the mixed water characterized with the Black Sea above the interface. During daytime, the layer between interface and transducer depth was deserted by the plankton. Moderately high scattering was observed in the upper 100 m in the Mediterranean Sea at night, while the scattering observed in the upper 60 m layer during the day was less intense since vertical migratory species deserted the upper layers.

References

1 - Niermann U., Bingel F., Ergun G., and Greve W., 1998. Fluctuation of dominant mesozooplankton species in the Black Sea, North Sea and the Baltic Sea: Is a general trend recognizable? *Tr. J. Zool.*, 22: 63-81.

2 - Kovalev A.V., Skryabin V.A., Zagorodnyaya YuA., Bingel F., Kideys A.E., Nierman U., and Uysal Z., 1999. The Black sea Zooplankton: Composition, spatial/temporal distribution and history of investigations. *Tr. J. Zool.*, 23: 195-209.

3 - Kovalev A.V., Mazzocchi M.G., Siokou-Frangou I., and Kideys A.E., 2001. Zooplankton of the Black Sea and the Eastern Mediterranean: Similarities and dissimilarities. *Medit. Mar. Sci.*, 2/1: 69-77.

4 - Mutlu E., 2002. A comparison study on biology and bioacoustics of the Turkish Seas and TS of European flying squid. ICES Symposium "Acoustics in Fisheries and Aquatic Ecology" Montpellier, France 10-14 June 2002, 444-451.

5 - Mutlu E (in review). An intercomparison of the contribution of zooplankton and nekton taxa to the near-surface acoustic structure of three Turkish Seas. *Mar Ecol: PSZN.*

6 - Salihoglu I., and Mutlu E., 2000. National Sea research and monitoring program Mediterranean Sea, Sea of Marmara, Turkish Straits System, Black Sea and atmospheric subprojects period 1995-1999: Synthesis Report. "Ulusal Deniz Araştırma ve İzleme Programı, Akdeniz, Marmara Denizi, Türk Boğazlar Sistemi, Karadeniz ve Atmosfer Alt projeleri, 1995 - 1999 dönemi sentez raporu". TUBITAK, IMS-METU, Erdemli, Nov 2000, 449 p. (In Turkish).

7 - Mutlu E., (submitted). Does the other layer belong to *Sagitta setosa*?: Diel vertical migration as inferred acoustically in the Black Sea. *Mar. Ecol. Prog. Ser.*

8 - Mutlu E., 2003. Acoustical identification of the concentration layer of a copepod species, *Calanus euxinus*. *Mar. Biol.*, 142: 517-523.

9 - Korneliussen R.J., 2000. Measurement and removal of echo integration noise. *ICES J. Mar. Sci.*, 57(4): 1204-1217.

10 - Mutlu E., 1996. Target strength of the common jellyfish (*Aurelia aurita*): a preliminary experimental study with a dual-beam acoustic system. *ICES J. Mar. Sci.*, 53: 309311.