# DIVERSITY AND CURRENT STATE OF FISH COMMUNITIES OF THE RESERVE "UTRISH" (CAUCASIAN COAST OF THE BLACK SEA, ABRAU PENINSULA)

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*DOI: 10.2478/trser-2023-0021*

**KEYWORDS**: species richness, diversity, dominance, European black scorpionfish.

**ABSTRACT**

The article is focused on the current state of biodiversity in the aquatic environment of the Utrish Nature Reserve. Implementation of the multi-level monitoring program for fish and crustacean fauna, conducted in the waters of the Utrish Nature Reserve during the period 2016-2018, using classical methods of biological analysis, as well as visual underwater fish counting, allowed us to assess the overall state of biodiversity in this area as sufficiently stable. The population status of the model indicator species, the European black scorpionfish *Scorpaena porcus*, was also stable during this period, confirming the effectiveness of protective measures in this area. Due to the continued increase in anthropogenic pressure on coastal marine biocenoses, monitoring studies require further continuation.

**RÉSUMÉ**: Diversité et état actuel des communautés de poissons de la réserve d'Utrish (côte caucasienne de la mer Noire, péninsule d'Abrau).

L'article se concentre sur l'état actuel de la biodiversité dans l'environnement aquatique Utrish de la réserve. La mise en œuvre du programme de suivi à plusieurs niveaux de la faune piscicole et crustacée, réalisé dans les eaux de la réserve d'Utrish au cours de la période 2016-2018, en utilisant des méthodes classiques d'analyse biologique, ainsi que le comptage visuel des poissons sous-marins, a permis d'évaluer l'état général de la biodiversité dans cette zone comme suffisamment stable. L'état de la population de l'espèce indicatrice modèle, la rascasse noire européenne *Scorpaena porcus*, était également stable pendant cette période, confirmant l'efficacité des mesures de protection dans cette zone. En raison de l'augmentation continue de la pression anthropique sur les biocénoses marines côtières, les études de surveillance doivent être poursuivies.

**REZUMAT**: Diversitatea și starea actuală a comunităților de pești din Rezervația „Utrish" (Coasta Caucaziană a Mării Negre, Peninsula Abrau).

Articolul se concentrează asupra stării actuale a biodiversității în mediul acvatic al Rezervației Utrish. Implementarea programului de monitorizare pe mai multe niveluri a faunei de pești și crustacee, desfășurat în apele Rezervației „Utrish" în perioada 2016-2018, folosind metode convenționale de analiză biologică, precum și numărarea vizuală subacvatică a peștilor, a făcut posibilă evaluarea stării generale a biodiversității în această zonă ca fiind suficient de stabilă. Statutul populației speciei indicator model, peștele scorpion negru European *Scorpaena porcus*, a fost, de asemenea, stabil în această perioadă, confirmând eficacitatea măsurilor de protecție în această zonă. Datorită creșterii continue a presiunii antropice asupra biocenozelor marine de coastă, studiile de monitorizare trebuie continuate.

## INTRODUCTION

The problem of studying and preserving biodiversity using monitoring research methods is one of the most pressing global environmental issues due to the constantly growing anthropogenic impact on individual species and the biosphere as a whole (Zakharov and Trofimov, 2019).

The combination of factors such as unique natural conditions, scarce knowledge about the species composition of hydrobionts in the coastal zone, and the abundance of protected reserve waters makes studies of the marine fauna in the coastal zone of the Abrau Peninsula, which marks the beginning of the Caucasus region of the Black Sea, extremely relevant. The Utrish Reserve is located between Cape Bolshoy Utrish and Cape Malyy Utrish and includes a significant part of the coastal zone of the territorial waters of the Black Sea.

Ichthyological monitoring is an important component of environmental monitoring since the most comprehensive information about the overall state of the environment can be obtained by studying biota communities that contain the largest number of sedentary and low – migratory animal species constantly present within the surveyed waters, i.e., benthic communities and ichthyocenosis.

Monitoring of fish community dynamics is the most important component of the study and conservation of aquatic environments, as the analysis of process dynamics allows for identify general patterns of ecosystem changes, coenotic connections, and the biology of individual animal and plant species. Within the framework of ichthyological monitoring programs, the development and implementation of scientific methods for the conservation of ichthyofauna are possible.

Ichthyological studies near the eastern coast of the Black Sea are relatively few and mainly sporadic (Kruglov, 1991; Luzhnyak and Chikhachev, 2000; Plotnikov, 2001; Luzhnyak, 2003; Vasilyeva and Bogorodsky, 2004; Bogorodsky, 2006; Pashkov et al., 2013; Prokofiev, 2016; Karpova et al., 2021). In general, the insufficiency of the study of ichthyofauna can be stated both in the coastal marine zones and in the brackish-water lakes and watercourses of the reserve.

The goal of this study is to assess the state of diversity of the fish community in the Utrish Reserve, which is one of the most important characteristics of community status under the impact of various environmental factors.

The program of comprehensive monitoring ichthyological research in the Utrish Reserve was initiated in 2016 and further continued and developed in 2017–2019.

## MATERIAL AND METHODS

### Fish populations

The research methods for studying fish populations in the marine waters of the Utrish Nature Reserve included visual underwater observations using photography and videography equipment. During these studies, both surface and free-diving observations were employed. Surface observations involved monitoring the water column and counting fish while in motion on the water's surface, while free-diving allowed for more detailed exploration of the benthic areas. The duration of the counting transect, depending on the benthic landscape, is up to 50 meters.

To increase the accuracy of the counts, underwater compact video and photo cameras were used to record the number of fish in a flock, especially when there were large numbers of individuals. Underwater photography with subsequent image analysis in laboratory conditions was employed to improve the reliability of species identification. The surveys were conducted at six stations in the coastal waters (Fig. 1).

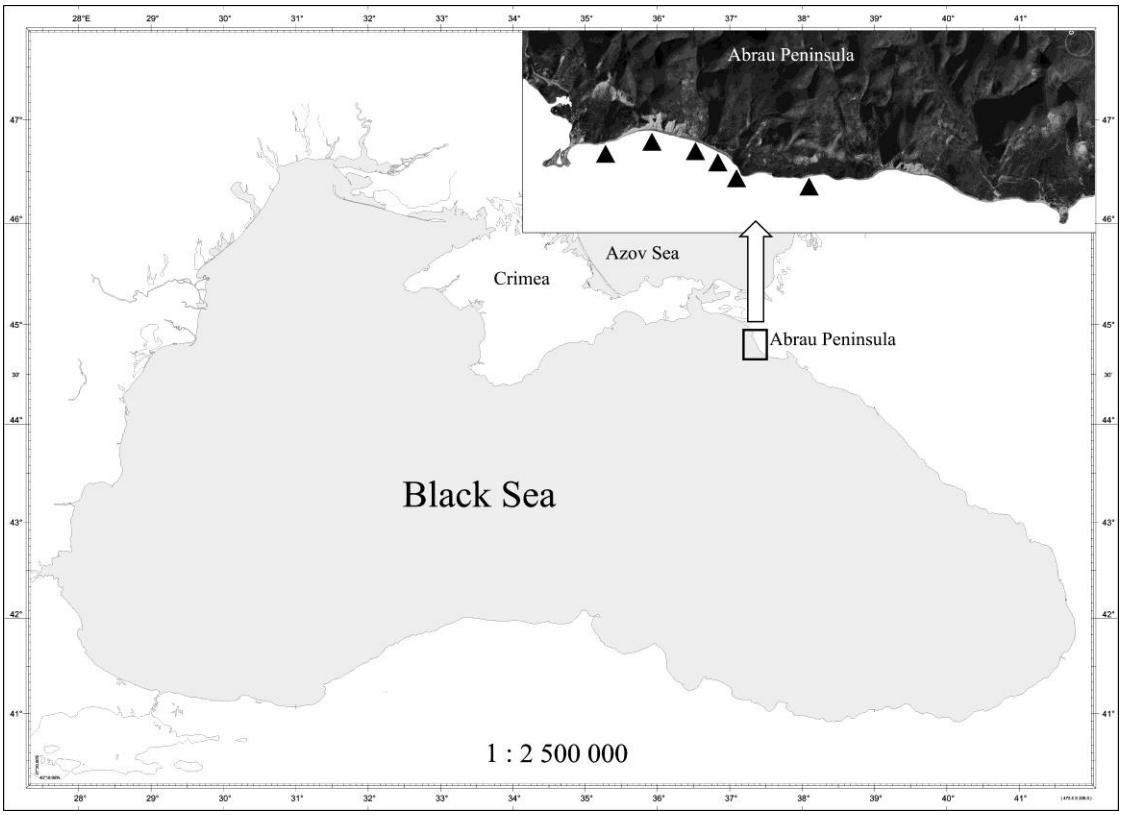


Figure 1: The schematic map of the studied area.

**Species richness**

In order to analyze indicators of species richness and diversity based on the survey data, the following indices were calculated (Smith and Van Belle, 1984):

1) Margalef index: $I = (S–1)/\ln N$,

where *S* is the total number of recorded species, *N* is the total number of individuals counted.

2) Simpson index: $C = \sum p_i^2$,

where $p_i$ is the evaluation of the significance of each species (abundance or biomass).

3) Shannon-Weaver index: $H = -\sum p_i \times \log_2 p_i$,

where *pi* is the proportion of individuals of the i-th species.

4) Inverse Berger-Parker index: $IBP = N/N_{max}$,

where N*max* is the number of individuals of the dominant species.

**Catches analysis**

To study the biological status and population characteristics of fish, data from fishing net catches near the boundaries of the reserve's waters within characteristic biotopes for the region were used.

After obtaining ichthyological material, the following types of work were conducted (Pravdin, 1966):

– initial analysis of the catch, including species identification, counting the number of individuals, and determining the total mass of fish for each species;

– biological analysis, including measurements of mass (total, standard length, and fish mass), determination of gender and stage of sexual maturity.

## RESULTS AND DISCUSSION

### The diversity of fish communities

The species diversity of fish communities consists of two components: species richness, or species density, which is characterized by the total number of species, and evenness, based on the relative abundance or other indicator of species importance and their position in the dominance structure.

One of the main components of biodiversity – species richness or species density – is the total number of species, which is expressed in comparative terms as the ratio of the number of species to the number of individuals (Margalef's species richness index) (Fig. 2).

The highest values of this indicator were observed in spring and summer (in 2016), which may be explained by the active approach of many species to the shore for feeding and spawning. Overall, during the research, fluctuations in this indicator were not significant.

During research, adult individuals of 64 fish species belonging to 46 genera from 36 families and 14 orders were recorded to be more and less regularly present (Tab. 1).

Table 1: The GenBank accession numbers of nematode species.

| No. | Order | Species | | Number of genus | Number of families |
|---|---|---|---|---|---|
| | | number | % | | |
| 1 | Squaliformes | 1 | 1.6 | 1 | 1 |
| 2 | Rajiformes | 2 | 3.1 | 2 | 2 |
| 3 | Acipenseriformes | 2 | 3.1 | 1 | 1 |
| 4 | Clupeiformes | 4 | 6.3 | 3 | 2 |
| 5 | Salmoniformes | 1 | 1.6 | 1 | 1 |
| 6 | Gadiformes | 2 | 3.1 | 2 | 2 |
| 7 | Ophidiiformes | 1 | 1.6 | 1 | 1 |
| 8 | Mugiliformes | 4 | 6.3 | 2 | 1 |
| 9 | Atheriniformes | 2 | 3.1 | 1 | 1 |
| 10 | Beloniformes | 1 | 1.6 | 1 | 1 |
| 11 | Gasterosteiformes | 2 | 3.1 | 1 | 1 |
| 12 | Scorpaeniformes | 2 | 3.1 | 2 | 2 |
| 13 | Perciformes | 36 | 56.3 | 24 | 16 |
| 14 | Pleuronectiformes | 4 | 6.3 | 4 | 4 |
| Total | | 64 | 100 | 46 | 36 |

The family Gobiidae, with ten species, is characterized by great species richness; the families Labridae and Blenniidae have five species each. Four species were recorded for the family Mugilidae, and three species for the families Sparidae and Clupeidae. Three other families are represented by two species, and the remaining families by one species each. Thus, representatives of ten families out of 36 constitute about 60% of species richness.

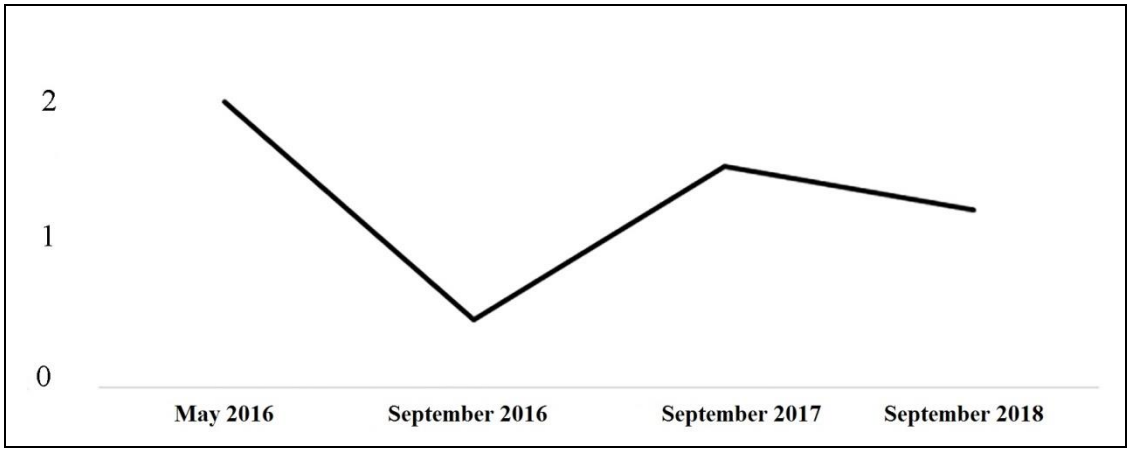


Figure 2: Temporal dynamics of the fish species richness index in the water area of the Utrish Nature Reserve.

To assess differences in the species structure of fish communities, a dominance-diversity curve analysis was used (Fig. 3).

It is known that the more steeply a curve falls, the lower the overall diversity (in terms of evenness) and the stronger the dominance of one or several species. The distribution over different time periods is represented by an intermediate S-shaped curve that corresponds to the log-normal type of estimate of the significance of individual species, which indicates the complex nature of differentiation and overlapping of niches and the presence of developed fish communities. According to the obtained data, the lowest homogeneous community structure was observed in September 2016.

The main indicators of species diversity – Simpson's Dominance Index (C), Pielou's Evenness Index (E), Shannon-Wiever Species Diversity Index (H), Berger-Parker Index (IBP) – were calculated based on long-term data series of census data (Fig. 4).

Dominance indicators (Simpson's and Berger-Parker indices) in fish communities during the observation period reached their highest values in 2016, followed by a decrease and a slight increase in the evenness of communities, which was reflected in the dynamics of the Pielou's Index. Overall, the fluctuations can be considered insignificant and caused by local hydrological and biocenotic conditions.

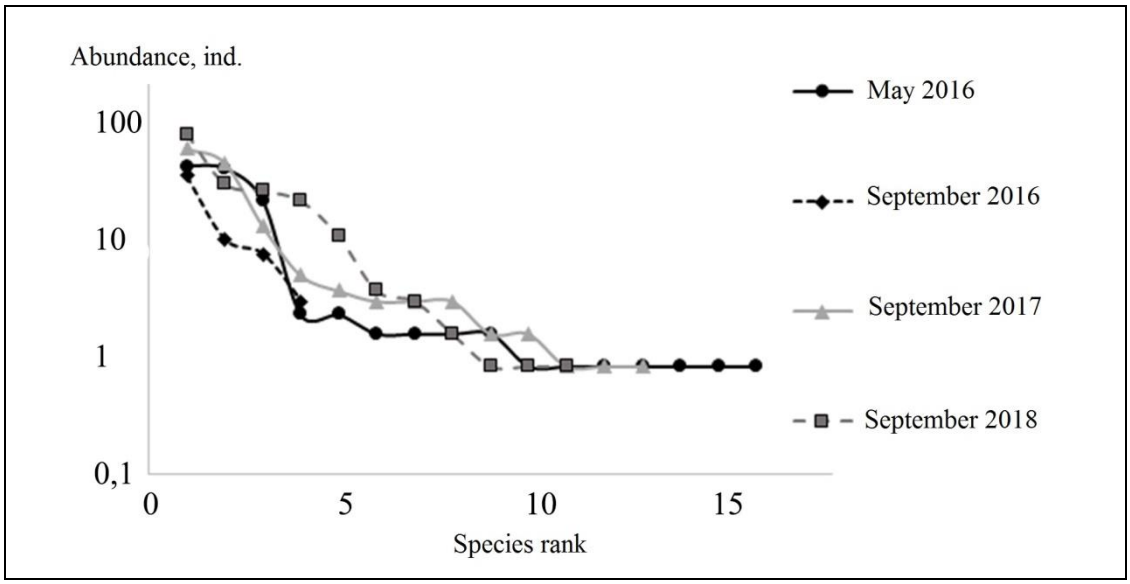


Figure 3: Dominance-diversity curve in fish communities
in the area of the Utrish Nature Reserve in different periods.

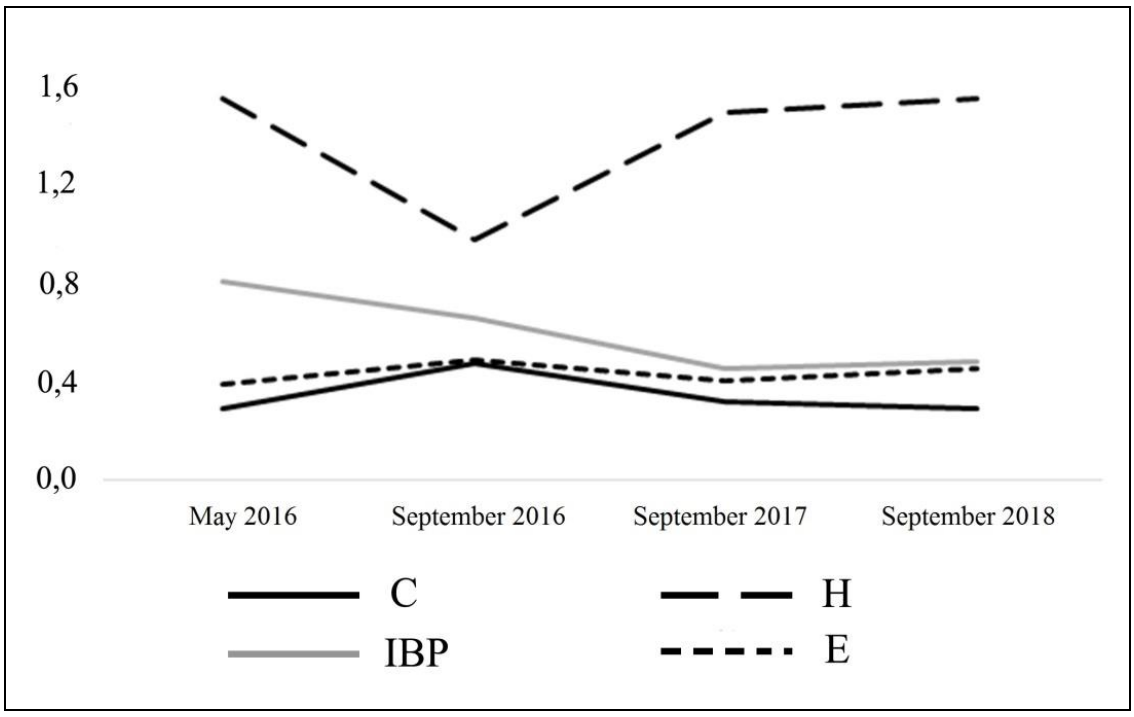


Figure 4: Dynamics of species diversity indices.

**The black scorpionfish population condition**

Studying the biological characteristics of indicator species is an important source of information about the overall condition of aquatic organisms as a result of the complex impact of natural and anthropogenic factors. In the reserve's marine environment, the black scorpionfish *Scorpaena porcus* Linnaeus, 1758, can be classified as such species due to its abundance and benthic sedentary lifestyle. The black scorpionfish is one of the most widespread predators, inhabiting all types of coastal biotopes, and is a model species for assessing the state of biota in various marine habitats. In May and September 2016, among the fish of this species, individuals of the size class 100-110 mm predominated; three other size classes – 110-120 mm, 120-130 mm, and 190-200 mm noticeably prevailed over the rest. In September 2017, an abundance of larger size groups (140-150 mm, 160-170 mm, and 170-180 mm) was observed, with the 120-130 mm size class being dominant. At the end of the warm period in 2018, the scorpionfish exhibited an abundance of size groups of 110-120 mm (in both females and males) and 120-130 mm (in females). A significant proportion of individuals in larger size classes was also observed, primarily 170-180 mm, as well as 140-150 mm, 150-160 mm, and 200-210 mm, with the 140-150 mm size class being numerous in both males and females, while the others were predominantly females.

Overall, the characteristics of the size-frequency structure of the scorpionfish population in different years are quite similar (Fig. 5), indicating the stability of the species and the overall favorable state of the environment.

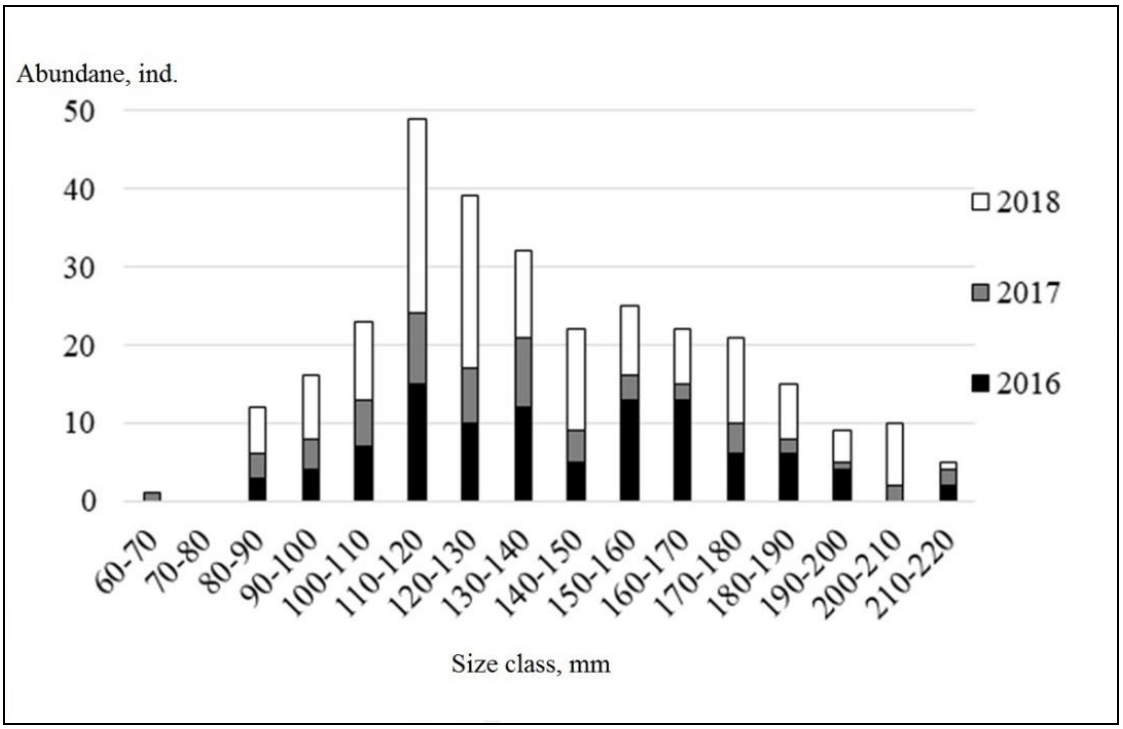


Figure 5: Size-frequency composition of the scorpionfish population in 2016-2018.

## CONCLUSIONS

The complex ichthyological studies have confirmed the effectiveness of measures for the protection of marine, brackish, and freshwater biocenoses on the Utrish Reserve as a center of conservation of the gene pool of natural fauna of the North Caucasus region. It should be emphasized once again that Utrish is the only reserve with a marine area on the Black Sea coast of the Krasnodar Territory, which is clearly insufficient to ensure the ecological safety of this region. This area contains several well-preserved marine biocenoses, of which fish communities are an integral component. During the warm season, there is a spawning and growth of juvenile summer-producing fish, which account for about 95% of the number of species found in the reserve's water area, while the remaining species reproduce during the cold period. Due to the uniqueness of the coastal biotopes of the reserve, adjacent to the Abrau Peninsula, it is advisable to establish a kilometer-wide buffer zone along the perimeter of the water boundaries of the reserve's water area due to the specific nature of the habitat, namely its mobility.

The passage of vessels and crafts negatively affects both the reproducers during the spawning period as well as the fish during the early stages of ontogeny. The main negative factors of navigation include the stressful factor of noise pollution, mechanical damage to passive hydrobionts during the operation of propellers and water intake for cooling ship power units, chemical pollution when fuels and lubricants enter the water, etc.

Localized biotopes with specific fish communities, whose life cycles are directly linked to these biocenoses, have been found in the reserve's water area and therefore require special protection. However, further research is required to clarify the specific structural characteristics of these communities and their mapping.

**ACKNOWLEDGEMENTS**

We want to express our gratitude to the Utrish Reserve Administration for the opportunity to conduct our research. The study was partially performed within the framework of IBSS state research assignment "Biodiversity as the basis for the sustainable functioning of marine ecosystems: criteria and scientific principles for its conservation" (No. 1023032000049-6-1.6.21) as well as RC FBH state contracts "Study of peculiarities, structure, and dynamics of freshwater ecosystems of the Northern Black Sea coast" (No. 123101900019-5) and "Assessment and development of the fishery potential of perspective areas of the Northern Black Sea region".

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