БИОЛОГИЧЕСКИЕ РЕСУРСЫ, БИОТЕХНОЛОГИЯ И АКВАКУЛЬТУРА

TO THE QUESTION OF THE STRUCTURE OF THE EUROPEAN ANCHOVEE STOCK WINTERING OFF THE COAST OF ABKHAZIA AND THE REASONS AFFECTING THE LOW VALUE OF THE FISHING (*ENGRAULIS ENCRASICOLUS* L., 1758) IN THE FISHING SEASON 2022/2023

Dbar R. S.[1, 2], Gamakharia P. D.[1]

[1]*Institute of Ecology of the Academy of Sciences of Abkhazia (IE ANA), Sukhum, Abkhazia,*
e-mail: pgamakhariya@mail.ru

[1, 2]*Azov-Black Sea Branch of the FSBSI «VNIRO» («AzNIIRKh»), Rostov-on-Don, Russian Federation,*
e-mail: romandbar@mail.ru

Abstract: The analysis of the results of the fishing season 2022/2023, as well as the analysis of the commercial biological and basic biometric parameters of the European anchovy (E. *encrasicolus* L., 1758) wintering in the coastal waters of Abkhazia were made. The characteristic of the dynamics of the size and age structure of fish in catches is given and the intra-annual patterns of the dynamics of anchovy (Black Sea anchovy and Azov anchovy) fishing are presented. Changes in population characteristics in the composition of catches compared to previous years were noted. The absolute values of catches by month and their fluctuations are given. The dependence of the biomass coming to the anchovy wintering on the main environmental factors: temperature, current and wind regime is considered.

Keywords: European anchovy, Azov-Black Sea form of anchovies, size-age structure, fishing dynamics, Abkhazia, regression analysis.

Introduction

The European anchovy, or anchovy, E. *encrasicolus* L., 1758, due to its abundance, plays an important role in the marine ecosystem, as it acts as an intermediate link between zooplankton and representatives of the highest trophic level — large predatory fish, dolphins and birds [Zuyev, Current population structure … , 2019]. At the same time, we can say that this species consistently ranks first in terms of catch volume and is an important commercial object in all countries located on the Black Sea coast. The main fishery is carried out in the coastal waters of Turkey, Georgia, Russia and Abkhazia, where anchovy migrates in large numbers from the northern part of the Black Sea and from the Sea of Azov for wintering, forming dense and stable aggregations [Zuyev, Modern state of the population … , 2019]. A relatively small part of the herd winters near the Caucasian coast and near the southern and southwestern coast of Crimea [Vodyasova, Abramson, 2016; Zuyev, Klimova, 2017]. Anchovy fishing is one of the traditional types of Black Sea fishing [Dbar, Gamakhariya, Long-term dynamics … , 2020; Dbar, Gamakhariya, Mnogoletnyaya dinamika … , 2020].

According to the results of modern population genetic studies, in the Azov-Black Sea basin, the European anchovy is represented by two forms — the Black Sea and the Azov, each of which is characterized by the presence of spatially isolated reproductive, feeding and wintering areas and, accordingly, represents an independent unit of the commercial stock [Vodyasova, Soldatov, 2017; Zuyev et al., 2014; Zuyev et al., 2012; Nebesikhina et al., 2019; Nebesikhina, Lebedeva, 2019; Chugunova, 1959; Castilla-Espino et al., 2014].

Off the coast of Abkhazia, anchovy is present only during wintering (December — March). It is a commercial object, and the recommended catch is about 30–45 thousand tons annually according to the materials of the Russian-Abkhaz Commission on Fisheries or the decree of the Cabinet of Ministers of Abkhazia.

Fishing in Abkhazia was carried out by leased Turkish fishing vessels in the amount of 17 units and transport vessels in the amount of 9 units. The state of the population can be assessed as stable with a low stock.

The purpose of the research is to assess the state of the anchovy stock in the 2022/2023 fishing season, and characteristics of local populations wintering in the Abkhazian waters of the Black Sea.

Given the identified signs of excessive fishing pressure on the population of the Azov-Black Sea anchovy, it is important to understand the state of the dynamic characteristics of the population and what factors determine the size of the stock.

Materials and Methods

The object of research was the local populations of anchovy wintering in the waters of Abkhazia in 2022/2023. As additional sources of data, we used materials from fishing journals, which were presented by the State Committee for Ecology of the Republic of Abkhazia. In addition, they carried out direct control of the caught fish at the sites of unloading the catch at the fisheries. The material was obtained from the catches of fishing vessels. Anchovy was caught using a purse seine. The study area covered the shelf zone from the Sukhum region up to the Gal region, the range of working depths of vessels was 20–60 m, and partially the Gagra water area.

Sampling (2700 individuals) and their cameral processing were carried out in accordance with the methods generally accepted in the practice of ichthyological research. Fish measurements were made with an accuracy of 1 mm, the age of the fish was determined by otoliths and the mass of individuals on an electronic scale with an accuracy of tenths of a gram. Gender was determined by standard methods. In all calculations, only the body length FL was used [Pravdin, 1966] . In addition, we analyzed the literature data on temperature, currents and wind activity of the Black Sea.

Results and Discussion

Fishing in the anchovy season 2022/2023 began in the first half of December and lasted until the end of March. The largest daily catch did not exceed 200 tons. The fishing area (Fig. 1) covered mainly the eastern part of the Abkhaz water area. At the end of February, there was a move of anchovy with a sharp decrease in numbers in March. We estimate the number of anchovy individuals that came for wintering at 200–300 million individuals, with the predominant modal group in body length 6–9 cm and weight 4–9 g [Vodyasova, Abramson, 2017; Vodyasova, Soldatov, 2017; Ivanova, Dobrovolov, 2006].

It is important to note that the intensity of fishing in the current fishing season was quite low compared to the previous year, while estimating the magnitude of fishing effort and catch per effort, one can speak of an unstable catch throughout the fishing season.

During the period under review, the anchovy catch amounted to 6846 tons. Anchovy catch statistics by months of the winter-spring season in the 2022/2023 fishing season shows significant variation (Fig. 2). Increased catch rates in January are associated with the beginning of a decrease in sea water temperature and the entry of anchovy from the eastern part.

The age structure of a population is an indicator of its stability, making it possible to estimate the number of spawners at the start of spawning. During the period under review, the anchovy population was in a stable condition, and the number of spawners was at a high level. The dynamics of the age composition of anchovy catches shows that in December, fish aged 2+ dominated, accounting for more than half of the fish caught by the fishery, but in March their share fell to 17 %, while the proportion of fish aged 3+ was noticeably higher than in previous years months. Fish aged 0+ dominated in January, their biomass was 32 % of the total biomass of the January catches (Fig. 3).

Fig. 1. Maps of fishing area for the Azov-Black Sea anchovy in the 2022/2023 fishing season
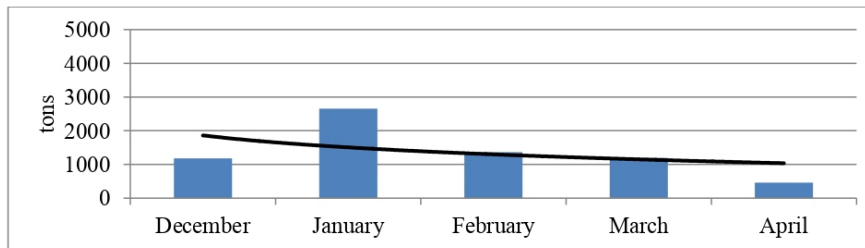

Fig. 2. Anchovy catch statistics by months of the winter-spring fishin season in 2022/2023

The dynamics of the biomass of the stock during the wintering period shows that anchovy will spawn with a dominant group of individuals aged 2+ and 3+, which indicates that the biomass of anchovy for the fishing season 2023/2024 can be predicted as medium productive.

According to the data obtained by us, fish at the age of 1+ dominate, while the ratios are approximately the same in fish of the age of 1+ and 3+. The proportion of fish of age 3+ and 4+ is about 14 %, but fish of this age will die almost completely during migration, leaving no offspring. About 86 % of fish will be able to leave offspring, but taking into account the small number of the stock, it can be argued that the fishing stock in the waters of Abkhazia for the next fishing season will be lower under other favorable conditions. In the current fishing season, the Azov anchovy is found; its share is insignificant and amounts to only about 0.79 % of the total number.

The sexual structure of the Azov-Black Sea anchovy determines its reproductive abilities. Such a structure is considered favorable, in which the anchovy in wintering clusters is dominated by under-yearlings and two-year-olds. According to the data obtained, the sex distribution of anchovies by age was favorable. The ratio of males and females in different age groups was not the same: males dominated at the age of 0+, females dominated at the age of 1+, females dominated at the age of 2+ (Fig. 4). Potentially, under favorable conditions, such a population can give a fairly high number of offspring with a high abundance of stock [Gamakhariya, 2021] .
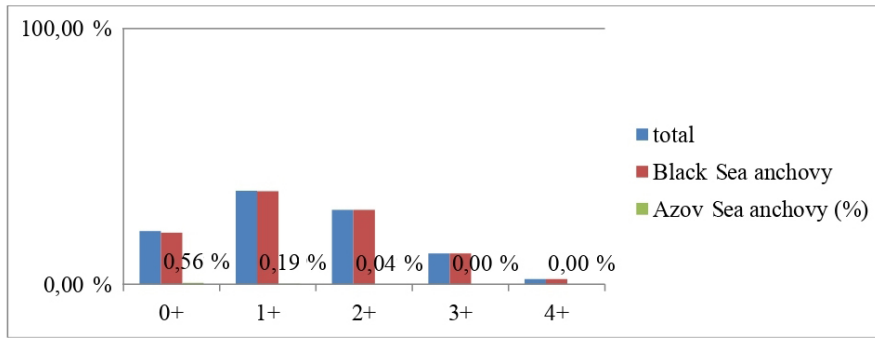
Fig. 3. Age structure of local anchovy stocks in commercial catches in the 2022/2023 season
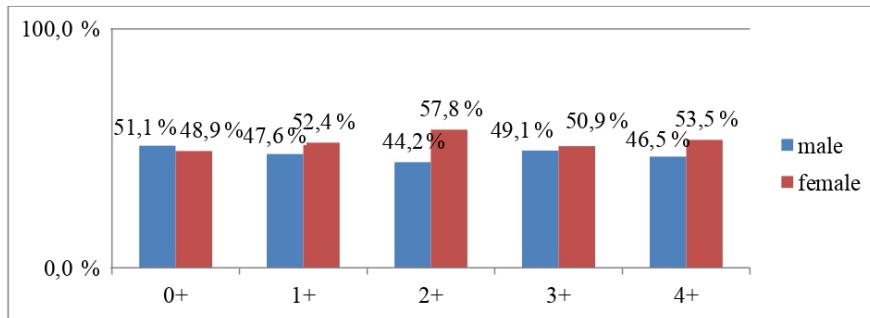

Fig. 4. Sex structure of anchovies in the 2022/2023 season

Based on the regression analysis (Fig. 5), a functional relationship was established between length and age, weight and age, as well as weight and length of anchovy. In all cases, the coefficient of determination was quite high. The dependence of length on age was approximated by the equation of the power growth function; weight on age was approximated by an exponential function, where the coefficients of determination were equal to 0.95, 0.84, and 0.91. This equation has a concave graphic form, the growth rate decreases with age. The decrease in linear growth in fish of older age groups is explained by the fact that in anchovy, energy expenditure for generative metabolism increases with age, therefore, the feed coefficient increases, i. e., the efficiency of using food for growth decreases. With an increase in body length, the mass of anchovies naturally increases. The associated change in the average values of mass and length indicates a close functional relationship between these indicators, while the coefficient of determination is 0.87.

In order to understand the processes affecting the formation of the stock of the Azov-Black Sea anchovy in the waters of Abkhazia, in addition to biometric analysis, it is necessary to analyze the relationship between the biomass of the stock and environmental factors (Fig. 6). Since in recent years, sharp fluctuations in stocks have been increasingly observed. It was necessary to establish a relationship with which you can assess the state of the stock and explain the reasons for the failed route.

Taking into account the available data on the structure of the anchovy stock, we conducted a regression analysis of the relationships between the size of the stock and the main environmental factors.

To assess the relationship between temperature and biomass anchovy wintering in the waters of Abkhazia, 10 points were selected in the coastal part of the Black Sea. Six of them were in Turkish waters, three in Georgian and three in Abkhazian. The data were analyzed from September to December inclusive every day. As a result, according to the regression analysis of the dependence of the biomass of migrating anchovy on temperature during the winter migration period, we see a correlation between these data, which is 0.7387.
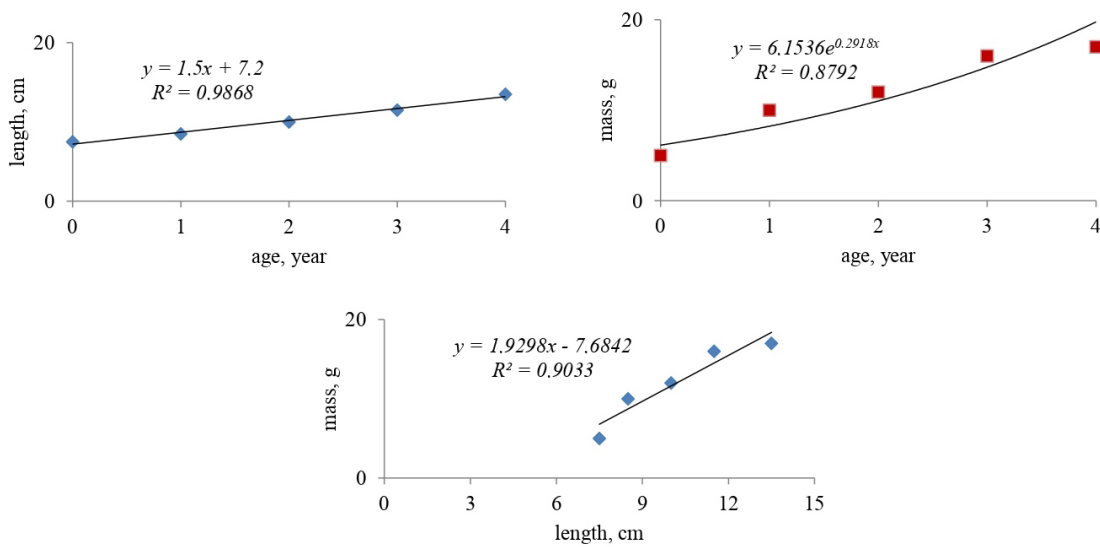
Fig. 5. Linear growth (a), weight growth (b) and the relationship between the length and body weight of the anchovy in the period 2022/2023

Data on the correlation analysis of the dependence of migrations on currents gave a negative indicator.

The data on the regression analysis of the dependence of the biomass of wintering and migrating anchovy on winds did not give a positive correlation in any of the months of the period under review.

Therefore, it can be assumed that the biomass of the migrating and wintering anchovies depends on the temperature in the autumn months and partially depends on the currents in the autumn months of the anchovy migrating and wintering in the waters of Abkhazia. In this case, the speed of the currents matters. A greater dependence is observed on currents, the speed of which is higher. We did not observe dependence on winds.
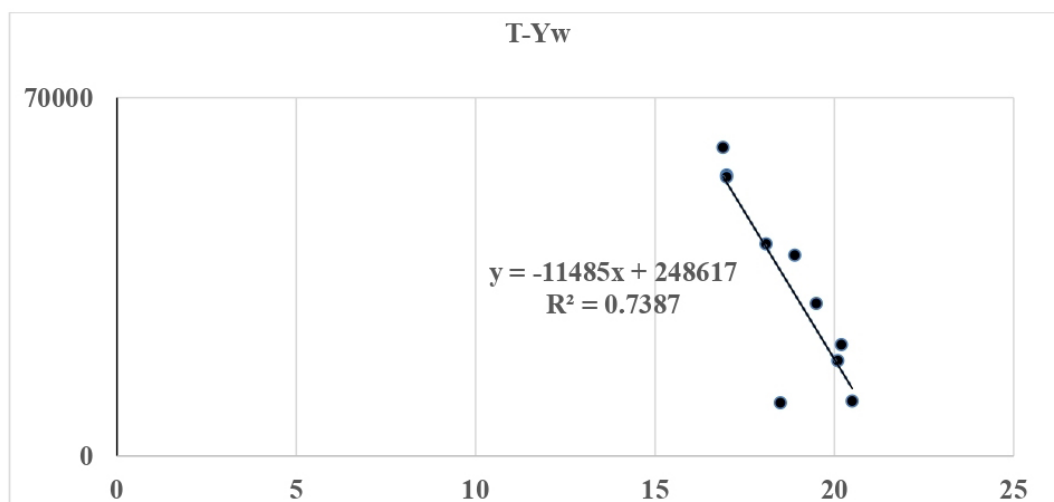

Fig. 6. Data of regression analysis of the dependence of the biomass of anchovy wintering in the waters of Abkhazia on water temperature during the fishing season 2022/2023

Conclusion

1. In the fishing season 2022/2023 anchovy catch amounted to 6846 tons. The increase in the catch in March is associated with the beginning of the spring migration of anchovy.

2. The age distribution of anchovy shows that in the wintering population there are all five age groups and the age group 1+ dominates, accounting for 36.6 % of individuals. This indicates a high level of exploitation in the previous season. At the same time, the absence of a large number of underyearlings shows that in the previous year, the operational capabilities of wintering flocks were significantly exceeded.

3. In the territorial waters of Abkhazia, the Azov anchovy was present in small quantities, accounting for no more than 0.8 % in terms of numbers, while with the beginning of spring migration, its share decreased to 0.1 % of the total number. What can say that the commercial stock of the Azov anchovy is being restored in the territorial waters of Russia.

4. The sex ratio of the anchovy during the wintering period remained quite favorable for the population. On average, females prevailed by age, and their share was slightly more than 55.2 % of the total number.

5. The regression analysis data show the dependence of anchovy's migration on the temperature regime and, to a lesser extent, on the currents of the Black Sea. This dependence shows that the water temperature in the Black Sea during the period of migration and wintering was higher than necessary for the massive entry of anchovies for wintering into the waters of Abkhazia and averaged 11.5 °C in the water area, from Turkish waters to Abkhazia, with the optimal anchovies at a water temperature of 10.3 °C.

6. Regression analysis showed a functional relationship between length and age, weight and age, as well as weight and length of anchovy.

References

1. *Castilla-Espino D., García-del-Hoyo J. J., Metreveli M., Bilashvili K.* Fishing capacity of the southeastern Black Sea anchovy fishery // Journal of Marine Systems. – 2014. – Vol. 135. – P. 160–169. – https://doi.org/10.1016/j.jmarsys.2013.04.013

2. *Chugunova N. I.* Rukovodstvo po izucheniyu vozrasta i rosta ryb : (metod. posobie po ikhtiologii). – Moskva : Izd-vo AN SSSR, 1959. – 164 s.

3. *Dbar R. S., Gamakharia P. D.* Long-term dynamics of fishing and size-age structure of anchovy catches (*Engraulis encrasicolus* Linnaeus) wintering off the coast of Abkhazia // Biologicheskoe raznoobrazie: izuchenie, sokhranenie, vosstanovlenie, ratsional'noe ispol'zovanie : materialy II mezhdunar. nauch.-prakt. konf., Kerch', 27–30 maya 2020 / Kerchen. gos. mor. tekhnol. un-t [i dr.]. – Simferopol' : ARIAL, 2020. – P. 298–303. (in Russ.). – URL: https://www.elibrary.ru/item.asp?id=43095471 (access date: 11.04.2023).

4. *Dbar R. S., Gamakhariya P. D.* Mnogoletnyaya dinamika ulovov khamsy *Engraulis encrasicolus* Linnaeus, 1758, zimuyushchei u beregov Abkhazii // Sovremennye problemy i perspektivy razvitiya rybokhozyaistvennogo kompleksa : VIII nauch.-prakt. konf. molodykh uchenykh s mezhdunar. uchastiem, 5–6 noyab. 2020, Moskva / Feder. agentstvo po rybolovstvu, Vseros. nauch.-issled. in-t ryb. khoz-va i okeanografii. – Moskva : VNIRO, 2020. – S. 41–43. – URL: https://www.elibrary.ru/item.asp?id=44755221 (access date: 11.04.2023).

5. *Gamakhariya P. D.* Mnogoletnyaya dinamika promysla i razmerno-vozrastnoi struktury ulovov khamsy (*Engraulis encrasicolus* Linnaeus)[,] zimuyushchei u beregov Abkhazii // Pontus Euxinus – 2021 : XII All-Russ. sci. and appl. conf. for young scientists … A. O. Kovalevsky Inst. of Biology of the Southern Seas of RAS, Sevastopol, Sept. 20–24, 2021 / A. O. Kovalevsky

Inst. of Biology of the Southern Seas of RAS. – Sevastopol : IBSS, 2021. – P. 18–19. – URL: https://www.elibrary.ru/item.asp?id=46638883 (access date: 14.04.2023).

6. *Ivanova P. P., Dobrovolov I. S.* Population-genetic structure on European anchovy (*Engraulis encrasicolus* Linnaeus, 1758) (Osteichthyes: Engraulidae) from mediterraneum Basin and Atlantic Ocean // Acta Adriatica. – 2006. – Vol. 47, no. 1. – P. 13–22.

7. *Nebesikhina N. A., Barmintseva A. E., Timoshkina N. N., Vodyasova E. A.* Microsatellite variability of the European anchovy *Engraulis encrasicolus* Linnaeus, 1758 // Aquatic Bioresources & Environment. – 2019. – Vol. 2, no. 4 – P. 73–84. (in Russ.). – https://doi.org/10.47921/2619-1024_2019_2_4_73

8. *Nebesikhina N. A., Lebedeva E. V.* Study of the genetic structure of the European anchovy *Engraulis encrasicolus* population in the Azov and Black Sea basin // Proceedings of AzNIIRKH. – Rostov-on-Don : AzNIIRKH, 2019. – Vol. 2. – P. 47–52. (in Russ.).

9. *Pravdin I. F.* Rukovodstvo po izucheniyu ryb (preimushchestvenno presnovodnykh). – 4-e izd., pererab. i dop. – Moskva : Pishch. prom-st', 1966. – 376 s.

10. *Vodyasova E. A., Abramson N. I.* Genetic variability of anchovy in the Azov-Black Sea basin // Russian Journal of Genetics. – 2017. – Vol. 53, iss. 6. – P. 680–687. – https://doi.org/10.1134/S1022795417060138

11. *Vodyasova E. A., Abramson N. I.* Phylogeography of European anchovy *Engraulis encrasicolus* // Marine biological research: achievements and perspectives : All-Russ. sci.-pract. conf. … Sevastopol Biol. Station, Sevastopol, Sept. 19–24, 2016 / Federal Agency for Sci. Organizations [et al.] ; ed. A. V. Gaevskaya. – Sevastopol : EKOSI-Gidrofizika, 2016. – Vol. 1. – P. 381–384. (in Russ.). – URL: https://elibrary.ru/item.asp?id=27547114 (access date: 23.03.2023).

12. *Vodyasova E. A., Soldatov A. A.* Identification of subspecies of European anchovy *Engraulis encrasicolus* (Engraulidae) in the wintering aggregations based on morphological parameters of otoliths // Journal of Ichthyology. – 2017. – Vol. 57, iss. 4 – P. 553–559. – https://doi.org/10.1134/S0032945217040191

13. *Zuyev G. V.* Current population structure of European anchovy *Engraulis encrasicolus* L. (Engraulidae: Pisces) in the Sea of Azov – Black Sea basin and history of its formation // Marine Biological Journal. – 2019 – Vol. 4, iss. 1 – P. 45–62. (in Russ.). – https://doi.org/10.21072/mbj.2019.04.1.05

14. *Zuyev G. V.* Modern state of the population of the European anchovy *Engraulis encrasicolus* (L.) (Pisces: Engraulidae) wintering off the coast of the Eastern Crimea and the North Caucasus // Marine Biological Journal. – 2019. – Vol. 4, iss. 3 – P. 56–68. (in Russ.). – https://doi.org/10.21072/mbj.2019.04.3.06

15. *Zuyev G. V., Bondarev V. A., Murzin Yu. L., Novoselova Yu. V.* Intraspecific structural-functional differentiation of Black Sea anchovy wintering near the Crimea coast and its long-term dynamics // Current fishery and environmental problems of the Azov-Black Sea Region : materials VII intern. conf., Kerch, June 20–23, 2012) / State Agency of Fisheries of Ukraine [et al.] ; ed. O. A. Petrenko. – Kerch : YugNIRO, 2012. – Vol. 1. – P. 51–58. (in Russ.). – URL: https://elibrary.ru/item.asp?id=30535433&pff=1 (access date: 23.03.2023).

16. *Zuyev G. V., Bondarev V. A., Murzin Y[u]. L., Samotoy Y[u]. V.* Long-term dynamics of fishery and length-age structure of the Black Sea anchovy (*Engraulis encrasicolus* ponticusaleks) catches in Ukraine // Marine Ecological Journal. – 2014. – Vol. 13, no. 1. – P. 27–34. (in Russ.). – URL: https://elibrary.ru/item.asp?id=22506158 (access date: 23.03.2023).

17. *Zuyev G. V., Klimova T. N.* Long-term dynamic of reproductive performance of European anchovy *Engraulis encrasicolus* Linnaeus, 1758 and its connection with temperature // Marine Biological Journal. – 2017. – Vol. 2, iss. 2 – P. 3–19. (in Russ.). – https://doi.org/10.21072/mbj.2017.02.2.01

К ВОПРОСУ О СТРУКТУРЕ СТАДА ЕВРОПЕЙСКОГО АНЧОУСА, ЗИМУЮЩЕГО У БЕРЕГОВ АБХАЗИИ, И ПРИЧИНАХ, ПОВЛИЯВШИХ НА НИЗКУЮ ВЕЛИЧИНУ ПРОМЫСА (*ENGRAULIS ENCRASICOLUS* L., 1758) В ПРОМЫСЛОВЫЙ СЕЗОН 2022/2023 гг.

Дбар Р. С.[1, 2], Гамахария П. Д.[1]

[1]Институт экологии Академии наук Абхазии (ИЭ АНА), Сухум, Абхазия,
e-mail: pgamakhariya@mail.ru

[1, 2]Азово-Черноморский филиал ФГБНУ «ВНИРО» («АзНИИРХ»),
Ростов-на-Дону, Российская Федерация,
e-mail: romandbar@mail.ru

Аннотация: Произведён анализ результатов промыслового сезона 2022/2023, а также анализ промыслово-биологических и основных биометрических параметров европейского анчоуса (E. *encrasicolus* L., 1758), зимовавшего в прибрежных водах Абхазии. Дана характеристика динамики размерно-возрастной структуры уловов хамсы и представлены внутригодовые закономерности динамики промысла анчоуса (черноморского и азовского). Отмечены изменения популяционных характеристик в составе уловов по сравнению с предыдущими годами. Даны абсолютные значения выловов по месяцам и их колебания. Рассмотрена зависимость биомассы приходящей на зимовку хамсы от основных факторов среды: температуры, течения и ветрового режима.

Ключевые слова: европейский анчоус, азово-черноморская форма хамсы, размерно-возрастная структура, динамика промысла, Абхазия, регрессионный анализ.

Сведения об авторах

Дбар Роман Саидович	кандидат биологических наук, доцент кафедры экологии и морфологии животных, директор, Институт экологии АНА, Сухум, Абхазия, ул. Университетская, 3, 384900, romandbar@mail.ru
Гамахария Паата Джейранович	аспирант по направлению «ихтиология», Абхазский государственный университет; научный сотрудник отдела биотических исследований, Институт экологии АНА, Сухум, Абхазия, ул. Университетская, 3, 384900, pgamakhariya@mail.ru