OFFSHORE DIEL VERTICAL DISTRIBUTION OF MESO/MACRO-HOLO/ MERO ZOOPLANKTON IN THE SOUTHERN BLACK SEA

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ABSTRACT. Diel vertical distribution and migration (DVM) of meso and macro zooplankton in the Black Sea were studied at one constant station using plankton net in April 1995 and macro zooplankton in August 1993. Five common copepod species were found during the studies. *Acartia clausi* was distributed in the uppermost layers, *Pseudocalanus elongatus* within layer with temperature < 8 °C (the CIL), *Calanus euxinus* throughout the oxygenated layer, *Oithana similis* above the CIL in summer but in both the CIL and the upper mixed layer in spring and autumn, and *Paracalanus parvus* mostly in the upper layers. Additionally, eight taxa belonging to non-copepods were evaluated in the present work; namely, Appendicularia (*Oikopleura dioica*), Cladocera (*Pleopis polyphemoides, Podon leucarti, P. intermedius, Evadne spinifera, and E. nordmanni*), Cirripedia larvae, Polychaete larvae, Bivalvia larvae, Chaetognatha (*Sagitta setosa*), Scyphozoa (*Aurelia aurita*), and Ctenophora (*Mnemiopsis leidyi* and *Pleurobrachia pileus*). Three different groups were observed in regard to their vertical distribution layers: the uppermost layer inhabitants (Cladocera, Bivalvia and cirriped larvae, *Aurelia* and *Mnemiopsis*) that were distributed in correlation with the chlorophyll-α and fluorescence within a narrow depth range; the second group, appendicularians formed patch in both the upper layer with high Chl-α and fluorescence, and the deep water characterized with fine-particle maxima whereas *Pleurobrachia* and *Sagitta* were found within the CIL; deep layer dweller (Polychaete larvae) migrated within the deep homogenous layer in reverse relation to *Pleurobrachia* migration. *Mnemiopsis* extended over a narrow range of vertical depth by day and night being confined to the upper part of the mixed layer. Few individuals were localized below thermocline at night. *Pleurobrachia* was found mostly beneath the thermocline down to the anoxic layer. The vertical distribution of *Pleurobrachia* was manifested by a two-maximum structure at night. Upper maximum was less pronounced than the lower maximum during the day time. *Aurelia* was strictly associated to the upper mixed layer and layer above seasonal pycnocline.

Keywords: zooplankton, diel vertical distribution, DVM, marine snows, Black Sea

INTRODUCTION

The Black Sea has a wide spectrum of hydrographic features (sharp seasonal and permanent stratification layered with changing condition vertically in salinity, temperature, density, dissolved oxygen, and hydrogen sulfur, currents, aerobic and anaerobic zone). Vertical distribution and diel migration (DVM) of the zooplankton occurred within the oxygenated zone of the water column. The vertical distribution was restricted to the depth until H₂S present at about a depth corresponding to sigma theta equal to 16.2. Tiselius [1] showed variations in the diel vertical distribution under the different physical conditions with regard to their sex, stages, and size of the species. The first extensive study on the vertical distribution of the mesozooplanktonic multiple-species in the Black Sea was represented by Vinogradov et al. [2]. There are a few studies on vertical distribution of the meso and macro zooplankton in the southern Black Sea -
Turkish Economical Exclusive Zone. But the studies focused on some certain group of the zooplankton without including all at the same sampling and daily hour time series at one station [3-10].

The present study was aimed to show the diel vertical distribution and migration patterns of mero/holo meso/macrozooplankton in the southern Black Sea in spring (April 1995) and summer (July 1992 and August 1993) with respect to the biological, chemical and physical peculiarities of the water column.

MATERIALS AND METHODS

Samples for studying the vertical distribution and daily migration of the zooplankton were taken with a standard opening-closing Nansen net (0.7 m net diameter, 120 µm mesh) at one station in offshore waters of the western Black Sea in late April 1995 and at one station in August 1993 (00:00, 05:00, 10:00 and 19:00 h). for only gelatinous organisms (Fig.1a). A series of discrete vertical hauls was made at a speed of 1 cm s\(^{-1}\) from the top of the anoxic layer to the surface (0 to 150 m) at 15-m intervals over a times series (00:30-01:30, 01:30-02:30, 09:30-10:30, 17:30-18:30, 20:30-21:30, and 21:30-22:30 h in April 1995). The depth of the H\(_2\)S layer (according to sigma theta=16.2; [11]) was determined with a SeaBird CTD (Fig. 1c, d). On board ship, gelatinous macrozooplankton organisms were separated from the mesozooplankton using a 2 mm mesh sieve and sized. In the laboratory, specimens of copepods from the mesozooplankton were identified at the species level and enumerated. Vertical distribution was calculated from abundance data standardized on percent base.
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**RESULTS**

Appendicularia (*Oikopleura dioica*), Cladocera (*Pleopis polyphemoides, Podon leucarti, P. intermedius, Evadne spinifera, and E. nordmanni*), Cirripedia larvae, Polychaete larvae, Bivalvia larvae, Chaetognatha (*Sagitta setosa*), Scyphozoa (*Aurelia aurita*), and Ctenophora (*Mnemiopsis leidyi and Pleurobrachia pileus*) were additionally recorded for the diel vertical migration (DVM) besides the copepod species.

All specimens of *A. clausi* performed diel migration in the uppermost layer by staying above the pycnocline during the day and in the subsurface water at night (Fig 2A). Banse [12] showed that a salinity gradient of more than 0.3‰ m⁻¹ in 10 m prevented the vertical migration of small copepods as Bautista & Harris [13] also expressed that smaller neritic copepods migrate slightly in the upper layer.

*Calanus euxinus* migrated vertically through the entire oxygenated layer and did not however perform the diapause in April (Fig 2B). The females started migrating up earlier from the deep layer to the surface by dusk and stayed longer in the mixed layer at night than the male individuals did. Downward migration was the reverse. Vertical distribution of *O. similis* appeared in two different layers: One was above the core of the Cold Intermediate Layer (CIL) and the other below the core that acted (Fig. 2C). *P. elongatus* was a calanoid species that generally migrated and was distributed within the CIL profiled with a temperature less than 8 °C (Fig. 2D). Distribution of the male individuals below
the Minimum Temperature Layer (MTL, Fig 1c, d) could be due to representation of the MTL to the maximum Banse’s threshold with a value of 2%o throughout the 20-m layer what created a very effective barrier for the migration of small-sized male individuals (Fig. 2D, F). Copepodites and adult females of *P. parvus* were distributed above the CIL, and above the MTL, respectively while the males underwent regular diel migrations between the subsurfacial water and 110 m (Fig 2E).
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Fig. 2. Pattern of vertical percent distribution of the copepod species (A; A. clausi, B; C. euxinus, C; O. similis, D; P. elongatus, and E; P. parvus), and F; Banse’s threshold simulated to data of the present work. (a’; Calanus nauplii. a; copepodites. b; copepodid female. c; female. d; male. e; adults. and f; total).

Aurelia aurita were distributed over a narrow depth range in and above the thermocline both day and night. M. leidyi showed a similar pattern to A. aurita occupying the same layer (Fig. 3).

A few small-sized individuals were observed below the thermocline in April while M. leidyi was confined to a layer above the thermocline in August. P. pileus was distributed below the CIL but most of them performed diel migrations between the MTL and suboxic zone in spring while it was vertically distributed below the thermocline in summer resulting in two maxima just below the thermocline and just below the CIL during the day and night. A. aurita performed midnight sinking in August (00:00 hr) and April (22:00) (Fig. 1, 3).

Most specimens of Appendicularia were generally distributed above the MTL and showed an inconsistent migration pattern during both day and night (Fig. 3). Appendicularia peaked in the subsurface water where Chl-a displayed its highest value at a depth of 50 m where the pycnocline started, at a depth of 100 m where NO₂ + NO₃ levels peaked, and at a depth of 150 m where the light transmission dropped suddenly. The second accumulation layer of Appendicularia was a depth where the light transmission dropped to a minimum value of 80s% (Fig. 3).

Sagitta setosa was vertically distributed from the surface to the upper limit of the anoxic zone, but they accumulated mainly in the pycnocline and halocline during the day and by twilight the specimens were concentrated in the deepest of their distribution (Fig. 3). The species appeared in two main aggregations during the nighttime: One was just above the permanent halocline, the other was at a depth where NO₂ + NO₃ corresponded...
to the fine particle maxima displaying a peak in concentration. By day the chaetognaths were entirely absent in the upper waters but were concentrated within the lower part of the oxycline, where the oxygen content was 0.5-0.8 ml l\(^{-1}\) as was repeatedly observed in this study in the Oxygen Minimum Layer (OML) (Fig. 1, 3).

The aggregation was observed between 00:30 and 02:00 in a layer where the temperature ranged from about 7-to-11 °C (MTL). The present work showed that this species started to ascend after 18:00. Juvenile bivalves were found in the upper warm water above the permanent pycnocline, halocline, and the CIL, generally characterized by having a high Chl-\(\alpha\) concentration depicting the presence of phytoplankton that the Bivalvia filter as food. Barnacle nauplii remained completely unchanged as to their inhabitance of surface waters during the day (Fig. 3).
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Total mesozooplankton appeared with two maximum abundance concentrations in the water column during the day: The lower concentration occurred in the daytime and early nighttime while they yielded only a peak at surface around midnight. The upper concentration was above about 75 m, which was the area above the MTL extended to the thermocline and the lower concentration was found below 100 m where the microbial loop started and where the Dissolved Oxygen (DO) dropped to less than 150 µM l⁻¹ (3.36 ml/l = 4.8 mg/l) (Fig. 1-3) The remaining intermediate layers constituted the transition layer which the zooplankton used for the immigration. The subsurficial maximum was composed of Noctiluca, Paracalanus, Oithana, Pseudocalanus, Acartia, and sometimes Calanus species. In general, the cladoceran species were found in the uppermost layer situated above the pycnocline. The Polychaete larvae showed negative geotaxis in response to daylight between the anoxic and the MTL layer. They settled down to the subsoxic zone during the nighttime and during the daytime, rose up to the MTL corresponding to the mid-part of the oxycline where the NO₂ + NO₃ and Particulate Organic Carbon peaked. The larvae were found in the Oxygenated Zone (OZM) during the night when the other mesozooplankton and a gelatinous species, P. pileus deserted the OML. This suggests that the larvae could avoid others during the daytime by rising to the upper layers (100 m). Actually P. pileus captures fast moving organisms to eat. The larvae of benthic animals were one of the food items of this ctenophoran species (Fig 3).

Marine snow particles (stringers and globular aggregates) were observed at all depths. Certain layers showed higher concentration than others. Aurelia and Mnemiopsis inhabited the same layer while the preference of Pleurobrachia extended from the lower limit of Aurelia to the layer where the oxygen is almost depleted. Pleurobrachia was observed to possess two different appearances, namely, individuals with and without tentacles i.e. the individuals retracted the tentacles into its sheaths (Fig.4). Visual *in situ* inspection using Mini-ROVER (Mini-Remote operated vehicle, BENTHOS), ROV was carried out at two stations in July 1992 during which the organisms were observed throughout the water column. At station 41° 30’ N 31° 15’ E at noon (12:10 p.m.), while Aurelia seemed to share accompanying the upper mixed layer with Mnemiopsis, Aurelia was found to extend further down to the upper part of cold intermediate layer (25 m). Mnemiopsis was homogeneously distributed in the mixed layer (12-15 m) whereas Aurelia formed aggregations at 10 and 17 m depths. Overall, Pleurobrachia was first observed at the beginning of the thermocline (10-12 m), down to 20-25 m depth, where scattered individuals without tentacles were common. At the upper layer of cold intermediate layer, less abundant individuals of Pleurobrachia were delicate with the tentacles. On the pycnocline at 70-110 m, mass aggregations of Pleurobrachia with protracted tentacles were observed, below this depth down to the lower limit of inspection by Mini-ROVER (140 m), individuals of Pleurobrachia with retracted tentacles were found very rarely (Fig.4a). Marine particles (marine snows) was apparently observed at two layers. One was at 3 m and other was found at 30-40 m depth, with very high concentrations. The second layer of marine snow was well overlapped with the upper depth of the cold intermediate layer (Fig.4a).
At station 41° 30’ N 31° 30’ E at 03:40 p.m., all organisms displayed the same vertical distribution as mentioned before, i.e. the main layer of *Aurelia* and *Mnemiopsis* shifted upwards towards the surface. *Pleurobrachia* without tentacles formed aggregations more in the upper layer than that observed at station 41° 30’ N 31° 15’ E (12:10 p.m.). *Pleurobrachia* with the tentacles kept its position constant in the deep layer (Fig.4b). Apart from the visual observation by Mini-ROVER in July 1992 in the western Black Sea, two stations (41° 15’ N 37° 45’ E at 13:30 p.m. and 41° 10’ N 37° 45’ E at 14:50 p.m.) in the eastern Black Sea were also visually inspected for these organisms in August 1993. The surface waters were warmer in that period (25-26 °C) compared to that measured in July. Individuals of *Aurelia* and *Mnemiopsis* were found in the lower depths. At station 41° 15’ N 37° 45’ E (13:30), *Aurelia* was found from 10 m down to 30-35 m depths. However, none of the individuals of *Mnemiopsis* and *Aurelia* were observed above the thermocline. Swarm of *Aurelia* was observed at a depth range of 5 m thickness in the upper part of the cold intermediate layer. Abundance of individuals with and without tentacles increased homogeneously with depth down to 60 m. The first visual detection of *Pleurobrachia* with tentacles started below 60 m depth reached a maximum concentration between 95 and 115 meters where the pycnocline occurred, and then decreased towards 140-145 m depth, below which none of individuals of *Pleurobrachia* existed. Higher concentrations of marine snow were found in the upper 5 m (Fig.4b). At the station 41° 10’ N 37° 45’ E (14:50), individuals of *Aurelia* were found in the mixed layer of the water column while few individuals were observed above the layer of marine snows (10 m). However, specimens of *Mnemiopsis* were not observed at this station. In the thermocline layer (20-22 m) *Pleurobrachia* with retracted tentacles exhibited homogeneous distributions. Individuals which outstretched the tentacles were observed at 60-70 m depths. Their abundance increased throughout the cold intermediate layer in which temperature varied between 7 °C and 8 °C (Fig.4b).
The zooplankton was numerically dominated by the copepods in the Black Sea. More than half of the abundance of the copepod was composed of a moderate sized-copepod, *Pseudocalanus elongatus* (Fig. 5).

![Fig. 5. Percent numerical occurrence of the zooplankton and abundance of the copepods in April 1995.](image)

**DISCUSSION**

The organisms which migrated daily in a narrow layer of the upper waters were featured with remarkable adaptation to a depth range from 0-15 to 50 m, slightly affected by variation in temperature and light intensity, correlated with primary production, and the chl-a maximum layer, less than 7% of the variation in the vertical distribution due to variation in primary production, confined to the upper warmer layer, survival rate declined sharply in severely depleted oxygen-condition, do not stay outside the limits of the phytoplankton, inhibited by temperatures below 10 °C and growth and reproduction rates decreased with decreasing temperatures, a salinity gradient of more than 0.3‰/m in 10 m prevented vertical migration of small copepods, smaller neritic copepods migrate slightly in the upper layer (Fig 6) [12, 15, 16, 20, 31, 37, 38, 39, 40].
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Fig. 6. Diel vertical migration of the upper layer zooplankton with percent numerical (abundance) distribution with the environmental parameter profiles. a) Acartia spp, female, b) Acartia spp, male, c) gastropod larvae, d) Cirriped larvae, e) Cladoceran larvae, f) bivalve larvae, g) Aurelia aurita and h) Mnemiopsis leidyi in April 1995.

All specimens of *A. clausi* performed diel migration in the uppermost layer by staying above the pycnocline during the day and in the subsurface water at night. Fulton [14] showed that *A. tonsa* was found to be a strong nocturnal migratory species. Bautista & Harris [13] also expressed that smaller neritic copepods migrate slightly in the upper layer. Stalder & Marcus [15] showed that adults of *A. tonsa* declined sharply in survival with DO=0.9 to 0.6 ml l\(^{-1}\). Petipa et al. [16] determined that *A. clausi*, a mixed food consumer does not stay outside the limits of the phytoplankton as observed in the present work. Petipa et al. [17] ascertained that the vertical range of *C. euxinus* was restricted to a lower depth characterized with oxygen deficiency and the appearance of H\(_2\)S [2, 5, 6]. Enright & Honegger [18] determined that the females of *C. euxinus* started migrating up earlier from the deep layer to the surface by dusk and stayed longer in the mixed layer at night than the male individuals did [19] as observed in the present study. Erkan et al. [5] and Besiktepe [6] gave the conclusion of inconsistent and unclear vertical migration of *O. similis*. Zenkevitch [20] classified *P. elongatus* as a cold water stenothermal form and Vinogradov et al. [2] concluded that the species did not reach the OML, which was below the CIL, during the daytime by downward migration and did not penetrate the upper mixed layer above the CIL during the night time migration [5, 6]. Distribution of the male individuals below the MTL could be due to representation of the MTL to the maximum Banse’s threshold with a value of 2‰ throughout the 20-m layer what created a very effective barrier for the migration of small-sized male individuals. Besiktepe (2001) observed a peak in abundance of copepodites and adult females of *P. parvus* in the CIL in spring whilst the highest density of individuals was reported to be above the CIL in September and June.

*Aurelia aurita* were distributed over a narrow depth range in and above the thermocline both day and night. Shushkina & Musayeva [21] first observed a similar vertical distribution in late September 1987; this pattern has been repeatedly observed [9, 22]. *M. leidyi* showed a similar pattern to *A. aurita* occupying the same layer; it was repeatedly observed [8, 22, 23]. A few small sized individuals were observed below the thermocline in April (present work) while *M. leidyi* was confined to a layer above the thermocline in August 1993 [8, 9, 24]. Mutlu & Bingel [7] reported that most *P. pileus* were observed below the thermocline in summer with two distinct depth maxima at 20 - 40 m and 90 - 120 m, where relatively cold waters occur. Kideys & Romanova [24] observed a similar pattern in June-July of summer 1996. Vinogradov et al. [2] found similar trends in April-May of spring 1984 with respect to the spring distribution detailed here.

The zooplankton which migrate through the water column were characterized with vertical distribution within a certain physicochemical condition, vertical range restricted to a lower depth characterized with oxygen deficiency and the appearance of H\(_2\)S, inconsistent and unclear vertical migration but were in agreement that the species were distributed in the *Calanus* layer, feeding depends on time: being uneaten in deep layers during daytime, and eaten in upper layers during nighttime, copepodites always in the upper layers, avoidance from predation, carnivorous feeding on nauplii as well, migration related with lipid content stored in the body, vertical migration differed between sex of
specimens, Banse’s threshold valid particularly for males of small-sized copepods (Fig. 7) [2, 5, 6, 12, 17, 18, 31, 34, 41, 42, 43, 44, 45, 46, 47].
Erkan et al. [5] reported that Appendicularia were found in the upper layer above the thermocline in summer while they were observed throughout the oxygenated water in autumn. Acuna [25] related the population dynamics of these gelatinous tunicates to the phytoplankton bloom that occurred in early spring and early autumn in the Black Sea [26].

All these depths of occurrence of Appendicularia could carry the fine scale living and non-living particles on which Appendicularia feed indifferently [27]. Flood [28] reported that even more remarkable is the accumulating body of evidence suggesting that, in addition to consuming submicron particulate matter, appendicularians seem capable of filtering and ingesting colloidal dissolved organic carbon (DOC). The subsurface accumulation was related to the presence of a high concentration of DOC between the surface and a depth where NO$_2$ + NO$_3$ levels peaked [29]. The second accumulation layer of Appendicularia was a depth where the light transmission dropped to a minimum value of 80%. Mopper & Kieber [30] reported the layer as fine particle maxima, which the Appendicularia could feed intensively on.

*Sagitta setosa* appeared in two main aggregations during the nighttime: One was just above the permanent halocline, the other was at a depth where NO$_2$ + NO$_3$ corresponded to the fine particle maxima [30] displaying a peak in concentration. Besiktepe & Unsal [4] showed similar findings on the vertical distribution of this species. Erkan et al. [5] concluded that this species did not exhibit a clear migratory pattern in October 1996 and July 1997. Vinogradov et al. [2] found that by day the chaetognaths were entirely absent in the upper waters but were concentrated within the lower part of the oxycline, where the oxygen content was 0.5-0.8 ml l$^{-1}$ as was repeatedly observed in this study in the OML. Vinogradov et al. [2] observed onset and completion of migration to be between 20:00 and 00:00 with the most rapid phase of migration occurring between 21:00 and 22:00.

![Fig.7. Diel vertical migration of the zooplankton migrating daily through the water column with percent numerical (abundance) distribution with the environmental parameter profiles. a) Calanus euxinus, female, b) Calanus euxinus, male, c) Pseudocalanus elongatus, female, d) Pseudocalanus elongatus, male, e) Oithana spp, female, f) Oithana spp, male, g) Paracalanus parvus, female and h) Paracalanus parvus, male, in April 1995](image)
Inconsistent distribution; continuation of organisms through the water column was related for the DVM-environmental parameter relation with interest to the phytoplankton bloom, peak in subsurface water where chl-a displayed its highest value, consuming microbes, submicron particulate matter, colloidal dissolved organic carbon (DOC), fine particle, exhibition of an unclear migratory pattern, and DO content and profile of the water playing a crucial role in triggering and initializing the upward vertical migration (Fig. 8a-b) [2, 4, 5, 25, 26, 27, 28, 29, 30, 43, 48, 49].

![Fig. 8](image-url)  
**Fig. 8.** Diel vertical migration of the zooplankton migrating daily with inconsistent distribution through the water column and deep water dwellers with percent numerical (abundance) distribution with environmental parameter profiles. a) Appendicularia, b) Sagitta setosa, c) Pleurobrachia pileus and d) Polychaetea larvae in April 1995.

The deep water dwellers, zooplankton which migrated in the deep water were typified with the features of cold water groups, distribution below thermocline or Minimum Temperature Depth (MTD), vertical range in difference depending on seasons, overwhelming majority of individuals migrated vertically upward at night. A second group did not migrate and remained at depth (Fig. 8c-e) [2, 7, 24, 50].

Juvenile bivalves were found in the upper warm water above the permanent pycnocline, halocline, and the CIL, generally characterized by having a high Chl-a...
concentration depicting the presence of phytoplankton that the Bivalvia filter as food. Magnesen et al. [31] showed that less than 7% of the variation in the vertical distribution was due to variation in primary production. Barnacle nauplii remained completely unchanged as to their inhabitance of surface waters during the day.

Total mesozooplankton appeared with two maximum abundance concentrations in the water column during the day. Vinogradov et al. [2] determined that the distributional pattern of the total mesozooplankton biomass in the whole oxygen zone had a two-maximum structure clearly manifested during the daytime. Erkan et al. [5] found that the cladoceran specimens, regardless of species, were observed only in the mixed layer in October 1996 with exception of a few individuals found in the deeper layer while they were irregularly distributed in the oxic zone in July 1997. The Polychaete larvae settled down to the suboxic zone during the nighttime and during the daytime, rose up to the MTL corresponding to the mid-part of the oxycline where the NO$_2$ + NO$_3$ and Particulate Organic Carbon (POC; [32]) peaked. Wishner et al. [33] observed that the polychaetes peaked in a layer where the POC peaked around 750 m depth in the Eastern Pacific OZM. This suggests that the larvae could avoid others during the daytime by rising to the upper layers (100 m). Actually *P. pileus* captures fast moving organisms to eat. As Vinogradov & Shushkina [34] and Mutlu & Bingel [7] stated, the larvae of benthic animals were one of the food items of this ctenophoran species.

Marine particles called marine snow were apparently observed with very high concentrations at two layers. One was at 3 m and other was found around 30-40 m depth. The deeper layer of marine snow overlapped with the upper depth of the cold intermediate layer. Visual inspections made by Diercks and Kempe [35] showed that marine snow particles exist at all depths of the mixed layer of the Black Sea with occasionally higher concentrations at 20-30 and 70-80 m depths. Although *Aurelia* shares the upper mixed layer with *Mnemiopsis* they may extend further down to the upper layer of cold intermediate layer (25 m). The *Mnemiopsis* was confined to the mixed layer (12-15 m) of the Black Sea and homogeneously distributed whereas *Aurelia* formed aggregations at 10 and 17 m depth. Similarly, observations from the submersible revealed that in spring and early summer the medusae inhabit the upper mixed layer, the thermocline and down to the core of cold intermediate layer in the open sea areas, i.e. they occur down to a depth of 70-80 m in the meandering rim current and to 55-60 m over the domes of gyres [34]. *Pleurobrachia* was inspected first in the upper edge of the thermocline (10-12 m) where its individuals were delicate with the tentacles and not abundant. From this layer down to 20-25 m, there were non-aggregating individuals without tentacles. *Aurelia* and *Pleurobrachia* were observed together at 10-20 m depths. On the pycnocline (70-110 m), high aggregations of *Pleurobrachia* with protracted tentacles were observed. Vinogradov et al. [2] observed that in the layer of deep ctenophore maxima they were suspended inactive in the water with widely outstretched tentacles. This inactive appearance of *Pleurobrachia* with outstretched tentacles may suggest that individuals were able to gather the prey. *Pleurobrachia* picks up the food with their tentacles using it as flagellate. Then the tentacles were rolled, leading to an appearance of helix. It directs the attached preys on the tentacles to its mouth and grazes them at the edge of mouth (visual inspection from available records in IMS-METU, 1996). Below this depth (70-110 m) down to 140 m, *Pleurobrachia* was found very rarely and all individuals retracted its tentacles. During in situ visual inspection, Kempe et al. [36] found three zones of macro-plankton. A top zone dominated by coelenterate (medusae), *Aurelia aurita*; these animals appeared during both daytime and nighttime at the surface of the Black Sea. Below this zone a layer
dominated by ctenophora, *Pleurobrachia* is located. A transition zone located between these two zones was occupied by both species occurred.

**CONCLUSION**

In general, *Pleurobrachia* was found mostly beneath the thermocline down to the anoxic layer in the CIL where the temperature is less than 8 °C. *Aurelia* was strictly associated with the upper mixed layer and the layer above the seasonal pycnocline. *Aurelia* has moved down to a maximum depth of 60 m nearly at midnight and was confined to the upper layer of seasonal halocline within the cold intermediate layer. *Mnemiopsis* extended over a narrow range in the water column during the day and night. No individuals of *Mnemiopsis* were observed below the thermocline in summer; however, a few individuals were localized at around 60-80 m below thermocline at night in spring.

All specimens of *A. clausi* performed diel migration in the uppermost layer by staying above the pycnocline during the day and in the subsurface water at night. *C. euxinus* migrated vertically trough the entire oxygenated layer and did not however perform the diapause in spring. The females of *C. euxinus* started migrating up earlier from the deep layer to the surface by dusk and stayed longer in the mixed layer at night than the male individuals did and downward migration was the reverse. Vertical distribution of *O. similis* appeared in two different layers: One was above the core of the CIL and the other below the core that acted. *P. elongatus* was a calanoid species that generally migrated and was distributed within the CIL. Total mesozooplankton appeared with two maximum abundance concentrations in the water column during the day: The lower concentration occurred in the daytime and early nighttime while they yielded only a peak at surface around midnight. The subsurface maximum was composed of *Noctiluca, Paracalanus, Oithana, Pseudocalanus, Acartia*, and sometimes *Calanus* species. In general, the cladoceran species were found in the uppermost layer situated above the pycnocline. The Polychaete larvae showed negative geotaxis in response to daylight between the anoxic and the MTL layer contrasted to *P. pileus* in the CIL.

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