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Original article

Seasonal distribution of fish eggs and larvae off sinop (the southern Black Sea) in 1999-2000

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Abstract

The seasonal distribution of fish eggs and larvae off Sinop, the central southern Black Sea, was studied by using vertical and horizontal tows at two stations at biweekly intervals between January 1999 and November 2000. Besides basic oceanographic parameters, macro gelatinous was also sampled to evaluate their relation to fish eggs and larvae. Eggs or larvae of a total 23 fish species were present in the samples. Most of the species were found to occur during spring and summer. It is observed that especially anchovy (*Engraulis encrasicolus*) eggs and larvae were highly abundant during this period. Additionally, beginning from May, the eggs and larvae of species, such as *Mullus barbatus*, *Solea lascaris*, *Trachurus mediterraneus*, *Ctenolabrus* sp., Blennidae and Gobiidae were represented in samples. In the colder period of the year, early life stages of sprat (*Sprattus sprattus*) were dominant in ichthyoplankton. According to overall quantitative evaluation, anchovy (87%) had superiority in abundance among egg samples and *Gobius* sp. (35%) among larvae samples.

Keywords: Black Sea; Sinop; Fish; Eggs; Larvae; Ichthyoplankton

1. Introduction

Several fodder zooplankton species have either disappeared from or substantially decreased in number at different sampling sites of the Black Sea over the last one or two decades. Some other species adapted to thrive in eutrophic conditions have either appeared or increased in quantity. Similarly, over the last few decades, the abundance of fish larvae has decreased significantly when compared either to past records or with larval abundances of other seas. This was shown to be due mainly to malnutrition of larvae. One of the most striking changes in the ichthyoplankton has been the shift in the spawning areas of the main fish species, the anchovy *Engraulis encrasicolus* from the northwestern to the southeastern Black Sea (Niermann et al., 1994).

In the Black Sea, recent studies have generally dealt with long-term changes in zooplankton composition due to anthropogenic factors (Kovalev et al., 1998a; Kovalev et al., 1998b; Kovalev et al., 1998c; Kovalev et al., 1998d; Niermann and Greve, 1997; Niermann et al., 1998; Konsulov and Kamburska, 1997; Shiganova, 1997; Shiganova, 1998; Shiganova et al., 1998). A few specific studies on zooplankton have also been carried out (Araskevitch et al., 1998; Besiktepe et al, 1997; Shulman et al., 1998).

In the Black Sea, investigations on the distribution of ichthyoplankton started in the early 1950s. During the 1950s and 1960s the average number of eggs of all fish species was in the range of some thousands per square metre and larvae some hundreds per square metre (Dekhnik, 1973; Gordina and Klimova, 1996; Pavloskaya, 1950).

Since the beginning of the 1970s, disturbances in the ecological condition of the Black Sea started, particularly in the shallow coastal areas of the northwestern area. Over-regulations of river flows, the extensive use of fertilisers and chemicals in agriculture, and the removal of soil or sand along the coastal areas must have adversely affected the ichthyoplankton of the Black Sea in two ways. Firstly, it is known that 90% of fish species with a summer reproduction cycle spawn in the coastal waters of the Black Sea (Dekhnik, 1973; Gordina and Klimova, 1996; Pavloskaya, 1950; Arkhipov and Rovnina, 1990) and hence spawning populations would inevitably be affected due to changes in water

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quality in these regions. Secondly, the highest mortality rate during the life span of fish occurs at the early stages of ontogenesis, which normally takes place in the coastal areas.

Another profound change in the ichthyoplankton of the Black Sea has been caused by the recently introduced ctenophore *Mnemiopsis leidyi*, which became the dominant species in terms of biomass (wet weight) among zooplankton very rapidly. This species is a voracious predator on zooplankton and became the main food competitor of pelagic plankton feeding fishes and their larvae. Besides being a food competitor, it feeds on the eggs and particularly, larvae of fish. In experimental conditions, *M. leidyi* having a length of 2-2.5 cm consumed larvae of *E. encrasicolus*. Yolk sack larvae were eaten with high preference (Lipskaya and Luchinskaya, 1990). It was estimated that one individual consumes 4-8 fish larvae a day. During its spawning period in summer, *Mnemiopsis* is able to consume 74% of the present fish larvae (Tsichon-Lukanina et al., 1992).

Such events must have resulted in significant changes in the abundance and distribution of the Black Sea ichthyoplankton. However, the aim of this study is to evaluate the seasonal distribution of fish eggs and larvae Sinop cape of Black sea between 1999 and 2000 at two stations at 15 d intervals.

2. Materials and methods

The ichthyoplankton samples were collected from 70 to 0 m (surface) for vertical haul in station I (max. depth 75 m) and from 180 to 0 m in station II (max. depth 400) (Fig. 1A,B). Horizontal hauls were also utilised by towing the net for 10-15 min at a vessel speed of 2 miles h^{-1}.

The ichthyoplankton were sampled with the Arastirma-1 research vessel. The average number of stations per cruise was 83 surveys. All the samples were obtained from vertical tows from the anoxic zone to the surface using a plankton net (mesh size 112 µm and 50 cm diameter of net opening). The bucket contents were filtered using a 2 mm sieve to retain and subsequently to quantify gelatinous organisms. The volume of each ctenophore *M. leidyi* was measured. The filtrates were then fixed with buffered formalin (final concentration of 4%) for ichthyoplankton analysis in the laboratory under a stereomicroscope. Temperature and salinity were measured by U-10 Horiba model equipment.

At the laboratory, after the identification of fish eggs and larvae, certain characteristics of theirs (dead or alive, normal or abnormal), egg diameter, structure of yolk were noted as described by Dekhnik (1973) and Russel (1976).

3. Results and discussion

The minimum and maximum temperature values of the water were 7 °C in March and 25.1 °C in July, respectively. The salinity values of the water were between 16.1‰ and 17.0‰ in autumn, 15.8‰ and 16.8‰ in winter, 15.4‰ and 17.7‰ in spring and 15.8‰ and 16.9‰ in summer.

The most abundant of the fish eggs and larvae was found in June, July and August (the water temperature and salinity values were between 10 and 25 °C and 15‰ and 17‰, respectively).

During the present study, either the eggs or larvae of 23 fish species were found in samples obtained from both vertical and horizontal tows (Table 1). However, both eggs and larvae of only three species were present throughout the year. Thus, eggs of 13 fish species and larvae of 13 fish species were found off Sinop, respectively. According to Dekhnik (1973), ichthyoplankton of the Black Sea comprised a total of 56 fish species: 28 fish species producing pelagic eggs and larvae with another 28 species having pelagic larvae only. Gordina et al. (1998) observed eggs of 28 and larvae of 44 fish species in the Black Sea during their survey period of 1986-1996. In the last decade (1991-1996), for the first time, the Sea of Marmara anchovy (*E. encrasicolus*) (Gordina et al., 1997), the mackerel *Scomber scombrus* and the blennid *Blennius ocellaris* spawn were found in the Black Sea (Gordina et al., 1998). These findings concluded the discussion of whether these species spawn in the Black Sea or not, which had been ongoing for a long time. In the present study, however, we did not observe ichthyoplankton of *Scomber scombrus* and the blennid *Blennius ocellaris* in the samples obtained off Sinop.

Both eggs and larvae of *E. encrasicolus*, *Mullus barbatus* and *Sprattus sprattus* were found. Only larvae belonging to Blennidae families (*Bl. pavo*, *Bl. tentacularis*, *Bl. sanguinolentus*, *Bl. zvonimiri*, *Bl. sphinx*), *Crenilabrus ocellatus*,

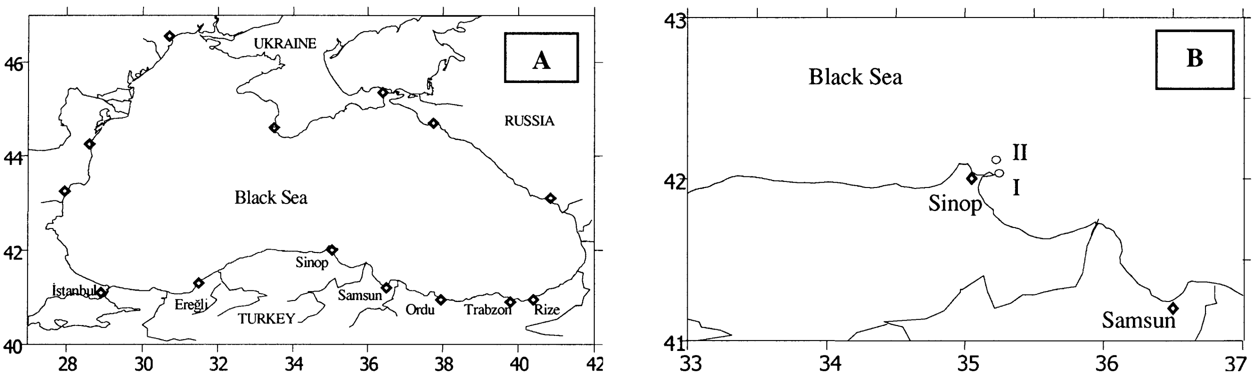

Fig. 1. (A) Map of Black Sea, (B) Map of sampling area.

Table 1
Qualitative composition of eggs and larvae off Sinop (the southern Black Sea) in 1999-2000 (+ = found,- = not found, V = vertical, H = horizontal)

Species	Eggs		Larvae	
	I	II	I	II
Blennius pavo (Risso)	–	–	+H	+H
Blennius tentacularis (Brünnich)	–	–	+H	–
Blennius sanguinolentus (Pallas)	–	–	+H	–
Blennius zvonimiri (Kollombatovic)	–	–	+H	–
Blennius sphinx (Valenciennes)	–	–	+H	+H
Callionymus sp.	+VH	+H	–	–
Crenilabrus ocellatus (Forskal)	–	–	+H	–
Ctenolabrus rupestris (Linne)	–	+V	–	–
Diplecogaster bimaculatus bimaculatus (Bonnaterre)	–	–	+H	–
Diplodus annularis (Linne)	+H	–	–	–
Engraulis encrasicolus ponticus (Aleksandrov)	+VH	+VH	+VH	–
Gobius sp.	–	–	+VH	+VH
Merlangius merlangus euxinus (Nordmann)	+V	+V	–	–
Mullus barbatus ponticus (Essipov)	+H	+H	–	–
Ophidon rochei (Müller)	+H	–	–	–
Pomatoschistus sp.	–	–	+H	–
Pomatomus saltatrix (Linne)	–	–	+H	–
Serranus scriba (Linne)	–	+H	–	–
Scorpaena porcus (Linne)	–	+H	–	–
Solea lascaris nasuta (Pallas)	+H	+H	–	–
Sprattus sprattus phalericus (Risso)	+VH	+V	+VH	+V
Trachinus draco (Linne)	+H	–	–	–
Trachurus mediterraneus ponticus (Aleev)	+H	+VH	–	–

Diplocogaster bimaculatus, Gobiidae (*Gobius* sp. and *Pomatoschistus* sp.) and *Pomatomus saltatrix* were found. These species have demersal eggs, whereas, eggs of *Callionymus* sp., *Ctenolabrus rupestris*, *Diplodus annularis*, *Merlangius merlangus*, *Ophidon rochei*, *Serranus scriba*, *Scorpaena porcus*, *Solea lascaris*, *Trachinus draco* and *Trachurus mediterraneus* which were found in their larval form were also demersal. Moreover, only a small mesh size 112 µm and 50 cm diameter of net opening was used in the present study.

Ctenolabrus rupestris, *Scorpaena porcus* and *Serranus scriba* were found only in Station II. *Blennius tentacularis*, *Blennius sanguinolentus*, *Blennius zvonimiri*, *Pomatoschistus* sp., *Diplecogaster bimaculatus bimaculatus*, *Diplodus annularis*, *Crenilabrus ocellatus*, *Ophidon rochei*, *Pomatomus saltatrix* and *Trachinus draco* were found only in Station I whereas, other species were sampled in both the stations (Table 1).

The most abundant species was *Sprattus sprattus* except in summer. In winter, its eggs for vertical hauls were found to be 253.33 ind. m^{-2} and 550 ind. m^{-2} in station I and II, respectively. However, *Callionymus* sp. was found to be minimum in summer 1.67 ind. m^{-2} in station I (Table 2).

Similarly, in winter, fish larvae for vertical hauls of the most abundant species was *Sprattus sprattus* and it was found to be 48.33 ind. m^{-2} in station II followed by *Gobius* and *E. encrasicolus* (Table 3).

The most abundant eggs found were of *E. encrasicolus*. These species eggs were found to be 189.25 and 216.4 ind. 100 m^{-3} I and II stations, respectively (Table 4). In autumn, only *Sprattus sprattus* larvae were found for horizontal hauls. The most abundant larvae were *Gobius* sp. in spring and summer. These species larvae were found to be 5.75 ind. 100 m^{-3} in summer for horizontal hauls. In autumn, no larva was found in station II (Table 5).

Table 2
Seasonal distribution of fish eggs off Sinop in 1999-2000 vertical (ind. m^{-2})

Species	Winter		Spring		Summer		Autumn	
	I	II	I	II	I	II	I	II
Callionymus sp.					1.67			
Ctenolabrus sp.						3.75		
Engraulis encrasicolus			2.86		35.24	39.84	5	15
Merlangius merlangus		5	0.98	1.25	2.5	6.18	3.34	61.5
Sprattus sprattus	253.33	550	23.57	35			58.33	188.75
Trachurus mediterraneus						1.69		
Unidentified					2.5			
Haul	3	3	11	12	6	7	4	5

Table 3
Seasonal distribution of fish larvae off Sinop in 1999-2000 vertical (ind. m^{-2})

Species	Winter		Spring		Summer		Autumn	
	I	II	I	II	I	II	I	II
Engraulis encrasicolus ponticus					3	3.13		
Gobius sp.					2.09	6.73		1.25
Sprattus sprattus phalericus	5	48.33	0.71					
Haul	3	3	7	8	5	6	3	4

Table 4
Seasonal distribution of fish eggs off Sinop in 1999–2000 horizontal (ind. 100 m^{-3})

Species	Spring		Summer	
	I	II	I	II
Callionymus sp.		0.2	0.2	
Diplodus annularis			0.6	
Engraulis encrasicolus ponticus	15.5	12.65	189.25	216.4
Mullus barbatus			0.3	0.2
Ophidon rochei			0.01	
Scorpaena porcus		0.2		0.5
Serranus scriba				0.5
Solea lascaris	0.01	0.01		0.2
Sprattus sprattus phalericus	3.7			
Trachinus draco			0.1	
Trachurus mediterraneus	0.01		13.4	2
Unidentified		0.5		
Haul	7	7	5	5

Table 5
Seasonal distribution of fish larvae off Sinop in 1999-2000 horizontal (ind. 100 m^{-3})

Species	Spring		Summer		Autumn
	I	II	I	II	I
Blennius pavo	0.01		0.2	0.1	
Blennius sanguinolentus			1.4		
Blennius sphinx			0.5	0.5	
Blennius tentecularis	0.2				
Blennius zvonimiri			2	0.5	
Crenilabrus ocellatus	2		3.5		
Diplecogaster bimaculatus			0.2		
Diplodus anularis			0.2		
Engraulis encrasicolus ponticus	0.01		1.15		
Gobius sp.	0.65		5.75	1.4	
Labridae	0.2				
Mullus barbatus			1.1	0.5	
Pomatoschistus sp.	0.1		3.35		
Pomatomus saltatrix	0.3				
Sprattus sprattus phalericus					0.4
Unidentified			2.3		
Haul	7	7	5	5	1

Normal, abnormal and dead eggs were 11.14%, 64.58% and 24.28% for *Sprattus sprattus* and 13.65%, 69.85% and 26.50% for *E. encrasicolus ponticus*. Egg diameters of *Sprattus sprattus* were 0.95-1.30 mm. The average small and big egg diameter of *E. encrasicolus ponticus* was 0.72 and 1.29 mm, respectively.

Table 6 shows the average number of fish larvae in different seas and in this study. Compared with the previous years, in 1988, the number of eggs had decreased 2-4 fold, the number of larvae had decreased 2-9 fold, in both coastal and offshore waters in different regions of the Black Sea. During 1989, when *M. leidyi* reached its peak biomass (Vinogradov et al., 1989), a further two fold decrease in the ichthyoplankton abundance was observed over the entire Black Sea (Gordina and Klimova, 1996).

In the present study, biomass levels of *M. leidyi* were up to 525 g wet weight m^{-2} in July. The average biomass for Stations I and II was 101 g wet weight m^{-2} for the entire sampling period.

The present study also showed that ichthyoplankton had increased with increasing water temperature, especially in June, July and August.

All these studies show that the Black Sea ichthyoplankton, which as a group contains complex interwoven relationships, responds intimately to both natural environmental factors and anthropogenic impacts. However, the responses of planktonic communities to these impacts differ among different areas of the Black Sea.

Eutrophication, being one of the main anthropogenic impacts, is a worldwide problem affecting all compartments of coastal marine ecosystems, including ichthyoplankton (Cattani and Corni, 1992; Leppakoski and Mihnea, 1996). It should be noted that enclosed seas like the Black Sea are more susceptible to eutrophication (and to other types of human induced activities) due to very limited water exchange with the neighbouring seas.

Table 6
Average number of fish larvae in different seas (Gordina et al., 1998)

Region	Period	Number of fish larvae (ind. m^{-3})
Mediterranean Sea	1958–1962	17
Azov Sea	1962–1963	570
Black Sea	1962–1963	160
Red Sea and Gulf of Aden	1966	75
Black Sea	1988	29
Black Sea	1989	7
Black Sea	1992	1
Southern Black Sea	1996	9
Present Study	1999–2000	0.02

The decline in fish eggs and larvae in 1988-2000 could be related not only to over-fishing but also to the eutrophication of the Black sea and the effect on the predation of the ctenophore. The northwestern Black Sea, the main spawning area for many valuable fish species, suffered the most. However, another ctenophora *Beroe ovata* have occurred in the Black Sea durring the early 1990s. The species of *Beroe ovata* is highly specific in its feeding, so that even its larval stage feeds on *M. leidyi*. Its reproductive rate and fecundity are almost as great as that of *M. leidyi*, so that its populations can grow at similar rates to its prey. *Beroe ovata* is probably not a potential food resource for Black Sea fish. The addition of *Beroe* is predicted to reduce the *Mnemiopsis* population significantly, with a slightly positive impact on fish, zooplankton and fisheries.

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References

Arkhipov, A.G., Rovnina, O.A., 1990. Seasonal and annual changeability of ichthyoplankton in the Black Sea. Works of All-Union research Institute of Marine Fisheries and Oceanography. Moscow. pp. 64–80 (in Russian).

Araskevitch, E., Svetlichny, L., Gubareva, E., Besiktepe, S., Gucu, A.C., Kideys, A.E., 1998. Physiological and ecological studies of *Calanus euxinus* (Hulsemann) from the Black Sea with comments on its life cycle. In: Ivanov, L., Oguz, T. (Eds.), NATO TU-Black Sea Project: Ecosystem Modeling as a Management Tool for the Black Sea, Symposium on Scientific Results. Kluwer Academic Publishers, pp. 351–366.

Besiktepe, S., Kideys, A.E., Unsal, M., 1997. In situ grazing rate and diel vertical migration of female *Clanus euxinus* in the Black Sea. Hydrobiologia 363, 323–332.

Cattani, O., Corni, M.G., 1992. The role of zooplankton in eutrophication, with special reference to the northern Adriatic Sea. In: Vollenweider, R.A., Marchetti, R., Viviani, R. (Eds.), Marine Coastal Eutrophication. Elsevier, pp. 137–158.

Dekhnik, T.V., 1973. The Black Sea ichthyoplankton 234 p. Nau-kova Dumka, Kiev. (in Russian).

Gordina, A.D., Klimova, T.N., 1996. The dynamics of specific composition and abundance of ichthyoplankton in the coastal and open waters of the Black Sea. Modern Condition of the Black Sea Ichthyofauna. NASU Kovalevsky Institute of biology of the Southern Seas, Sevastopol (in Russian), pp. 74–94.

Gordina, A.D., Nikolsky, V.N., Niermann, U., Bingel, F., Subbotin, A.A., 1997. New data of the morphological differences of anchovy eggs (*Engraulis encrasicolus* L.) in the Black Sea. Fisheries Research 31, 139–145.

Gordina, A.D., Niermann, U., Kideys, A.E., Subbotin, A.A., Artyomov, Yu, G., Bingel, F., 1998. State of summer ichthyoplankton in the Black Sea. In: Ivanov, L., Oguz, T. (Eds.), NATO TU-Black Sea Project: Ecosystem Modeling as a Management Tool for the Black Sea, Symposium on Scientific Results. Kluwer Academic Publishers, pp. 367–380.

Leppakoski, E., Mihnea, P.E., 1996. Enclosed seas under man-induced change: A comparison between the Baltic and Black Seas. Ambio 25, 380–389.

Lipskaya, N.Ya, Luchinskaya, T.N., 1992. The biology of jelly-fish *Mnemiopsis*. Rybnoe Hozyaistvo 9, 36–38 (in Russian).

Niermann, U., Bingel, F., Gorban, A., Gordina, A.D., Gücü, A., Kıdeyş, A.E., Konsulov, A., Radu, G., Subbotin, A.A., Zaika, V.E., 1994. Distribution of anchovy eggs and larvae (*Engraulis encrasicolus* cuv.) in the Black Sea in 1991 and 1992 in comparison to former surveys. Ices J. Mar. Sci 51, 395–406.

Niermann, U., Greve, W., 1997. Distribution and fluctuation of dominant zooplankton species in the southern Black Sea in comparison to the North Sea and Baltic Sea. In: Ozsoy, E., Mikaelyan, A. (Eds.), Sensitivity to Change: Black Sea, Baltic Sea and North Sea. Kluwer Academic Publishers, pp. 65–78.

Niermann, U., Kideys, A.E., Kovalev, A.V., Melnikov, V.V., Belokopytov, V., 1998. Long-term fluctuations of the zooplankton of the open Black Sea in comparison to other regions of the world. In: Bologa, A. (Ed.), Environmental Degradation of the Black Sea: Challenges and Remedies, Constanta, Romania, October 6-10, 1997. Kluwer Academic Publishers.

Konsulov, A., Kamburska, L., 1997. Sensitivity to anthropogenic factors of the plankton fauna adjacent to the Bulgarian coast of the Black Sea. In: Ozsoy, E., Mikaelyan, A. (Eds.), Sensitivity to Change: Black Sea, Baltic Sea and North Sea. Kluwer Academic Publishers, pp. 95–104.

Kovalev, A.V., Gubanova, A.D., Kideys, A.E., Melnikov, V.V., Niermann, U., Ostrovskaya, N.A., Skryabin, V.A., Uysal, Z., Zagorodnyaya, Yu.A, 1998a. Long-term changes in the biomass and composition of fodder zooplankton in coastal regions of the Black Sea during the period 1957-1996. In: Ivanov, L., Oguz, T. (Eds.), NATO TU-Black Sea Project: Ecosystem Modeling as a Management Tool for the Black Sea, Symposium on Scientific Results. Kluwer Academic Publishers, pp. 209–220.

Kovalev, A.V., Bingel, F., Kideys, A.E., Niermann, U., Skryabin, V.A., Uysal, Z., Zagorodnyaya, YuA., 1998b. The Black Sea zooplankton: history of investigations, composition, and spatial/temporal distribution. Turkish. J. of Zoology (in press).

Kovalev, A.V., Besiktepe, S., Zagorodnyaya, Yu.A., Kideys, A.E., 1998c. Mediterranization of the Black Sea zooplankton is continuing. In: Ivanov, L., Oguz, T. (Eds.), NATO TU-Black Sea Project: Ecosystem Modeling as a Management Tool for the Black Sea, Symposium on Scientific Results. Kluwer Academic Publishers, pp. 199–208.

Kovalev, A.V., Niermann, U., Melnikov, V.V., Belokopitov, V., Uysal, Z., Kideys, A.E., Unsal, M., Altukhov, D., 1998d. Long-term changes in the Black Sea zooplankton: The role of natural and anthropogenic factors. In: Ivanov, L., Oguz, T. (Eds.), NATO TU-Black Sea Project: Ecosystem Modeling as a Management Tool for the Black Sea, Symposium on Scientific Results. Kluwer Academic Publishers, pp. 221–234.

Pavloskaya, R.M., 1950. The spawning of food-fishes in Karkinite Bay and in other regions of the Black Sea. Report of USRR Academy of Sciences 7 (2), 311–315 (in Russian).

Russel, F.S., 1976. The Planktonic Stages of British Marine Fishes. Academic Press Inc. Ltd, London 524 p.

Shiganova, T.A., 1997. *Mnemiopsis leidyi* abundance in the Black Sea and its impact on the pelagic community. In: Ozsoy, E., Mikaelyan, A. (Eds.), Sensitivity to Change: Black Sea, Baltic Sea and North Sea. Kluwer Academic Publishers, pp. 117–130.

Shiganova, T.A., 1998. Invasion of the Black Sea by the ctenophore *Mnemiopsis leidyi* and recent changes in the pelagic community structure. Fisheries Oceanography 7, 305–310.

Shiganova, T.A., Kideys, A.E., Gucu, A.C., Niermann, U., Khoroshilov, V.S., 1998. Changes in species diversity and abundance of the main components of the Black Sea pelagic community during the last decade. In: Ivanov, L., Oguz, T. (Eds.), NATO TU-Black Sea Project: Ecosystem Modeling as a Management Tool for the Black Sea, Symposium on Scientific Results. Kluwer Academic Publishers, pp. 171–188.

Shulman, G.E., Yuneva, T.V., Yunev, O.A., Svetlichny, L.S., Anninsky, B.E., Romanava, Z.A., Arashkevitch, E..G., Kideys, A.E., Bingel, F., Uysal, Z., Yilmaz, A., 1998. A biochemical approach for the estimation of food provision for heterotrophic organisms of the Black Sea. In: Ivanov, L., Oğuz, T. (Eds.), NATO TU-Black Sea Project: Ecosystem Modeling as a Management Tool for the Black Sea, Symposium on Scientific Results. Kluwer Academic Publishers, pp. 263–280.

Tsichon-Lukanina, E.A., Reznichenko, O.G., Lukashova, T.A., 1992. The feeding of ctenophora *Mnemiopsis* in coastal waters of the Black Sea. Oceanol. Engl. Transl 32, 724–729.

Vinogradov, M.E., Shushkina, E.A., Musaeva, E.I., Sorokin, P.Yu, 1989. Ctenophore *Mnemiopsis leidyi* (A. Agassiz) (Ctenophora: Lobata)-a new settler in the Black Sea. Oceanology 29, 293–298 (in Russian).