БІОЛОГІЧНІ ДОСЛІДЖЕННЯ

УДК (UDC): 591.5:591.9:59.5(477.74)

DOI: https://doi.org/10.26565/1992-4259-2020-23-08

S. M. SNIHIROV[1], PhD (Biology)**, V. I. MEDINETS[1],** PhD (Physics and Mathematics)**,**
A. N. ABAKUMOV[1], V. Z. PITSYK[1], P. M. SNIGIROV[1], I. E. SOLTYS[1], O. P. KONAREVA[1],
V. V. ZAMOROV[1], PhD (Biology)
[1]*Odessa National I. I. Mechnikov University,*
Mayakovsky lane 7, Odessa, Ukraine

E-mail: snigirev@te.net.ua ORCID: https://orcid.org/0000-0003-3287-2519
medinets@te.net.ua http://orcid.org/0000-0001-7543-7504
alex.n.abakumov@gmail.com
v.z.pitsyk@gmail.com
snigirov@gmail.com
i.soltys@onu.edu.ua https://orcid.org/0000-0001-5109-1975
o.konareva@onu.edu.ua https://orcid.org/0000-0001-5109-1975
v.zamorov@onu.edu.ua https://orcid.org/0000-0001-5921-1580

THE RESULTS OF ZMIINYI ISLAND (BLACK SEA) COASTAL WATERS ICHTHYOFAUNA MONITORING IN 2016-2017

Purpose. To study the state of ichthyofauna in the Zmiinyi Island coastal waters in 2016-2017.

Methods. Standard methods of ichthyofauna sampling, determination, abundance and biomass estimation.

Results. During the period of studies, 68 species of marine, brackish-water and freshwater fish were found in the Zmiinyi Island area belonging to 18 orders, 41 families and 55 genera. The biggest number of taxa belongs to Perciformes order. The representatives of this order make one-half of all the species found near the island. Indicators of ichthyofauna species diversity in the Zmiinyi Island area were gradually decreasing in the period from 2003 to 2009. In 2015-2016 all those indicators grew significantly. Biodiversity level (Shannon index values calculated coming out of number) in 2016 varied from 0.86 to 3.06 making in the average 2.06; in 2017 – from 2.40 to 2.54 making in the average 2.47. Minimal values of biodiversity indicators were registered in the end of autumn and in winter, maximal – in May-June. In the Zmiinyi Island coastal waters 30.9% of all the fishes registered in the Black Sea were found. The fishes caught near the island belonged to 5 ecological groups. The basis of ichthyofauna in the area was formed by marine fish species – 52 species (76.5 % of the total number of species). Most of species (54 species or 89.4%) were bottom-dwelling or near-bottom. Pelagophylic and protecting species prevailed and their numbers were almost equal (24 species or 35.3% and 23 species or 33.8% respectively). On the type of feeding, predatory (37%) and benthos-eating (33%) species prevailed. Out of 68 species found in the island area, 16 species are included into the Red Book of Ukraine, 22 species – into the Black Sea Red Data Book, 7 species – into the IUCN Red List. More than one-half of the species registered in the area (36 species or 52% of all the species) have a protected status.

Conclusions. Results of analysis of biodiversity, structural characteristics and taxonomic composition of ichthyofauna in the Zmiinyi Island coastal waters have been presented. Seasonal dynamics of its number and biomass has been studied. The results of the analysis of some aspects of ecology and biology of the main mass species of fish are presented. Recommendations are given to improve monitoring of the ichthyofauna of coastal waters. Quality of bottom communities monitoring in the Zmiinyi Island coastal waters can be increased significantly by development and implementation of non-contact low-budget video-monitoring methods to solve the problem of fish stock and biodiversity studying in inaccessible areas. It is anticipated that the method developed will help high precision assess of fish stock in inaccessible shelf areas where application of other methods is

connected with technical difficulties, high cost and can lead to unreliable results. Elaboration of the method aimed at development of video materials received computer processing algorithms will significantly simplify analysis of the data collected.

KEYWORDS: ichthyofauna, biodiversity, abundance, biomass, Zmiinyi Island

Снігірьов С. М.[1], Медінець В. І.[1], Абакумов О. М.[1], Піцик В. З.[1], Снігірьов П. М.[1], Солтис І. Є.[1], Конарева О. П.[1], Заморов В. В. [1]

[1]Одеський національний університет імені І. І. Мечникова, м. Одеса, Україна

РЕЗУЛЬТАТИ МОНІТОРИНГУ ІХТІОФАУНИ ПРИБЕРЕЖНИХ ВОД ОСТРОВА ЗМІЇНИЙ (ЧОРНЕ МОРЕ) У 2016-2017 РР.

Мета. Вивчення сучасного стану іхтіофауни прибережних вод острова Зміїний в 2016-2017 рр. **Методи.** Стандартні методи відбору, визначення, оцінки чисельності і біомаси іхтіофауни.

Результати. Протягом досліджень виявлено 68 видів морських, солонуватоводних і прісноводних риб, що належать до 18 рядів, 41 родині, 55 родів. Найбільше число таксонів включає ряд окунеподібних Perciformes. Рівень біорізноманіття іхтіофауни (індекс Шеннона, розрахований за чисельністю) в 2016 році коливався в межах 0,86-3,06, в середньому складаючи 2,06, в 2017 – 2,40-2,54, в середньому – 2,47. Мінімальні показники біорізноманіття відзначені в кінці осені і в зимовий період, максимуми – в травні-червні. Всього в прибережних водах у о. Зміїний відзначено 30,9% від усіх видів риб, зареєстрованих в Чорному морі. Виловлені у о. Зміїний риби відносяться до 5 екологічних груп. Основу іхтіофауни цього району утворюють власне морські риби – 52 види (76,5% загальної кількості виявлених видів), більшість видів (54 види – 89,4%) ведуть донний і придонний спосіб життя, майже в рівній кількості переважають пелагофіли і охороняючи (24 виду – 35,3% і 23 види – 33,8%, відповідно), за характером живлення провідне місце в рівній кількості займають хижі і бентофаги. З 68 знайдених біля острова видів 16 видів занесені в списки Червоної книги України, 22 вид занесені до Червоної книги Чорного моря, 7 видів - до Червоного списку МСОП. Більше половини – 36 видів (52,9% загального числа видів) з виявлених у острова видів мають охоронний статус.

Висновки. Наведено результати аналізу біорізноманіття, структурних характеристик, таксономічного складу іхтіофауни прибережних вод острова Зміїний. Досліджено сезонну динаміку чисельності і біомаси. Наведено результати аналізу деяких аспектів екології та біології основних масових видів риб. Наведено рекомендації щодо поліпшення моніторингу іхтіофауни прибережних вод. Рівень якості моніторингових досліджень донних співтовариств прибережних вод острова Зміїний, включаючи іхтіофауну, може бути значно підвищений у разі розробки і застосування безконтактних методів відеоспостережень для вирішення проблеми вивчення стану запасів риб, їх біорізноманіття в важкодоступних місцях. Розвиток методу, спрямований на створення алгоритмів комп'ютерної обробки отриманих відеоматеріалів, дозволить значно полегшити аналіз отриманих даних.

КЛЮЧОВІ СЛОВА: іхітофауна, біорізноманіття, чисельність, біомаса, острів Зміїний

Снигирев С. М.[1], Мединец В. И.[1], Абакумов А. Н.[1], Пицык В.З.[1], Снигирев П. М.[1], Солтыс І. Е.[1], Конарева О. П.[1], Заморов В. В.[1]

[1]Одесский национальный университет имени И. И. Мечникова, г. Одесса, Украина

РЕЗУЛЬТАТЫ МОНИТОРИНГА ИХТИОФАУНЫ ПРИБРЕЖНЫХ ВОД ОСТРОВА ЗМЕИНЫЙ (ЧОРНОЕ МОРЕ) В 2016-2017 РР.

Цель. Изучение состояния ихтиофауны в прибрежных водах острова Змеиный в 2016-2017 гг. **Методы.** Стандартные методы отбора, определения, оценки численности и биомассы ихтиофауны.

Результаты. В течение исследований обнаружено 68 видов морских, солоноватоводных и пресноводных рыб, принадлежащих к 18 отрядам, 41 семействам, 55 родам. Наибольшее число таксонов включает отряд окунеобразные Perciformes. Уровень биоразнообразия ихтиофауны (индекс Шеннона, рассчитанный по численности) в 2016 году колебался в пределах 0,86-3,06, в среднем составляя 2,06, в 2017 – 2,40-2,54, в среднем – 2,47. Минимальные показатели биоразнообразия отмечены в конце осени и в зимний период, максимумы индекса биоразнообразия были отмечены в мае-июне. Всего в прибрежных водах у о. Змеиный отмечено 30,9% от всех видов рыб, зарегистрированных в Черном море. Выловленные у о. Змеиный рыбы относятся к 5 экологическим группам. Основу ихтиофауны этого района образуют собственно морские рыбы – 52 вида (76,5% общего количества обнаруженных видов), большинство видов (54 вида – 89,4%) ведут донный и придонный образ жизни, почти в равном количестве преобладают пелагофилы и охраняющие (24 вида – 35,3% и 23 вида – 33,8%, соответственно), по характеру питания ведущее место в равном количестве занимают хищные и бентофаги. Из 68 найденных у острова видов 16 видов занесены в списки Красной книги Украины, 22 вида - в Красную книгу Черного моря, 7 видов – в Красный список МСОП. Более половины – 36 видов (52,9% общего числа видов) из обнаруженных у

острова видов имеют охранный статус.

Выводы. Проанализировано биоразнообразие, структурные характеристики, таксономический состав и сезонная динамика численности и биомассы ихтиофауны прибрежных вод острова Змеиный. Приведены рекомендации по улучшению мониторинга ихтиофауны прибрежных вод. Уровень качества мониторинговых исследований донных сообществ прибрежных вод острова Змеиный, включая ихтиофауну, может быть значительно повышен в случае разработки и применения бесконтактных малобюджетных методов видеонаблюдения для решения проблемы изучения состояния запасов рыб, их биоразнообразия в труднодоступных местах. Развитие метода, направленное на создание алгоритмов компьютерной обработки полученных видеоматериалов, позволит значительно облегчить анализ полученных данных.

КЛЮЧЕВЫЕ СЛОВА: ихтиофауна, биоразнообразие, численность, биомасса, остров Змеиный

Introducton

The most complete ichthyofauna studies in the north-western Black Sea were performed by the outstanding scientists of the 19th and 20th centuries I.M. Vidgalm, A.V. Yatsentkovskiy, P.Yu. Shmidt, A.N. Popov, V.A. Krotov, D.K. Tretyakov, V.S. Chepurnov and N.S. Burnashev, K.A. Vinogradov, F.S. Zambriborsch [1, 2]. First brief information on ichthyofauna of the Zmiinyi Island coastal waters were presented in the works by A. D. Nordman, G.O. Solianik, A. Borza, R. Calienescu [1, 2]. The comprehensive hydrobiological and ichthyological studies of the island coastal waters were performed in 1993-1997 by the researchers of the Institute of Biology of Southern Seas, Odessa Branch (OB IBSS) [1]. From 2003 till present regular observations of ichthyofauna are being performed by the staff of the Research Station «Zmiinyi Island» of Odessa National I.I. Mechnikov University; their results were partly described in the papers [1, 2-9].

The purpose of the present research was to study the state of ichthyofauna in the Zmiinyi Island coastal waters in 2016-2017.

Materials and Methods

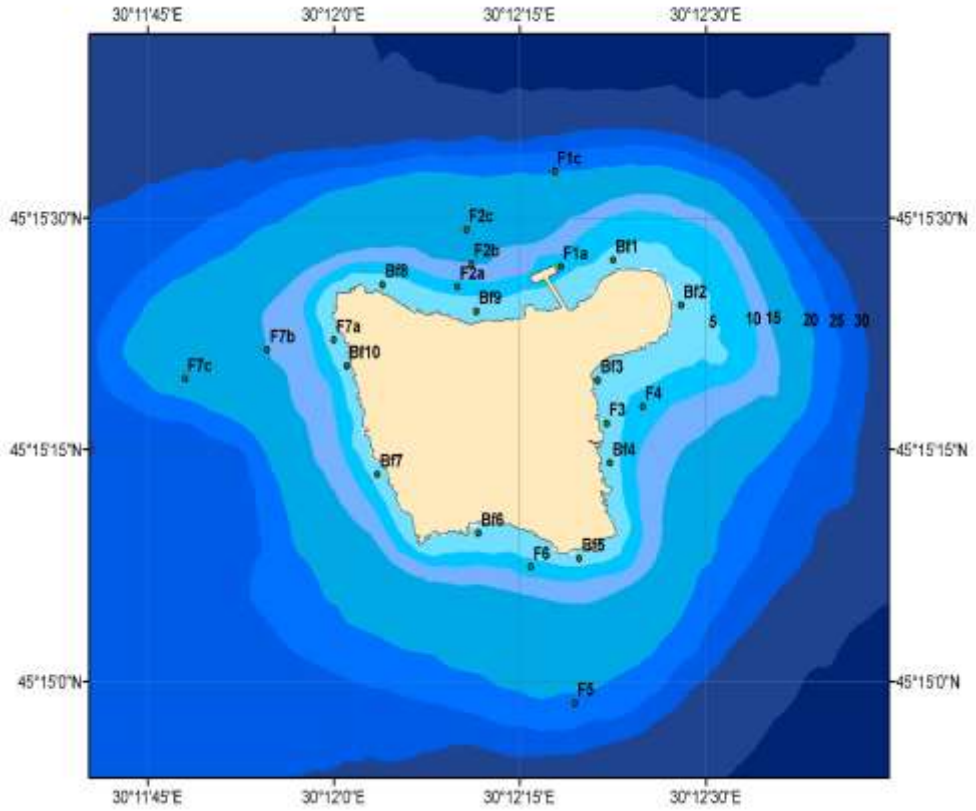
The results of ichthyological observations carried out by the staff of the "Zmiinyi Island" Research Station in 2016-2017 in the framework of the research projects funded by the Ministry of Education and Science of Ukraine and the EMBLAS-II International Project have been used. Most of ichthyological studies (about 90.0% of fishing) were carried out in the coastal waters of the Zmiinyi Island at the distance of up to 5.0 km from the coastline (Fig. 1).

Fishing gear were set in the coastal zone of the island, the area of which totaled to ca. 2.0 km^2. Standard ichthyological fishing methods were used [10, 11]:

- gillnets and Nieman nets (length 100.0 m, mesh size 1.6-10.0 cm, material – kapron, monofilament) at the depths 1.5-30 m, distance from water edge 2.0 - 500.0 m. In case the nets were set on stony substrate they were placed under water between stones and boulders by divers. The nets were set at 1.00-3.00 p.m. and checked once a day;
- rectangular fish traps with openings on each side (mesh size 0.8 cm);
- dual trap net (length 3.0 m, mesh size 0.8 cm).
- flat-bottom fry net (diameter 1.5 m, mesh size 0.6 cm);
- big aquarium dip-net (diameter 0.5 m, mesh size 0.02 cm);
- hook and line gear with natural and artificial bites.

To assess fish number in the period of studies near the island coast (depth 1.0 – 1.5 m) we have selected plots of stony substrate (boulders) with the area of ca. 1.0 m^2. In those areas observations and catching of fishes belonging to families Gobiidae, Blenniidae, Gobiesocidae, and Labridae were carried out from 12.00 to 3.00 p.m. in the days when the conditions were the following: water transparency – not less than 2.0 m, waves – under force 1, no clouds. Underwater observations, description of bottom relief and substrate in the areas of ichthyological material collecting were performed using diving outfit in accordance with the methodologies [12-14].

Fish species identification was done in field conditions using key-books [15-30]. h taxonomy is presented in accordance with the Black Sea Fish Check List [31].



Notes: -5-…. -35 – isobaths with depth; F1 – F7 – ichthyological stations (depth from 5.0 to 30.0 m); Bf1 – Bf10 – coastal ichthyological stations (depth not more than 2.0 m)

Fig. 1 – Schematic map of ichthyological stations location near the Zmiinyi Island

Ecological characteristic of species is presented in accordance with [18-24]. Analysis of fishing dynamics was done coming out of size of catch per fishing effort – quantity of individuals per one 100 m long fishing net per day (ind/day). Full biological analysis of the caught fish was performed according to general methodologies [10, 11, 32]. During the analysis we measured: general (absolute or zoological) length (cm), commercial (standard) length (cm), body mass (g), identified fish sex, stage of gonads maturity, stomach fullness level on a scale from 1 to 3. Digestive tracts of fish were fixed with 4% formaldehyde for subsequent laboratory study. Otholiths reading was performed to determine fish age. Fertility was calculated using eggs quantity in the ovaries of females at 4^{th} and 5^{th} stages of maturity.

Studying ichthyofauna diversity, we used three indicators of community species composition calculated in accordance with general formulas: Margalef's species richness index [33], Shannon index of general diversity [34] and Pielou evenness index [35]. Indices were calculated coming out of number. Statistical processing was performed using Excel 7.0.

Results and Discussion

General characteristics of fish habitat. As a biotope characteristics determine species omposition and structure of the organisms forming biocoenoses around the island, we identified four main biotopes depending on bottom substrate type based on results of the studies carried out from 2003 to 2017 [1, 2, 9 36, 37]: stones and boulders; mixed substrate; sand, shelly ground; sand, shelly ground and silt. The areas covered by those substrates

where different in size: stones and boulders – ca. 0.2 km^2, mixed substrate – ca. 0.1 km^2, sand and shelly ground – ca. 0.2 km_2, sand, shelly ground and silt – ca. 1.5 km^2 [1, 2]. Right near the island (depth of ca. 8.0 m) stones and boulders can be found. The highest number of taxa was registered there (33 to 37), as well as maximal number of benthic organisms. The most mass species, mussel, forms a mussel biocoenoses typical of the Black Sea coastal areas (*M. galloprovincialis* –up to 100% of surface coverage) with a respective composition of different crustaceans, polychaetes, bryozoans, actiniae and many other invertebrates. This substrate is notable for the highest macrophytes biomass. All that attracts lot of different fish species, especially juveniles during feeding period. The state of the bottom areas covered with stones and boulders could be considered satisfactory during 2016-2017. Insignificant local fish-kill phenomena were only registered in summer of 2016 in the deepest areas between stones where water mixing is weak in the periods of windless conditions.

Mixed substrate found at the depth of 8.0-12.0 m near the island consists of boulders lying separately on soft soil (sand, shelly ground). There 11 to 34 macrozoobenthos taxa were registered, as well as numerous macrophytes and fish. No fish-kills were found at those areas in 2016-2017.

Analysis of the materials collected from the depth of 12.0 to 37.0 m has shown that sand and shelly ground (45.0%) and shelly (47.0%) substrate dominate in the studied areas around the island. Share of silty and silt and shelly ground substrate is insignificant – 3.0 and 5.0% respectively. Sand and shelly ground where we previously (2003-2005) observed biocoenoses of mussels *M. galloprovincialis* were located within the depth range of 12.0 – 20.0 m. The substrate formed by soft soils - sand, shelly ground and silt was found at the depths exceeding 20.0 m. On sand and shelly ground 19 - 35 taxa of benthos were found. On softer soils benthos was more diverse (9 to 16 taxa) and its biomass was insignificant. Biocoenoses of those biotopes were exposed to the most significant changes. The kill phenomena typical of the north-western Black Sea were observed in those bottom areas quite regularly. We have to underline that mussel biocoenoses previously found on soft substrate were practically destroyed by predatory mollusc Rapa whelk; recently Rapa whelk individuals distributed significantly in the coastal areas near the island. As the result of its negative impact the bottom area with dense aggregations of mussels shrunk from 78 Ha in 2004-2005 to 19 Ha in 2010-2014, at that the total biomass of macrozoobenthos decreased from 8300 t to 3700 t [39]. No kill phenomena were observed on soft soils in 2016-2017. Visual observations at the depth of 15.0-20.0 m registered different species of crabs and other crustaceans quite often, which evidenced the satisfactory state of soft soil biocoenoses.

General ichthyofauna characteristics. Species composition and biodiversity of ichthyofauna. During the period from 2003 to 2017, 68 species of marine, brackish-water and freshwater fish were found in the Zmiinyi Island area belonging to 18 orders, 41 families and 55 genera (Table 1).

In the period from April to December 2016, around 50 fish species were registered in the island coastal waters; during 2 months (May and June) of 2017 – 37 species (Table 1).

Out of 68 species of marine, brackish-water and freshwater fish, the biggest number of taxa belong to Perciformes order. Half of all the species found near the island are the representatives of this order (Tables 2, 3).

Analysis of the results received in April-December 2016 and May-June 2017 had shown that the level of ichthyofauna biodiversity (Shannon index calculated coming out of number) varied in 2016 from 0.86 to 3.06 making in average 2.06, in 2017 – 2.40-2.54, with average value 2.47 (Fig. 2).

Minimal indicators of biodiversity were registered in the end of autumn and in winter when most of fishes migrated for wintering to deep areas and the thermophilic species migrated to the coasts of the Crimea, Georgia and Turkey. Maximums of biodiversity index were registered in May-June – the period when many different fish species came to the island coastal zone to spawn, as well as in October – the period of feeding and winter migration for many ichthyofauna species.

Ichthyofauna structure. Fishes caught near the Zmiinyi Island belong to 5 ecological groups. The basis of ichthyofauna in the area is formed by sea fish – 52 species or 76.5% of all the species found (Table 4).

Other groups in the island coastal waters are presented by lower number of species:

Table 1

Taxonomic composition of the Zmiinyi Island coastal ichthyofauna: ecological characteristics, protection status and occurrence of species

Taxa	Ecological characteristics	Protection status	Occurrence of species						
			2003-17	2016				2017	
				IV-V	VI-VIII	IX-XI	XII	V	VI
Squalidae									
Squalus acanthias L., 1758	I; M; P; Ov	1R	++	++	-	++	++	-	-
Rajidae									
Raja clavata L., 1758	I; M; NB; LPsp	1R	++	++	-	-	-	++	-
Dasyatidae									
Dasyatis pastinaca (L., 1758)	I; M; NB; Ov		++	-	++	-	-	-	-
Acipenseridae									
Acipenser stellatus Pallas, 1771	III; M; NB; Lp	1R; 2R; 3R	+	-	-	-	-	-	-
A. gueldenstaedtii Brandt et Ratzeburg, 1833	III; M; NB; Lp	1R; 2R; 3R	+	-	-	-	-	-	-
Huso huso (L., 1758)	III; M; NB; Lp	1R; 3R	+	-	-	-	-	-	-
Engraulidae									
Engraulis encrasicolus (L., 1758)	I; M; P; Pf		++	++	++	++	++	++	++
Clupeidae									
Alosa maeotica (Grimm, 1901)	III; M; P; Pf		++	++	-	+	-	-	-
Sprattus sprattus (L., 1758)	I; M; P; Pf		++	++*	++*	++*	-	+	+*
Cobitidae									
Misgurnus fossilis (L., 1758)	IV; S; B; Pp		+	-	-	-	-	-	-
Cyprinidae									
Carassius gibelio (Bloch, 1782)	IV; S; NB; Pp		+	-	-	-	-	-	-
Rutilus rutilus (L., 1758)	IV; S; NB; Pp		+	-	-	-	-	-	-
Siluridae									
Silurus glanis L., 1758	IV; S; B; Bnp		+	-	-	-	-	-	-
Salmonidae									
Salmo labrax Pallas, 1814	III; M; P; Lp	1R; 3R	+	-	+	-	-	-	-
Phycidae									
Gaidropsarus mediterraneus (L., 1758)	I; S; B; Pf		++	++	++	++	++	++	++
Gadidae									
Merlangius merlangus euxinus (Nordmann, 1840)	I; M; NB; Pf		++	++	++	++	++	++*	++*
Ophidiidae									
Ophidion rochei Muller, 1845	I; S; B; Pf		++	++*	++*	++*	+*	++*	++*
Mugilidae									

Taxa	Ecological characteristics	Protection status	Occurrence of species						
			2003-17	2016				2017	
				IV-V	VI-VIII	IX-XI	XII	V	VI
Liza aurata (Risso, 1810)	I; M; P; Pf		++	++*	++	++	-	+*	++
L. haematocheila (Temminck et Schlegel, 1845)	I; M; P; Pf		++	-	++**	-	-	-	+*
Atherinidae									
Atherina pontica (Eichwald, 1831)	I; M; P; Pp		++	++	++	++*	-	++*	++
Belonidae									
Belone belone euxini Gunther, 1866	I; M; P; Pp	2R	++	-	+*	++*	-	-	+*
Gasterosteidae									
Gasterosteus aculeatus L., 1758	I; S; NB; Bnp		+	+*	-	-	-	-	-
Syngnathidae									
Hippocampus hippocampus (L., 1758)	I; S; NB; Ce	2R; 3R	++	+*	++*	++*	-	-	++*
Nerophis ophidion (L., 1758)	I; S; NB; Ce	2R	+	-	-	-	-	-	-
Syngnathus abaster Risso, 1827	I; S; NB; Ce	1R	+	-	+*	-	-	-	+*
S. acus L., 1758	I; S; NB; Ce		+	-	+*	-	-	-	-
S. tenuirostris Rathke, 1837	I; S; NB; Ce	2R; 3R	+	-	-	-	-	-	-
S. typhle L., 1758	I; S; NB; Ce	2R	+	-	+*	-	-	-	+*
S. variegatus Pallas, 1814	I; S; NB; Ce	3R	+	-	-	-	-	-	-
Scorpaenidae									
Scorpaena porcus L., 1758	I; S; B; (Lp)Pf	2R	++	++	++	++	++	++	++
Triglidae									
Chelidonichthys lucernus L., 1758	I; S; B; Pf	2R; 3R	+	-	-	-	-	-	-
Pomatomidae									
Pomatomus saltatrix (L., 1766)	I; M; P; Pf		++	-	++	++	-	-	-
Carangidae									
Trachurus mediteraneus ponticus Aleev, 1956	I; M; P; Pf		++	-	++	++	-	-	++
Sparidae									
Diplodus annularis (L., 1758)	I; S; NB; Pf	2R	+	-	-	-	-	-	-
Centracanthidae									
Spicara flexuosa Rafinesque, 1810	I; S; P; Bnp		+	+	-	-	-	-	+
Centrarchidae									
Lepomis gibbosus (L., 1758)	IV; S; NB; Bnp		+	-	-	-	-	-	-
Sciaenidae									
Sciaena umbra L., 1758	I; S; NB; Pf	3R	+	-	-	-	-	-	-
Umbrina cirrosa (L., 1758)	I; S; NB; Pf	3R	+	-	-	+	-	-	-

Taxa	Ecological characteristics	Protection status	Occurrence of species						
			2003-17	2016				2017	
				IV-V	VI-VIII	IX-XI	XII	V	VI
Mullidae									
Mullus barbatus ponticus Essipov, 1927	I; S; B; Pf	2R	++	++	++	++*	-	++	++
Pomacentridae									
Chromis chromis (L., 1758)	I; S; NB; Bnp	3R	+	-	+*	-	-	-	-
Labridae									
Symphodus cinereus (Bonnatterre, 1788)	I; S; NB; Bnp		++	++	++	++	+*	++	++
S. ocellatus (Forsskål, 1775)	I; S; NB; Bnp	2R	+	+*	+*	+*	-	-	+*
S. tinca (L., 1758)	I; S; NB; Bnp	2R	+	-	-	-	-	-	+*
Ammodytidae									
Gymnammodytes cicerellus (Rafinesque, 1810)	I; S; B; Psp		++	+*	++*	++*	-	-	++*
Trachinidae									
Trachinus draco L., 1758	I; S; B; Pf	2R	+	-	+	+	-	+	+
Uranoscopidae									
Uranoscopus scaber L., 1758	I; S; B; Pf	2R	+	+	+	+	-	+	+
Blenniidae									
Aidablennius sphynx (Valenciennes, 1836)	I; S; B; Bnp	2R	++	++*	++*	++*	++*	++*	++*
Parablennius sanguinolentus (Pallas, 1814)	I; S; B; Bnp		++	++	++	++	+*	++	++
P. tentacularis (Brünnich, 1768)	I; S; B; Bnp		++	++	++	++	+*	++	++
P. zvonimiri (Kolombatovič, 1892)	I; S; B; Bnp		+	+*	+*	+*	-	+*	+*
Salaria pavo (Risso, 1810)	I; S; B; Bnp	2R	+	-	+*	+*	-	+*	+*
Callionymidae									
Callionymus risso Lesueur, 1814	I; S; B; Pf	3R	+	-	-	-	-	-	-
Gobiidae									
Aphia minuta (Risso, 1810)	I; M; P; Pp		+	+*	-	+*	-	-	-
Benthophilus nudus (Berg, 1898)	II; S; B; Bnp		+	-	-	-	-	-	-
Gobius niger L., 1758	I; S; B; Bnp		++	++*	++*	++*	+*	+*	++*
G. paganellus L., 1758	I; S; B; Bnp	3R	+	-	+*	+*	-	-	+*
Mesogobius batrachocephalus (Pallas, 1814)	II; S; B; Bnp	2R	++	++	++	++	+	++	++
Neogobius cephalargoides Pinchuk, 1976	II; S; B; Bnp		+	-	-	-	-	-	-
N. melanostomus (Pallas, 1814)	II; S; B; Bnp		++	++	++	++	++	++	++

Taxa	Ecological characteristics	Protection status	Occurrence of species						
			2003-17	2016				2017	
				IV-V	VI-VIII	IX-XI	XII	V	VI
N. ratan (Nordmann, 1840)	II; S; B; Bnp	2R	++	+*	++*	+*	-	+*	++*
Proterorhinus marmoratus (Pallas, 1814)	II; S; B; Bnp	2R	+	-	+*	+*	-	-	+*
Scombridae									
Sarda sarda (Bloch, 1793)	I; M; P; Pf	2R	+	-	-	+*	-	-	-
Gobiesocidae									
Diplecogaster bimaculata (Bonnaterre, 1788)	I; S; B; Bnp	3R	+	-	+*	+*	-	-	-
Lepadogaster candollii Risso, 1810	I; S; B; Bnp	3R	++	++*	++*	++*	++*	+*	++*
Scophthalmidae									
Psetta maeotica (Pallas, 1814)	I; S; B; Pf		++	++	+*	++	-	++	+*
Pleuronectidae									
Platichthys flesus luscus (Pallas, 1814)	I; S; B; Pf		+	+	-	-	-	+	-
Bothidae									
Arnoglossus kessleri Schmidt, 1915	I; S; B; Pf	3R	+	-	+*	+*	-	-	-
Soleidae									
Pegusa lascaris (Risso, 1810)	I; S; B; Pf	2R	+	+	-	+	-	-	-
Всего		**30**	**68**	**32**	**39**	**38**	**14**	**25**	**35**

Notes: Ecological and faunistic characteristics of species: I – marine; II – brackish-water; III – anadromous; IV – freshwater (including semi-anadromous); M – migratory; S – sedentary; B – bottom-dwelling; P – pelagic, NB – near-bottom; Pf – pelagophyl; Pp – phytophyl; Lp – lithophyl; Psp – psammophyl; LPsp – lithopsammophyl; Ce – carrying eggs; Ov – ovoviviparous; Bnp –building nests and protecting eggs. Protection status: 1R – IUCN Red List; 2R – Black Sea Red Data Book; 3R – Red Book of Ukraine. Occurrence of species: – species not found, + – rare species, ++ – common and mass species, * – species registered by visual observation.

brackish-water species – 8.7%, freshwater species – 7.4%, anadromous species – 7.4%.

Most of species (54, or 89.4% of species) are bottom-dwelling and near bottom. The group of pelagic fish is represented by much lower number of species (14, or 20.6% of species).

As to spawning habits, pelagophyls and protecting species equally dominate in the island coastal waters (24 species or 35.3% and 23 species or 33.8% respectively). The quantity of phytophyls, lithophyls, psammophyls and lithopsammophyls is insignificant, their shares are, respectively, 8.8; 5.9; 1.5 and 1.5%. Seven species of Syngnathidae family (10.3%) lay eggs in brood pouch. Two species (2.9%), dogfish and chuco, are ovoviviparous. On feeding habits, predatory and benthos-eating species equally dominate, comprising one-half of all the species found in the area. The share of the rest of species is much smaller.

Analysis of the mass species number and biomass, size, age and sex composition and feeding habits of mass species had shown the following. During the year 2016 (from April to December) the following species prevailed in the catches in the Zmiinyi Island coastal zone: anchovy (36.7%), sea scorpion (16.2%), horse mackerel (12.7%), round goby (11.5%) and whiting (9.6%). The share of other species was insignificant and made 0.02 – 2.8% (Table 5).

Anchovy formed significant aggregations in the island area during winter migrations December (86.0% of total number caught

Table 2

Ranking of the Zmiinyi Island coastal waters ichthyofauna orders on the number of taxa

Ranking of orders (n = 18) on the number of taxa								
Order	**Number of families**		**Order**	**Number of genera**		**Order**	**Number of species**	
	n	**%**		**n**	**%**		**n**	**%**
Perciformes	16	39,0	Perciformes	24	43,6	Perciformes	31	45,6
Pleuronectiformes	4	9,8	Pleuronectiformes	4	7,3	Syngnathiformes	7	10,3
Clupeiformes	2	4,9	Clupeiformes	3	5,5	Pleuronectiformes	4	5,9
Cypriniformes	2	4,9	Cypriniformes	3	5,5	Clupeiformes	3	4,4
Gadiformes	2	4,9	Syngnathiformes	3	5,5	Cypriniformes	3	4,4
Rajiformes	2	4,9	Acipenseriformes	2	3,6	Acipenseriformes	3	4,4
Scorpaeniformes	2	4,9	Gadiformes	2	3,6	Gadiformes	2	2,9
Other 11 orders represented by one family each	11	26,8	Gobiesociformes	2	3,6	Gobiesociformes	2	2,9
			Rajiformes	2	3,6	Mugiliformes	2	2,9
			Scorpaeniformes	2	3,6	Rajiformes	2	2,9
			Other 8 orders represented by one family each	8	14,5	Scorpaeniformes	2	2,9
						Other 7 orders represented by one species each	7	10,3
Total	41	100,0	Total	55	100,0	Total	68	100,0

Table 3

Ranking of the Zmiinyi Island coastal waters ichthyofauna families on the number of taxa

Ranking of families (n = 41) on the number of taxa						Ranking of genera (n = 55) On the number of species		
Family	**Number of genera**		**Family**	**Number of species**		**Genus**	**Number of species**	
	n	**%**		**n**	**%**		**n**	**%**
Gobiidae	6	10.9	Gobiidae	9	13.2	Syngnathus	5	7.4
Blennidae	3	5.5	Syngnathidae	7	10.3	Neogobius	3	4.4
Syngnathidae	3	5.5	Blennidae	5	7.4	Parablennius	3	4.4
Acipenseridae	2	3.6	Acipenseridae	3	4.4	Symphodus	3	4.4
Clupeidae	2	3.6	Clupeidae	2	2.9	Acipenser	2	2.9
Cyprinidae	2	3.6	Cyprinidae	2	2.9	Gobius	2	2.9
Gobiesocidae	2	3.6	Gobiesocidae	2	2.9	Liza	2	2.9
Sciaenidae	2	3.6	Labridae	3	4.4	Other 48 genera represented by 1 species each	48	70.6
Other 33 families represented by 1 genus each	33	60.0	Mugilidae	2	2.9			
			Sciaenidae	2	2.9			
			Other 31 families represented by 1 species each	31	45.6			
Total	55	100.0	Total	68	100.0	Total	68	100.0

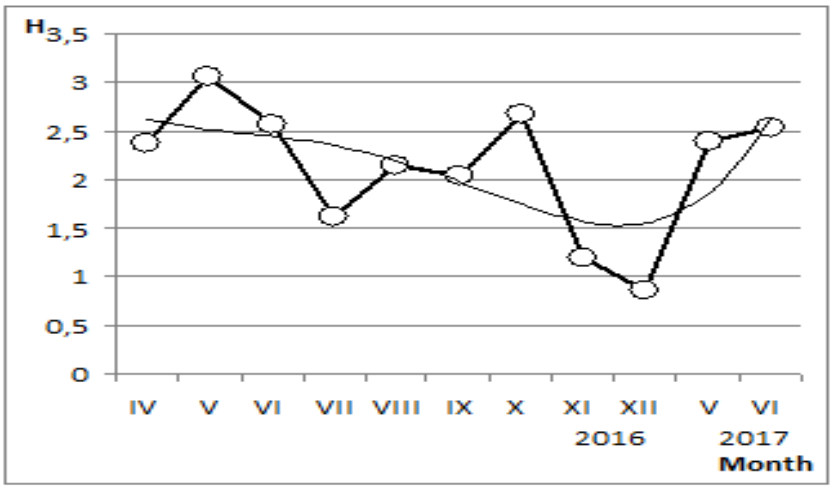


Fig. 2 – Shannon index H (ln) of species diversity (out of number) of the Zmiinyi Island coastal waters ichthyofauna in 2016-2017

Table 4

Ecological and zoogeographical characteristics of the Zmiinyi Island coastal waters ichthyofauna

Ecological and zoogeographic characteristics	No. of species	%	Ecological and zoogeographic characteristics	No. of species	%
Marine	52	76.5	Pelagophyls	24	35.3
Brackish-water	6	8.7	Protecting	23	33.8
Anadromous	5	7.4	Phytophyls	6	8.8
Freshwater	5	7.4	Lithophyls	4	5.9
Total	**68**	**100.0**	Psammophyls	1	1.5
Migratory	19	27.9	Lithopsammophyls	1	1.5
Sedentary	49	72.1	Ovoviviparous	2	2.9
Total	**68**	**100.0**	Carrying eggs	7	10.3
Bottom-dwelling	30	44.1	**Total:**	**68**	**100.0**
Near-bottom	24	35.3			
Pelagic	14	20.6			
Total	**68**	**100.0**			

during the period of fishing). The biggest number of sea scorpion individuals was caught in summer months and in September during its spawning. Maximal catches of horse mackerel and round goby took place in May during spawning migration of those species. Highest number of whiting (cryophilous species) was caught in December 2016.

Like in previous years, the most significant on biomass were catches of demersal species sea scorpion and round goby. Out of the group of pelagic species, anchovy and horse mackerel prevailed in catches. In 2017 (May-June), as well as in 2016, round goby (38.76%) and horse mackerel (37.15%) dominated in catches in number. Catches of combtooth blenny were relatively high (7.63%). Share of other species was insignificant and made from 0.1 to 2.31% (Table 6).

Pelagic fish species. During the period of studies, 2 years' old individuals of anchovy and silverside were most often found in the catches near the island, 2-3 years' old horse mackerel, 1 year old bluefish. Average values of general length and weight, as well as intensity of feeding (total index of stomach fullness, TISF) for anchovy, silverside, bluefish and horse mackerel are presented in Table 6. Sex ratio (males:females) of these species in the catches was 1.2:1.0; 1.0:1.5; juv and 1.0:1.3

Table 5

Relative number of representatives of the Zmiinyi Island coastal waters ichthyofauna in the period from April to December 2016

Specise	Month									Total Number, ind	Percentage, %
	IV	V	VI	VII	VIII	IX	X	XI	XII		
En. encrasicolus	0,0	4,2	1,8	0,7	5,6	0,1	0,0	1,5	86,0	2197	36,7
S. porcus	1,0	5,7	13,6	20,8	32,6	23,6	0,0	1,8	0,9	971	16,2
T. m. ponticus	0,0	50,2	38,9	1,3	3,7	3,8	1,6	0,5	0,0	761	12,7
N. melanostomus	19	61,4	10,3	0,9	2,0	2,3	0,0	2,9	1,0	689	11,5
M. m. euxinus	9,4	6,6	0,2	0,0	0,0	0,0	0,0	8,5	75,3	575	9,6
P.sanguinolentus	18	71,9	3,6	1,2	0,6	3,0	0,0	1,8	0,0	167	2,8
S. cinereus	1,8	43,1	20,2	5,5	8,3	21,1	0,0	0,0	0,0	109	1,8
U. scaber	0,9	22,0	26,6	35,8	8,3	6,4	0,0	0,0	0,0	109	1,8
M. b. ponticus	0,9	92,6	6,5	0,0	0,0	0,0	0,0	0,0	0,0	108	1,8
G. mediterraneus	6,9	43,7	23,0	0,0	0,0	0,0	0,0	17,2	9,2	87	1,5
M. batrachocephalus	10	41,2	2,9	2,9	2,9	0,0	0,0	13,2	26,5	68	1,1
A. pontica	12	50,0	21,4	9,5	7,1	0,0	0,0	0,0	0,0	42	0,7
P. saltatrix	0,0	0,0	0,0	0,0	24,1	31,0	41	3,4	0,0	29	0,5
L. aurata	0,0	0,0	0,0	0,0	80,0	20,0	0,0	0,0	0,0	15	0,3
P. flesus luscus	0,0	61,5	0,0	0,0	0,0	0,0	0,0	23,1	15,4	13	0,2
T. draco	0,0	0,0	55,6	22,2	11,1	11,1	0,0	0,0	0,0	9	0,2
P. maeotica	0,0	50,0	0,0	0,0	0,0	25,0	0,0	25,0	0,0	8	0,1
S. acanthias	17	16,7	0,0	0,0	0,0	0,0	0,0	33,3	33,3	6	0,1
A. immaculata	60	0,0	0,0	0,0	0,0	20,0	0,0	20,0	0,0	5	0,1
P. lascaris	0,0	80,0	0,0	0,0	0,0	0,0	0,0	20,0	0,0	5	0,1
S. flexuosa	0,0	0,0	100,0	0,0	0,0	0,0	0,0	0,0	0,0	5	0,1
D. pastinaca	0,0	0,0	0,0	0,0	100	0,0	0,0	0,0	0,0	3	0,1
S. sprattus	33	66,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3	0,1
R. clavata	0,0	100,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1	0,02
S. labrax	0,0	0,0	100,0	0,0	0,0	0,0	0,0	0,0	0,0	1	0,02
S. umbra	0,0	0,0	0,0	0,0	0,0	100	0,0	0,0	0,0	1	0,02

respectively. Intensity of feeding of all the four species was rather high in the island area; the share of individuals with empty stomach did not exceed 25.0%. The highest values of TISF were registered during autumn feeding period (Table 7).

The diet of anchovy in the Zmiinyi Island coastal waters comprised organisms belonging to 15 taxa. The most significant for the diet appeared to be mysids, rotifers, zooplankton crustaceans Copepoda and planktobenthos organisms: Polychaeta and amphipods. As we know, under conditions of zooplankton shortage anchovy feed on phytoplankton. During the period of studies near the Zmiinyi Island, the share of phytoplankton in food boluses of anchovy made 3.8 to 78.0% of its total mass. Most often phytoplankton organisms were registered in anchovy bowels in winter. Silverside diet comprised 17 of food objects. In the diet dominated polychaetes, amphipods, mysids. Plankton crustaceans played significant

Table 6

Relative number of ichthyofauna representatives (%) in the Zmiinyi Island coastal waters in May-June period of 2016 and 2017

Species	Период исследований							
	2016				2017			
	V	VI	No. of ind.	%	V	VI	No. of ind.	%
A. pontica	70,0	30,0	30	1,48	0,0	100,0	1	0,10
En. encrasicolus	70,2	29,8	131	6,44	90,9	9,1	11	1,10
G. mediterraneus	65,5	34,5	58	2,85	78,3	21,7	23	2,31
L. aurata	0,0	0,0	0	0,00	0,0	100,0	1	0,10
M. barbatus	93,5	6,5	107	5,26	10,3	89,7	39	3,92
M. batrachocephalus	93,3	6,7	30	1,48	76,9	23,1	13	1,31
M. merlangus euxinus	97,4	2,6	39	1,92	0,0	0,0	0	0,00
N. melanostomus	85,6	14,4	494	24,30	78,2	21,8	386	38,76
P. flesus luscus	100,0	0,0	8	0,39	100,0	0,0	1	0,10
P. lascaris	100,0	0,0	4	0,20	0,0	0,0	0	0,00
P. maeotica	100,0	0,0	4	0,20	100,0	0,0	2	0,20
P. sanguinolentus	95,2	4,8	126	6,20	94,7	5,3	76	7,63
R. clavata	100,0	0,0	1	0,05	100,0	0,0	1	0,10
S. acanthias	100,0	0,0	1	0,05	0,0	0,0	0	0,00
S. cinereus	68,1	31,9	69	3,39	52,2	47,8	23	2,31
S. flexuosa	100,0	0,0	5	0,25	0,0	0,0	0	0,00
S. labrax	0,0	100,0	1	0,05	0,0	100,0	1	0,10
S. porcus	29,4	70,6	187	9,20	23,1	76,9	13	1,31
S. sprattus	100,0	0,0	2	0,10	100,0	0,0	1	0,10
T. draco	0,0	100,0	5	0,25	12,5	87,5	8	0,80
T. mediteraneus	56,3	43,7	678	33,35	0,0	100,0	370	37,15
U. scaber	45,3	54,7	53	2,61	15,4	84,6	26	2,61

Table 7

Size and mass characteristics, Total Index of Stomach Fullness (TISF) of four pelagic fish species in the Zmiinyi island coastal waters

Fish species (age)	Parameters	Period of studies			
		spring	осень	осень	spring
E. encrasicolus (2)	L, cm	11,6±0,1	10,9±0,3	11,6±0,3	10,5±0,1
	m, g	9,5±0,3	8,1±0,8	11,3±0,6	9,2±0,2
	TISF, $^0/_{000}$	59,2±11,7	67,6±37,2	30,7±7,4	10,6±5,1
A. pontica (2)	L, cm	7,6±0,2	8,8±0,3	-	-
	m, g	3,1±0,2	4,9±0,6	-	-
	TISF, $^0/_{000}$	101,3±22,4	126,5±47,8	-	-
P. saltatrix (1)	L, cm	-	19,7±0,4	18,7±0,3	-
	m, g	-	79,6±4,3	67,0±3,9	-
	TISF, $^0/_{000}$	-	104,2±15,2	216,9±22,4	-
T. m. ponticus (3)	L, cm	15,6±0,3	17,0±0,4	14,1±0,1	-
	m, g	37,0±2,4	47,5±4,1	25,7±0,9	-
	TISF, $^0/_{000}$	208,1±31,5	241,0±67,2	186,3±34,3	-

Notes: L – general length, m – mass of fish, n – number of individuals, TISF – total index of stomach fullness.

role in the diet of this species in the island coastal waters. According to the data received during summer period of 2009, in the diet of the studied silverside individuals prevailed copepods making up to 45.0% of food bolus mass.

The share of pelagic larvae of decapods, molluscs and polychaetes was insignificant. Comparative analysis of anchovy and silverside diet in the Zmiinyi Island coastal waters showed low similarity of food objects' species composition between these fish species (Index of Taxonomic Similarity ITS – 39.1%).

On the other hand, high values of the ITS Index (70.0 %) evidenced similar food preferences of the two fish species compared, which was expressed in intensive consumption of polychaetes by both species. The spectrum of bluefish diet in the island coastal waters was presented by 8 objects. Fishes dominated in food boluses: anchovy, horse mackerel, silverside, sprat and whiting. In the island coastal waters, remaining of *Palaemon elegans* was also found in the stomachs of bluefish. The study established that the diet of horse mackerel comprised organisms belonging to 16 taxa. Near the island, horse mackerel was feeding mainly on fish. Polychaetes and crustaceans Amphipoda, Isopoda also played a significant role in the diet. In food boluses of big individuals the juveniles of the same species were found; the significance of juveniles in the diet of big fishes was quite high (Index of Relative Significance (IRS) – 295.9-492.1%). The values of Index of Food Similarity (70.4%) and the Index of Taxonomic Similarity (50.0%) of food objects in the diet of horse mackerel and bluefish were quite high, which showed similar diet of those two species.

The results received by us coincide with the data from literature, according to which anchovy and silverside were mainly zooplankton-eating species with wide food spectrum comprising meroplankton and planktobenthos organisms. Under the current conditions connected with growth in number and distribution of comb jelly *Mnemiopsis leidyi* A. Agassiz, 1865, which undermined the food basis of plankton-eating fish, significance of benthos organisms for zooplankton-eating fish diet will increase. The main role in the diet of horse mackerel and bluefish is played by different fish species, both in the Zmiinyi Island area and in other parts of the Black Sea. Near the island, horse mackerel also consumes actively amphipods and polychaetes.

Table 8

Size and mass characteristics of three bottom-dwelling fish species in the Zmiinyi Island coastal waters for the entire period of studies

Species	Sex	Parameters	Age, years				
			1 (1+)	2 (2+)	3 (3+)	4 (4+)	5 (5+)
G. mediterraneus	Males	Gen. length, cm	18,0±0,3	22,4±0,2	24,9±0,3	26,9±0,6	-
		Mass, g	51,7±3,2	102,3±3,2	135,8±7,5	167,0±10,4	-
		Number of fish, ind	48	111	25	7	-
	Females	Gen. length, cm	18,5±0,3	22,8±0,1	24,9±0,2	28,2±0,4	28,6±0,9
		Mass, g	60,0±3,2	112,3±1,5	137,1±2,7	208,4±12,0	209,8±9,3
		Number of fish, ind	65	374	179	33	4
S. porcus	Males	Gen. length, cm	9,9±0,2	12,7±0,4	14,1±0,1	16,3±0,2	17,5±0,5
		Mass, g	26,3±1,6	48,9±0,9	64,8±1,1	92,1±2,7	109,6±3,5
		Number of fish, ind	45	126	125	42	14
	Females	Gen. length, cm	10,4±0,2	12,8±0,2	14,5±0,2	16,9±0,4	19,5±0,4
		Mass, g	27,9±1,3	52,5±2,2	76,7±3,9	113,3±2,5	174,5±1,6
		Number of fish, ind	45	43	41	22	12
N. melanostomus	Males	Gen. length, cm	-	14,5±0,4	17,0±0,5	18,2±0,3	-
		Mass, g	-	54,5±1,2	82,1±2,7	98,9±3,5	-
		Number of fish, ind	-	30	35	30	-
	Females	Gen. length, cm	-	12,0±0,3	15,1±0,4	16,3±0,5	-
		Mass, g	-	35,9±2,4	65,4±2,8	74,5±2,8	-
		Number of fish, ind	-	25	30	30	-

Bottom-dwelling fish species. Silver rockling Gaidropsarus mediterraneus (L., 1758). The basis of silver rockling catch was formed by individuals of general body length of 23-24 cm. Maximal value of general length for males (age 4+) was 34.2 cm, mass – 210.0 g; for females (age 4+) – 33.0 cm and 367.0 g respectively (Table 8).

Analysis of Index of Relative Significance (IRS) of silver rockling food objects showed that its main food comprised crustaceans – representatives of Gammaridae (Table 9). The lowest intensity of silver rockling feeding was registered in summer period; its General Index of Stomach Fullness (GISF) was 177 to 280‰. In winter this parameter was reaching 326-414‰, in spring varied from 287 to 350‰. The changes in this parameter's values reflect activeness of food consumption by fish in different seasons. In November – December and April – May silver rockling individuals consumed more food to restore energy spent for breeding and wintering. Silver rockling diet comprised organisms belonging to 35 taxa. Crustaceans were represented by the highest number of species – 16.

Polychaeta *Nereis diversicolor* and 5 mollusc species were also found; among those musels *Mytilus galloprovincialis,* dominant species in the benthos of the area, prevailed. Out of vertebrates, 12 fish species were found, most of them bottom-dwelling (80.3%).

Not less important food objects for silver rockling were shrimps and crabs, as well as fishes Blenniidae, Gobiidae and Gadidae. Secondary food objects were other crustaceans (isopodes and crabs) and fishes (sprat, clingfish). Mussel was accidental food. Cases of cannibalism happen with silver rockling. We registered mass cases of cannibalism in this species in 2004, which probably was connected with increase in its number and, as the result, growth of tension inside the species.

Sea scorpion *Scorpaena porcus* L., 1758. Sea scorpion parameters varied within the following limits: minimal general length of males and females in the age of 1 – 6.9 and 5.7 cm, mass – 9.0 and 9.2 g respectively. Maximal values in the age of 5 – 20.5 and 23.7 cm, 160.3 g and 339.5 g respectively (Table 7). Intensity of sea scorpion feeding during spawning period (end of May – mid-July) was low, General Index of Stomach Fullness (GISF) made 103–149‰. More than half of individuals did not feed during those months. In August, when reproduction period ended, increase of feeding activeness was observed (GISF – 283-349‰). The highest feeding intensity (537‰) was registered in September – early October. In the period of studies food spectrum of sea scorpion in the Zmiinyi Island area comprised food objects that belonged to 25 taxa. Decapodes were represented in the diet by highest number of species (7 species). Secondary role was played by mass fish species – representatives of Blenniidae and Gobiidae families (3 and 4 species respectively). Nereis and mussels were found in insignificant quantity (Table 8).

Combtooth blenny *Parablennius sanguinolentus* (Pallas, 1814). Mean value of general length of the individuals caught near the Zmiinyi Island was 14.6±1.9 cm, mass – 54.2±2.2 g, the biggest length and mass – 17.5 cm and 93.0 g respectively. In the diet of the studied combtooth blenny individuals 21 macrophyte species were found (Chlorophyta – 12, Rhodophyta – 8 и Phaeophyta – 1), which made ca. 50.0 % of all microalgae species known for the island coastal waters. On the frequency of occurrence in food boluses of combtooth blenny the most mass were: *Cladophora hutchinsii* (50.0%), *Ceramium siliquosum var elegans* (30.0%), *Cladophora laetevirens, Ulothrix implexa, Callithamnion corymbosum* (20.0%). The rest of algal species were found in individual cases. Besides, diatoms of 35 species were found in food boluses of combtooth blenny (ca. 30.0% of all the diatoms known for the island area), as well as crustaceans (*Gammarus gen. sp.*) and molluscs (juveniles of *Mytilus galloprovincialis*).

Round goby *Neogobius melanostomus* (Pallas, 1814). Individuals with general length of 12.0-18.2 cm dominated in catches. At that, mass of fish did not exceed 99.0 g (Tabe 7). Males in the age 4+ reached maximal size. Their biggest length and mass were 19.1 cm and 106.7 g (Table 7). General Index of Stomach Fullness (GISF) of individuals varied from 120.0 to 597‰. In spring the GISF values were within 180-323‰. Quantity of fish with empty stomachs made 45%. The maximal values of GISF were registered in autumn – 597‰; percentage of individuals with empty stomach was 20%. The spectrum of round goby diet in the Zmiinyi Island coastal waters was represented by food objects belonging to).

Table 9

Mean IRS values (%) of food objects of silver rockling, sea scorpion and round goby in the Zmiinyi Island coastal waters

Food object	*G. mediterraneus*	*S. porcus*	*N. melanostomus*
Nematoda gen. sp.	-	-	1,8
Oligochaeta gen. sp.	-	-	1,7
Nereis diversicolor	399,1	209,6	76,7
Balanus gen. sp.	16,8	-	71,7
Stenothoe monoculoides	86,3	-	-
Corophium gen. sp.	88,5	-	-
Gammarus gen. sp.	2883,0	535,8	54,2
Sphaeroma gen. sp.	194,7	50,4	1,7
Idotea baltica basteri	17,9	11,4	-
Palaemon elegans	624,1	1985,1	1,3
Crangon crangon	233,0	4617,0	-
Pisidia longimana	44,9	-	-
Macropipus arcuatus	64,9	97,0	16,4
Carcinus mediterraneus	8,2	-	-
Eriphia verrucosa	179,5	-	-
Xantho poressa	547,1	815,8	65,8
Pilumnus hirtellus	87,7	262,7	-
Pachygrapsus marmoratus	86,4	46,0	-
Reptantia gen. sp.	117,4	162,4	30,5
Rissoa gen. sp.	-	-	679,6
Hydrobia gen. sp.	80,4	-	27,1
Nana donovani	1,2	-	-
Modiolus adriaticus	-	-	6,2
Mytilaster lineatus	0,2	-	255,7
Mytilus galloprovincialis	50,5	4,2	14976,8
Cerastoderma gen. sp.			20,5
Mollusca gen. sp.	104,3	-	4,7
Sprattus sprattus phalericus	355,7	-	93,1
Engraulis encrasicholus	9,2	-	-
Gaidropsarus mediterraneus	222,1	55,9	-
Ophidion rochei	-	1,8	-
Hippocampus guttulatus	-	106,2	-
Aidablennius sphynx	78,8	95,8	-
Parablennius sanguinolentus	11,9	-	-
Parablennius zvonimiri	-	2,8	-
Parablennius tentacularis	282,0	17,6	-
Blenniidae gen. sp.	64,4	25,6	19,6
Mesogobius batrachocephalus	-	27,7	-
Neogobius melanostomus	172,2	235,7	-
Gobius niger	140,0	76,3	-
Gobiidae gen. sp.	154,9	1037,6	-
Proterorhinus marmoratus	-	24,3	-
Lepadogaster candollei	24,7	-	-
Pisces gen. sp.	88,0	435,3	11,3
Икра рыб	+	-	+
Всего пищевых комков, шт.	420	186	120

Note: + – presence of a food object in the diet; **-** – absence of a food object from the diet.

Table 10

Protected fish species in the Zmiinyi Island coastal waters

Species	Protection status	SA (Boltachev, 2006)	OB (Zamorov, 2010)	ZMN (2003-2017)
Acipenser gueldenstaedtii Brandt et Ratzeburg, 1833	1R; 2R; 3R	+	+	+
Acipenser stellatus Pallas, 1771	1R; 2R; 3R	+	+	+
Aidablennius sphynx (Valenciennes, 1836)	2R	+	-	+
Arnoglossus kessleri Schmidt, 1915	3R	+	-	+
Belone belone euxini Gunther, 1866	3R	+	+	+
Callionymus risso Lesueur, 1814	3R	+	-	+
Chromis chromis (L., 1758)	3R	+	-	+
Diplecogaster bimaculata (Bonnaterre, 1788)	3R	+	-	+
Diplodus annularis (L., 1758)	2R	+	-	+
Gobius paganellus L., 1758	3R	+	-	+
Hippocampus hippocampus (L., 1758)	2R; 3R	+	+	+
Huso huso (L., 1758)	1R; 3R	+	+	+
Lepadogaster candollii Risso, 1810	3R	+	-	+
Mesogobius batrachocephalus (Pallas, 1814)	2R	+	+	+
Mullus barbatus ponticus Essipov, 1927	2R	+	+	+
Neogobius ratan (Nordmann, 1840)	2R	-	+	+
Nerophis ophidion (L., 1758)	2R	+	+	+
Pegusa lascaris (Risso, 1810)	2R	+	+	+
Proterorhinus marmoratus (Pallas, 1814)	2R	+	+	+
Raja clavata L., 1758	1R	+	-	+
Salaria pavo (Risso, 1810)	2R	+	-	+
Salmo labrax Pallas, 1814	1R; 3R	+	+	+
Sarda sarda (Bloch, 1793)	2R	+	-	+
Sciaena umbra L., 1758	3R	+	+	+
Scorpaena porcus L., 1758	2R	+	+	+
Squalus acanthias L., 1758	1R	+	+	+
Symphodus ocellatus (Forsskål, 1775)	2R	+	-	+
S. tinca (L., 1758)	2R	+	-	+
Syngnathus abaster Risso, 1827	1R	+	+	+
Syngnathus tenuirostris Rathke, 1837	2R; 3R	-	-	+
Syngnathus typhle L., 1758	2R	+	+	+
Syngnathus variegatus Pallas, 1814	3R	+	-	+
Trachinus draco L., 1758	2R	+	+	+
Chelidonichthys lucernus L., 1758	2R; 3R	+	+	+
Umbrina cirrosa (L., 1758)	3R	+	-	+
Uranoscopus scaber L., 1758	2R	+	+	+

Notes: SA – Sevastopol Area, OB – Odessa Bay, ZMN – Zmiinyi Island coastal waters, 1R – IUCN Red List; 2R – Black Sea Red Data Book; 3R – Red Book of Ukraine; - – species not found.

Table 11

Ecological and zoo-geographical characteristics of ichthyofauna in the Black Sea areas

Ecological and zoo-geographical characteristics	Sevastopol area (Boltachev, 2006)		Odessa bay (Zamorov et al., 2016)		Zmiinyi Island coastal waters (2003-2017)	
	No. of species	%	No. of species	%	No. of species	%
Bottom-dwelling	44	40,7	23	44,2	30	44,1
Near-bottom	33	30,6	14	26,9	24	35,3
Pelagic	31	28,7	15	28,8	14	20,6
Total	**108**	**100,0**	**52**	**100,0**	**68**	**100,0**
Pelagophyls	44	40,7	23	44,2	24	35,3
Protecting	41	38,0	15	28,8	23	33,8
Phytophyls	7	6,5	4	7,7	6	8,8
Lithophyls	4	3,7	4	7,7	4	5,9
Psammophyls	1	0,9	0	0,0	1	1,5
Lithopsammophyls	1	0,9	0	0,0	1	1,5
Ovoviviparous	3	2,8	2	3,8	2	2,9
Carrying eggs	7	6,5	4	7,7	7	10,3
Total	**108**	**100,0**	**52**	**100,0**	**68**	**100,0**
Marine species	92	85,2	36	69,2	52	76,5
Brackish-water	6	5,6	8	15,4	6	8,8
Anadromous	6	5,6	6	11,5	5	7,4
Freshwater	4	3,7	2	3,8	5	7,4
Total	**108**	**100,0**	**52**	**100,0**	**68**	**100,0**
Migratory	34	31,5	19	36,5	19	27,9
Sedentary	74	68,5	33	63,5	49	72,1
Total	108	100,0	52	100,0	68	100,0

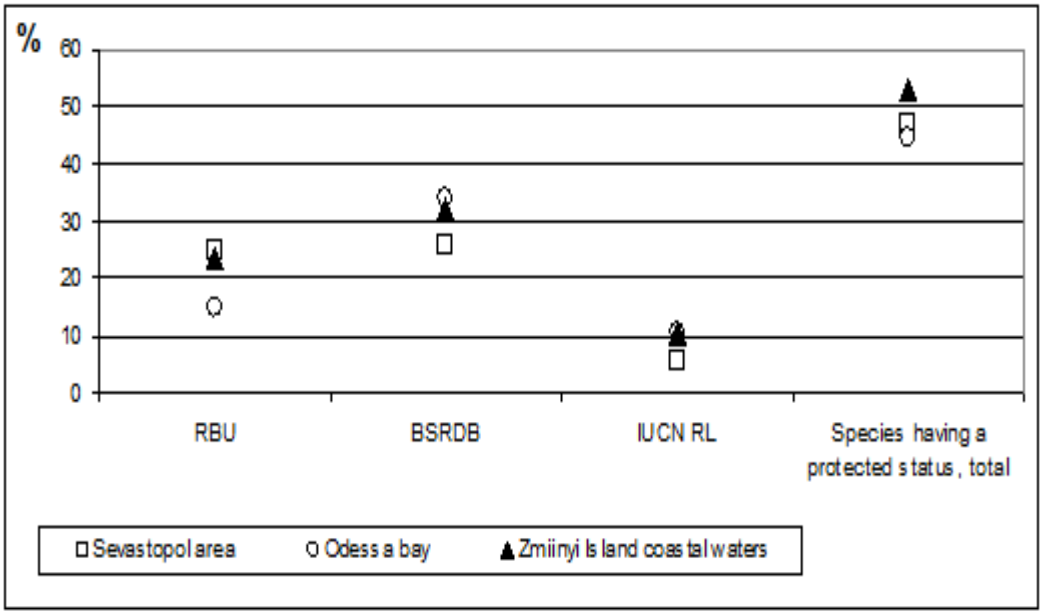


Fig. 3 – Share of protected species in the species composition of ichthyofauna of different Black Sea areas (RBU – Red Book of Ukraine, BSRDB – Black Sea Red Data Book, IUCN RL – IUCN Red List)

22 taxa (Table 8). Molluscs and crustaceans were represented by highest number of species in round goby diet (8 and 7 species respectively).

During the period of studies selectivity of silver rockling diet reflected in preference of small crustaceans belonging to families Gammaridae and Sphaeromatidae; the values of Selectivity Index (SI) of those species made up to 21.8 and 18.0%, respectively. Besides, silver rockling consumes actively the most mass fish species, for example, electivity for blennies was 15.6%. Maximal values of Selectivity Index of sea scorpion are for shrimp (up to 24.7%), Xantho (up to 18.2%) and Pilumnus (up to 14.2%), as well as polychaetes (23.1%), Sphaeroma (16.8%) and Idothea (11.4%). Food activeness of round goby is first of all aimed at consumption of Mitylus and Mytilaster. Selectivity indices in respect of those molluscs were maximal during the entire period of study and made 16.1 and 22.0%. Comparative analysis of bottom-dwelling fish diet in the Zmiinyi Island coastal area showed that the studied species had both similar and specific features in food preference. The highest values of Index of Food Similarity (IFS) and Index of Taxonomic Similarity (ITS) were obtained from comparison between the diets of silver rockling and sea scorpion (IFS – 19.6-59.4%, ITS – 21.1-50.0%). Variations of those values appeared to be quite significant and evidently are direct consequence of changes in number of both the studied fish species and benthos organisms.

Protected and rare species. Out of 68 fish species found near the island, 16 species were entered into the Red Book of Ukraine [38], 22 – into the Black Sea Red Data Book [31], 7 species – into the IUCN Red Data List [39]. In other words, 36 species, which means more than half of all the species found near the island (52.9% of all species) have a protection status (Table 10). Most of them, first of all sturgeons, are rare species for the Black sea and now can be found only episodically. Other species: *Belone belone euxini, Hippocampus hippocampus, Lepadogaster candollii, Mesogobius batrachocephalus, Mullus barbatus ponticus, Uranoscopus scaber* are common in the island coastal waters; *Scorpaena porcus* periodically forms mass aggregations.

Comparative analysis of fish communities structural characteristics in the areas of Sevastopol, Odessa bay and the Zmiinyi Island shows relatively similar features, which can be explained by similar conditions in the compared areas (Table 11).

Composition of ichthyofauna in Odessa bay and the Zmiinyi Island coastal waters is very similar (Index of Taxonomic Similarity, ITS – 0.7). Some difference in number of species found in two those areas are partly explained by the fact that near the island more diverse fishing gear was used (gillnets, traps, fry nets, dip-nets, hook and line gear, mid-water trawl), while in Odessa Bay only stake nets ad hook and line gear were used. Peciformes order was represented by biggest number of taxa in both areas. Most of fishes found in catches belonged to marine species – bottom-dwelling or near bottom. Anadromous and brackish-water species were represented in Odessa bay to the fullest extent possible. In the island coastal waters less representatives of those groups were found due to hydrological features of the two compared areas – the island coastal areas are more influenced by marine water masses. It should be pointed out that the shares of rare and protected fish species in Odessa bay and in the island area were practically similar during the period of study (Fig. 3). So, despite insignificant difference in number of species found and prevalence n number of some ichthyofauna representatives, fish communities of the areas compared have substantial similarity.

Conclusions

Summing up, we have to point out the following. The Zmiinyi Island is a unique natural complex, the only rock formation of the north-western Black Sea shelf. Diversity of hydrology and hydrochemistry, substrates (from loose to hard), relatively big depth in that part of the sea (30 m and more) and a number of other features have caused forming of specific biocoenoses characterized by high diversity of species, biomass and productivity. Organisms of water fauna, first of all fish, in the island coastal waters have diverse ecological, biological and zoo-geographic characteristics. Influenced by both natural and anthropogenic factors, the structural and functional features of the Black Sea ecosystem are chang-

ing on large shelf areas including the Zmiinyi Island area. However, the results of our stidies have shown that the island coastal waters are the most environmentally healthy districts of the north-western Black Sea containing reserve genetic fund due to which restoration of ichthyofauna takes place in the areas that have suffered full or partial suffocation of fish and other organisms.

Altogether 68 fish species were found near the Zmiinyi Island in 2016-2017, which made 30.9% of all the fishes registered in the Black Sea. The fishes caught near the island belonged to 5 ecological groups. The basis of ichthyofauna in the area was formed by marine fish – 52 species (76.5 % of the total number of species). Most of species (54 species or 89.4%) were bottom-dwelling or near bottom. On the mode of reproduction, pelagophylic and protecting species prevailed (24 species or 35.3% and 23 species or 33.8% respectively). On the type of feeding, predatory and benthos-eating species took the lead.

All the species registered belonged to 18 orders, 41 families and 55 geners. The biggest number of taxa belonged to Perciformes order, the representatives of which made one-half of all the species found near the island. The level of ichthyofauna species diversity (Shannon index values calculated coming out of number) in 2016 varied from 0.86 to 3.06 making in the average 2.06; in 2017 – from 2.40 to 2.54 making in the average 2.47. Minimal values of biodiversity indicators were registered in the end of autumn and in winter, maximal – in May-June.

Out of 68 species found in the island area, 36 species (52% of all the species) have a protected status: 16 species are included into the Red Book of Ukraine, 22 species – into the Black Sea Red Data Book, 7 species – into the IUCN Red List.

As the development of fish populations' dynamics theory is one of the most urgent tascs of modern ichthyology, experimental determination of such characteristics as fish number and species distribution is of first-rate importance. Standard stock assessment methods based on calculation of number using computed coefficients of mortality, capture level or the respective coefficients of fishing gear performance and capture level, according to our data, do not work in the areas inaccessible for commercial fishing. Therefore, the results of such calculations will be incorrect. Hence, it becomes evident that there is a need to develop new economically efficient methods of monitoring and assessment of number and stock of bottom-dwelling and near bottom fish and other hydrobionts in the hard-to-reach areas were standard methods cannot be used. We believe that one of the most advanced way to study the condition of fish stock and fish biological diversity is application of non-contact automatic video-monitoring methods and development of computer processing algorithms for the video materials received. This will help to increase significantly economic feasibility and accuracy of data.

Ichthyological observations in the Zmiinyi Island coastal waters in 2016-2017 were performed in the framework of Odessa National I.I. Mechnikov University's research projects with financial support from the EMBLAS-II International Project. In the work we used the materials collected in 2003-2015 during the research activities carried out with financial support of the Ministry of Education and Science of Ukraine and the EnviroGRIDS and PERSEUS International Projects.

Conflict of interests

The authors declare that the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

.

References

1. Smyntyna, V.A., Medinets, V.I. & Suchkov, I. O. (2008). Zmiinyi Island: Ecosystem of coastal waters: monohrafiya. Odesa National I.I. Mechnykov University: Astroprynt. Retrieved from http://dspace.onu.edu.ua:8080/handle/123456789/2776 (In Ukrainian).
2. Snigirov, S.M. (2011). Bottom ichthyofauna of the Zmiinyi Island coastal waters. (Master's thesis). Kyiv:

Institute of Hydrobiology NAS of Ukraine. (In Russian).
3. Snigirov, S.M. (2011). Nutrition and trophic relationships of three common species of bottom fish in the Zmiinyi Island coastal water area in 2003-2007. *Hydrobiological journal, 47*(4), 52-65. https://doi.org/10.1615/HydrobJ.v47.i6.60 (In Russian).
4. Snigirov, S.M. Abakumov, A.N., Pitsyk, V.Z. & Gazyetov, Ye.I. (2010). The first find of fish species Chromis chromis (Linnaeus, 1758) and Sarda sarda (Bloch, 1793) in the Zmiinyi Island water area. Proceedings of the International scientific and practical conference:Environmental problems of the Black Sea" (Odessa, 2010, October 28 - 29,(pp.400-402). Odessa: INVATS. (In Russian).
5. Snigirov, S.M., Medinets, V.I., Abakumov, O.M. (2010). Diversity of ichthyofauna in the coastal waters of the Zmiinyi Island in 2004 – 2009. *Transactions of Ternopil National Volodymyr Hnatyuk Pedagogical University. Series: Biology. Special issue "Hydroecology"*, (3-44), 250 - 252. (In Ukrainian).
6. Snigirov, S., Goncharov, O. & Sylantyev, S. (2012). The fish community in Zmiinyi Island waters: structure and determinants. *Marine Biodiversity*, *42* (2), 225-239. DOI: https://doi.org/10.1007/s12526-012-0109-4
7. Snigirov, S. (2013). Bluefish Pomatomus saltatrix (L., 1766) horse mackerel Trachurus mediterraneus ponticus Aleev, 1956 diet in the Zmiinyi Island coastal waters. *Proceedings of the IVth Bi-annual Black Sea Scientific Conference*, (Constanta, 2013, 28-31 October (pp.106-107). Romania, Constanta.
8. Snigirev, S.M. & Medinets V.I. (2010). Results of investigations of marine fish and benthos communities in western part of the Black sea (near Zmeiny island). *Journal of Environmental Protection and Ecology*, 11(3), 1037–1045. Retrieved from https://docs.google.com/a/jepejournal.info/viewer?a=v&pid=sites&srcid=amVwZS1qb3VybmFsLmluZm98amVwZS1qb3VybmFsfGd4OjRlODk1NjgwNTcwNTk5ZWE
9. Snigirov, S., Medinets, V., Chichkin, V., Sylantyev, S. (2013). Rapa whelk controls demersal community structure off Zmiinyi Island, Black Sea. *Aquatic Invasions, 8* (3), 289-297. http://www.aquaticinvasions.net/2013/AI_2013_3_Snigirov_etal.pdf; DOI: http://dx.doi.org/10.3391/ai.2013.8.3.05
10. Romanenko, V.D. (Ed.). 2006. Methods of hydroecological research of surface waters. Kyiv: LOGOS. (In Ukrainian).
11. Pryakhin, Yu.V., Shkitskiy, V.A. (2008). Methods of research in fishery. Rostov-on-Don: Publisher of YuNTs RAN. 256 p. (In Russian).
12. Getman, T. P. (2007). Visual underwater observations for assessment of the qualitative and quantitative indicators of ichthyocene. *Ecology of the sea*, (74), 13-17. Retrieved from https://www.elibrary.ru/item.asp?id=25457272 (In Russian).
13. Mochek, A.D. (1978). Ecological organization of coastal marine fish communities. Kyiv: Naukova dumka. (In Ukrainian).
14. Halford, A., Thompson, A.A. (1994). Visual census surveys of reef fish. – Townsville: Australian institute of marine science.
15. Berg, L.S. (1948-1949). Freshwater fishes of the USSR and neighbouring countries. Moskow-Leningrad: Publisher of the USSR. Retrieved from https://www.twirpx.com/file/285814/ (In Russian).
16. Vasilyeva, Ye.D. (2007). Fish of the Black Sea. Keys to marine, brackish, euryhaline and anadromous species with colour illustrations collected by S.V. Bogorodsky. Publisher VNIRO. Retrieved from http://dspace.vniro.ru/handle/123456789/2166 (In Russian).
17. Zambriborshch, F.S. (1968). On the taxonomy of gobies of the Black and Azov Seas (short guide). *Bulletin of Zoology*, *10*(1), 37-44. Retrieved from http://mail.izan.kiev.ua/vz-pdf/1968/1/68_1_05.pdf (In Russian).
18. Svetovidov, A.N. (1964). Fish of the Black Sea. Moskow-Leningrad: Nauka. https://doi.org/10.21072/Black_Sea_Fish (In Russian).
19. Pavlov, P.Y. (1980). Fish. Larval chordates (ascidians, appendiculars, cranial, cephalopods, roundworms, cartilaginous fish, bony fish - sturgeon, herring, anchovy, salmon, grayling, pike, umbrella. In Fauna of Ukraine, *8* (1). Kyiv: Nauk. Dumka. Retrieved from http://www.izan.kiev.ua/fau-ukr.htm (In Ukrainian).
20. Movchan Yu.V.& Smyrnov A.I. (1981). Pisces. Carp. Part 1. Gossip, fir, goliath, red perch, grass carp, linen, top, tench, Amur chub, podust, pichkur, madder. *In Fauna Ukrayiny*, *8*(2, part 1). Kyiv: Nauk. dumka. Retrieved from http://www.izan.kiev.ua/fau-ukr.htm (In Ukrainian).
21. Movchan Yu.V., Smyrnov A.I. (1983). Fish. Loach, catfish, ictaluric, freshwater eels, conger, sargan, cod, stickleback, needle, gambusia, zeus, spiren, mullet, atherine, erroneous. In *Fauna of Ukraine*, *8*(2-Part 2)] Kyiv: Nauk. Dumka.Retrieved from phttp://www.izan.kiev.ua/fau-ukr.htm (In Ukrainian).
22. Movchan Yu.V., Smyrnov A.I. (1988). Fish. Loach, catfish, ictaluric, freshwater eels, conger, sargan, cod, stickleback, needle, gambusia, zeus, spiren, mullet, atherine, erroneous. In *Fauna of Ukraine*, *8*(3). Kyiv: Nauk. Dumka. Retrieved from http://www.izan.kiev.ua/fau-ukr.htm (In Ukrainian).
23. Shcherbukha, A.Ya. (1982). Perch-shaped (perch-shaped, lip-shaped, dragon-shaped, dog-shaped, sandy-

shaped, lyre-shaped, mackerel-shaped. In *Fauna of Ukraine, 8*(4). Kyiv: Nauk. Dumka. Retrieved from http://www.izan.kiev.ua/fau-ukr.htm (In Ukrainian).
24. Smirnov A.I. (1986). Perch-like (goby-like), scorpion-like, flounder-like, sucker-like, angler-like. In *Fauna of Ukraine,* 8(5). Kyiv: Nauk. Dumka. Retrieved from http://www.izan.kiev.ua/fau-ukr.htm (In Ukrainian).
25. Jennings G. (Ed.). (1996). European sea fishes Gibraltar to Norway., London: Calypso Publications.
26. Froese, R., Pauly, D. (Eds). (2007). FishBase. World Wide Web electronic publication. (version (08/2007) Retrieved from **http**://www.**fishbase**.**org**/summary/speciessummary.php?id=108
27. IUCN Red List of threatened animals. (1996). Intern. Union of Conservation of Nature and Natural Resources. USA. Printed by Kervin press.
28. Kottelat, M. & Freyhof, J. (2007). Handbook of European freshwater fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany.
29. Miller, J. & Loates, M.J. (1997). Fish of Britain and Europe. Harper Collins Publishers, London.
30. Nelson, J.S. (2006). Fishes of the word (4th ed.). New York: J. Willey & Sons, Inc.
31. Yankova,M., Raykov, V., Ivanova ,P., Mgeladze, M., Diasamidze, R., Radu,G.& Nicolaev, S.,(2010). Black Sea Fish Check List. M. Yankova (Comp). – Black Sea Commission Publication. Retrieved from http://www.blacksea-commission.org/_publ-BSFishList.asp
32. Pravdin, I.F. (1966) Guide to studies of fish (mainly freshwater). Moskow: Pischevaya Promyshlennost. (In Russian).
33. Margalef, R. (1958). Information theory in ecology. *General Systems*, 3, 36-71.
34. Shannon, C.E. & Weaver, W. (1949). The mathematical theory of communication. Urbana: University of Illinois Press.
35. Pielou, E.C. (1966).The mesurements of diversity in different types of biological collections. *J. Theoret. Biol.*, 13, 131-144. https://doi.org/10.1016/0022-5193(66)90013-0
36. Gazyetov, Ye.I., Medinets, V.I., Snigirov, S.M., Snigirov, P.M., Abakumov, A.N. & Pitsyk, V.Z. (2019). Studies of seawater hydrological characteristics near the Zmiinyi Island in 2016-2017. Visnyk of V.N. Karazin Kharkiv National University Series "Ecology", (20), 42-55. https://doi.org/10.26565/1992-4259-2019-20-04 (In Russian).
37. Snigirov, S.M., Chernyavskiy, A.V., Naum, Ye.A., Galkina, A.A., Medinets, V.I., Gazyetov, Ye.I., Konareva, O.P. & Snigirov, P.M. (2019). The state of macrozoobenthos in coastal zone of Serpents' Island in 2016-2017. Visnyk of V.N. Karazin Kharkiv National University Series "Ecology", (21), 81-98. https://doi.org/10.26565/1992-4259-2019-21-07 (In Russian).
38. Akimov, I.A. (Ed.). (2009). Red Book of Ukraine. Fauna. Kyiv: Globalkonsalting. (In Ukrainian). https://redbook-ua.org/; https://redbook.land.kiev.ua/2.html
39. Dumont, H.J. (Ed.). (1999). Black Sea Red Data Book. New York: United Nations Office for Project Services.

Література

1. Сминтина В. А., Мединець В. І., Сучков І. О. Острів Зміїний: екосистема прибережних вод: монографія. Відп. ред. В. І. Мединець. Одес. Нац. ун-т ім. І.І. Мечникова. Одеса: Астропринт, 2008. XII. 228 с. URL: http://dspace.onu.edu.ua:8080/handle/123456789/2776
2. Снигирев С. М. Донная ихтиофауна прибрежных вод острова Змеиный: автореф. дис. … канд. биол. наук: 03.00.10. Киев, 2011. 20 с.
3. Снигирев С. М. Питание и трофические связи трех массовых видов донных рыб в прибрежной акватории о. Змеиный в 2003-2007 гг. *Гидробиологический журнал.* 2011. Т. 47, №. 4. С. 52-65. URL: https://doi.org/10.1615/HydrobJ.v47.i6.60
4. Снигирев С. М., Абакумов А. Н., Пицык В. З., Газетов Е. И. Первая находка рыбы-ласточки Chromis chromis (Linnaeus, 1758) и пеламиды Sarda sarda (Bloch, 1793) в акватории о. Змеиный. *Екологічні проблеми Чорного моря*: матеріали міжнар. наук.-практ. конф. м. Одеса, 28 - 29 жовт. 2010 р. Одеса, 2010. С. 400-402.
5. Снігірьов С. М., Мединець В. І., Абакумов О. М. Різноманітність іхтіофауни прибережних вод острова Зміїний у 2004 – 2009 рр. *Наукові записки Тернопільського національного педагогічного університету імені Володимира Гнатюка. Серія: Біологія. Спеціальний випуск „Гідроекологія".* 2010. № 3 (44). С. 250 – 252.
6. Snigirov S., Goncharov O., Sylantyev S. The fish community in Zmiinyi Island waters: structure and determinants. *Marine Biodiversity*. 2012. Vol. 42, № 2. P. 225-239. DOI: https://doi.org/10.1007/s12526-012-0109-4
7. Snigirov S. Bluefish Pomatomus saltatrix (L., 1766) horse mackerel Trachurus mediterraneus ponticus Ale-

ev, 1956 diet in the Zmiinyi Island coastal waters: Abstract Book of the 4-th Biannual Black Sea Scientific Conference, (28-31 October, 2013, Constanta, Romania). Constanta, 2013. P. 106-107.
8. Snigirev S. M., Medinets V. I. Results of investigations of marine fish and benthos communities in western part of the Black sea (near Zmeiny island). *Journal of Environmental Protection and Ecology*. 2010. Vol. 11. No 3. P. 1037–1045. URL: https://docs.google.com/a/jepe-our-nal.info/viewer?a=v&pid=sites&srcid=amVwZS1qb3VybmFsLmluZm98amVwZS1qb3VybmFsfGd4OjRlODk1NjgwNTcwNTk5ZWE
9. Snigirov S., Medinets V., Chichkin V., Sylantyev S. Rapa whelk controls demersal community structure off Zmiinyi Island, Black Sea. *Aquatic Invasions.* 2013. Vol. 8. No 3. P. 289-297. DOI: http://dx.doi.org/10.3391/ai.2013.8.3.05
10. Методи гідроекологічних досліджень поверхневих вод. / Під ред. В. Д. Романенко. К.: ЛОГОС, 2006. С.156-180.
11. Пряхин Ю. В., Шкицкий В. А. Методы рыбохозяйственных исследований. Ростов-на-Дону: Изд-во ЮНЦ РАН, 2008. 256 с.
12. Гетьман Т. П. Визуальные подводные наблюдения при оценке качественно-количественных показателей ихтиоцена. *Экология моря.* 2007. Отдельный вып. 74. С. 13-17. URL: https://www.elibrary.ru/item.asp?id=25457272
13. Мочек А.Д. Экологическая организация прибрежных сообществ морских рыб. Киев: Наукова думка, 1978. С. 3-18.
14. Halford A., Thompson A. A. Visual census surveys of reef fish. Townsville: Australian institute of marine science, 1994. 22 p.
15. Берг Л. С. Рыбы пресных вод СССР и сопредельных стран. М.; Л.: Изд-во АН СССР, 1948-1949. Ч. 1-3. 1382 с. URL: https://www.twirpx.com/file/285814/
16. Васильева Е. Д. Рыбы Черного моря. Определитель морских, солоноватоводных, эвригалинных и проходных видов с цветными иллюстрациями, собранными С. В. Богородским. М.: изд-во ВНИРО, 2007. – 238 с. URL: http://dspace.vniro.ru/handle/123456789/2166
17. Замбриборщ Ф. С. К систематике бычков Черного и Азовского морей (краткий определитель). *Вестник зоологии*. 1968. Т. 10, № 1. С. 37-44. URL: http://mail.izan.kiev.ua/vz-pdf/1968/1/68_1_05.pdf
18. Световидов А. Н. Рыбы Черного моря. – М.; Л.: Наука, 1964. – 551 с. URL: https://doi.org/10.21072/Black_Sea_Fish
19. Павлов П. Й. Фауна України. Т. 8. Риби. Вип. 1. К.: Наук. думка, 1980. 352 с. http://www.izan.kiev.ua/fau-ukr.htm
20. Мовчан Ю. В., Смирнов А. І. Фауна України. Т. 8. Риби. Вип. 2. Коропові. Ч. 1. Плітка, ялець, гольян, краснопірка, амур, білизна, верховка, лин, чебачок амурський, підуст, пічкур, марена. К.: Наук. думка, 1981. 428 с. http://www.izan.kiev.ua/fau-ukr.htm
21. Мовчан Ю. В., Смирнов А. І. Фауна України. Т. 8. Риби. Вип. 2. Коропові. Ч. 2. Шемая, верховодка, бистрянка, плоскирка, абраміс, рибець, чехоня, гірчак, карась, короп, гіпофтальміхтис, аристихтис. К.: Наук. думка, 1983. 360 с. http://www.izan.kiev.ua/fau-ukr.htm
22. Мовчан Ю. В. Фауна України. Т. 8. Рыбы. Вып. 3. Вьюновые, сомовые, икталуровые, пресноводные угри, конгеровые, саргановые, тресковые, колюшковые, игловые, гамбузиевые, зеусовые, сфиреновые, кефалевые, атериновые, ошибневые. Киев : Наук. думка, 198. – 368 с. http://www.izan.kiev.ua/fau-ukr.htm
23. Щербуха А. Я. Фауна України. Т. 8. Риби. Вип. 4. Окунеподібні (окуневидні, губаньовидні, драконовидні, собачковидні, піщанковидні, ліровидні, скумбрієвидні. К.: Наук. думка, 1982. 384 с.
24. Смирнов А. И.Фауна України. Т. 8. Рыбы. Вып. 5. Окунеобразные (бычковидные), скорпенообразные, камбалообразные, присоскоперообразные, удильщико-образные. К.: Наук. думка, 1986. 320 с. URL: http://www.izan.kiev.ua/fau-ukr.htm
25. European sea fishes Gibraltar to Norway / Ed. by G. Jennings. Calypso Publications, London, 1996. 208p.
26. Froese R., Pauly D. (Eds). FishBase. World Wide Web electronic publication, 2007. URL: **http**://www.**fishbase**.**org**/summary/speciessummary.php?id=108 **version (08/2007)**
27. IUCN Red List of threatened animals. Intern. Union of Conservation of Nature and Natural Resources. USA. Printed by Kervin press, 1996. 368 p.
28. Kottelat M., Freyhof J. Handbook of European freshwater fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany, 2007. 660 p. URL: http://www.blacksea-commission.org/_publ-BSFishList.asp
29. Miller J., Loates M J. Fish of Britain and Europe. Harper Collins Publishers, London, 1997. 288 p.
30. Nelson J. S. Fishes of the word (4 rd edition). New York: J. Willey & Sons, Inc., 4th edition, 2006. 601 p.
31. Black Sea Fish Check List. Compiled by M. Yankova. – Black Sea Commission Publication, 2010. – 53 p.
32. Правдин И. Ф. Руководство по изучению рыб (преимущественно пресноводных). М.: Пищ. пром-сть,

1966. 375 с.
33. Margalef R. Information theory in ecology. General Systems. 1958. 3. P. 36-71.
34. Shannon C. E., Weaver W. The mathematical theory of communication. Urbana: University of Illinois Press, 1949. 125 p.
35. Pielou E. C. The mesurements of diversity in different types of biological collections. *J. Theoret. Biol.* 1966. 13. P. 131-144. URL: https://doi.org/10.1016/0022-5193(66)90013-0
36. Газетов Е. И., Мединец В. И., Снигирев С. М., Снигирев П. М., Абакумов А. Н., Пицык В. З. Исследования гидрологических характеристик морских вод у острова Змеиный в 2016-2017 гг. *Вісник Харківського національного університету імені В. Н. Каразіна Серія «Екологія»*. 2019. Вип. 20. С. 42-55. DOI: https://doi.org/10.26565/1992-4259-2019-20-04
37. Снигирев С. М., Чернявский А. В., Наум Е. А., Галкина А. А., Мединец В. И., Газетов Е. И., Конарева О. П., Снигирев П. М. Состояние макрозообентоса в прибрежной зоне острова Змеиный в 2016-2017 гг. *Вісник Харківського національного університету імені В. Н. Каразіна Серія "Екологія"*. 2019. Вип. 21. С. 81-98. DOI: https://doi.org/10.26565/1992-4259-2019-21-07
38. Червона книга України. Тваринний світ / за ред. І. А. Акімова. К.: Глобалконсалтинг, 2009. 600 с. https://redbook-ua.org/; https://redbook.land.kiev.ua/2.html
39. Black Sea Red Data Book. / Ed. by H. J. Dumont. New York: United Nations Office for Project Services, 1999. – 413 p.

Надійшла: 27.09.2020 Прийнята: 20.10.2020