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Restoration of the Biocoenosis of the Black Sea Scallop *Flexopecten glaber* (Bivalvia: Pectinidae) off the Coast of Crimea (Laspi Area)

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Abstract
The paper presents a description of the quantitative representation, taxonomic structure and formation features of the Black Sea scallop *Flexopecten galaber* biocoenosis in the southwestern section of the Crimean shelf (Laspi area), after its depopulation off the coast of Crimea, which coincided with the period of ecological crisis of the Black Sea ecosystem during the second half of the 20th century. The material was benthic samples collected by SCUBA divers using a manual grab sampler in October 2020. A total of 64 macrozoobenthos species were identified in the scallop biocoenosis formed in the biotope of slightly silted sand with shell debris at a depth of 13–34 m. The total list of species was represented by Crustacea (12 species), Mollusca (21), Polychaeta (26), Miscellaneous group (5) and by not identified to species level of Acari, Gromia, Nematoda, Nemertea, Turbellaria. The mean abundance and biomass (after removing the mantle cavity fluid of bivalves) values of macrozoobenthos reached 11,231±2,424 ind./m^2 and 247.7±156.3 g/m^2, respectively. It is assumed that the forerunner to the *Flexopecten* biocoenosis in the area of its detection was the *Gouldia* biocoenosis. The zoobenthos biomass (with mantle cavity fluid of bivalves) in the *Flexopecten* biocoenosis (351 g/m^2) was similar to that values in the *Chamelea* biocoenosis at comparable depths off the coast of Crimea in the 1930s (388 g/m^2), 1957 (354 g/m^2), and 1981–2004 (475 g/m^2); *Chamelea* biocoenosis is classified as one of the most abundant coastal belt biocoenosis of the Black Sea basin. The recovery of *F. glaber* beds observed off the coast of Crimea and its transformation into a coenoses-forming species are in line with the modern recovery processes in the benthos of various areas of the Black Sea shelf, after the crisis period of 1980–1990s, which are associated with de-eutrophication and the improvement of the ecological status of its water areas.

Keywords: *Flexopecten galaber*, macrozoobenthos, Black Sea, biocoenosis

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Восстановление биоценоза черноморского гребешка *Flexopecten glaber* (Bivalvia: Pectinidae) у берегов Крыма (район Ласпи)

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Аннотация

Представлено описание количественного развития, таксономической структуры и особенностей формирования биоценоза черноморского гребешка на юго-западном участке крымского шельфа (район Ласпи) после его депопуляции у берегов Крыма, совпавшей с периодом экологического кризиса черноморской экосистемы второй половины XX в. Материалом послужили бентосные пробы, собранные в октябре 2020 г. ручным водолазным дночерпателем на четырех станциях полигона. В биоценозе гребешка, сформировавшемся в биотопе слабо заиленного песка с ракушей на глубине 13–34 м, отмечены 64 представителя макрозообентоса. Из них Crustacea – 12, Mollusca – 21, Polychaeta – 26, сборная группа Miscellaneous – 5 видов и не идентифицированные до вида представители Acari, Gromia, Nematoda, Nemertea, Turbellaria. Средняя численность и биомасса макрозообентоса (без учета мантийной жидкости двустворчатых моллюсков) составили 11 231 ± 2424 экз./м^2 и 247.7 ± 156.3 г/м^2 соответственно. Предполагается, что предшественником биоценоза *Flexopecten* в районе его обнаружения был биоценоз *Gouldia*. При аналогичных методиках взвешивания (с учетом мантийной жидкости двустворчатых моллюсков) биомасса зообентоса в биоценозе *Flexopecten* (351 г/м^2) оказалась сходной с аналогичными параметрами развития бентоса на сопоставимых глубинах у берегов Крыма в 1930-х гг. (388 г/м^2), 1957 г. (354 г/м^2) и 1981–2004 гг. (475 г/м^2) в биоценозе *Chamelea*, относимом к наиболее развитым прибрежным поясным биоценозам Черноморского бассейна. Наблюдаемое восстановление поселений *F. glaber* и его превращение у берегов Крыма в ценозообразующий вид согласуется с современными восстановительными процессами в бентосе различных участков черноморского шельфа в посткризисный (после 1980–1990-х гг.) период деэвтрофикации бассейна Черного моря и улучшения экологического состояния его акваторий.

Ключевые слова: биоценоз, *Flexopecten glaber*, макрозообентос, Черное море

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Introduction

The Black Sea scallop *Flexopecten glaber* (Linnaeus, 1758) is the only representative of the family Pectinidae (class Bivalvia) in the Black Sea [1)]. It forms aggregations from the water's edge to depths of 40 m in biotopes of dense shell, silty-sandy sediments with an admixture of shell debris and coarse sandy-pebble sediments [1]. At the beginning of the 20th century, *F. glaber* was abundant in all oyster beds and deeper layers of coastal sand near Sevastopol [2]. In the area of the Kerch Strait, the scallop together with *Ostrea edulis* Linnaeus, 1758 formed its own biocoenosis as a leading benthic form, and near the open coasts of Crimea, it was included in different biocoenoses as a characteristic or secondary species [1]. However, already in the 1950s and 1960s, the Black Sea population of *F. glaber* tended to decrease. On the soft bottom sediments (not including oyster beds), the Black Sea scallop was a member of only two biocoenoses – *Gouldia* (15–32 m depth, biotope of shells with sand and a slight admixture of silt, western coast of Crimea) [3] and *Parvicardium – Gouldia – Pholoe inornata* (10–25 m depth, gravel-sandy sediments, Southern coast of Crimea) [4]. Subsequent events in the 1970s (the beginning of eutrophication in the Black Sea basin, the death of oyster beds) followed by a peak of ecological crisis in the Black Sea ecosystem in the late 1980s and early 1990s determined the actual depopulation of *F. glaber*, so this species was included in the Red Book of the Republic of Crimea and the Red Data Book of Sevastopol as species declining in abundance [2), 3)].

An improvement in the ecological state of the Black Sea basin in the early 2000s resulted in the recovery of populations of some benthic species whose abundance and habitat had previously decreased [5, 6]. Since 2010, information has started to appear about the discovery of *F. glaber* aggregations in various parts of the Crimean coast (Donuzlav Bay, Kazachya and Laspi bays) [7, 8] and the mass settlement of their larvae on collectors of mussel and oyster farms [9, 10], which led to practical recommendations for the development of aquaculture of this species off the coast of Crimea [10].

The return of the scallop into the benthos of the region was expected, but required monitoring in terms of possible changes in the structural indicators of benthos development. The work aims at describing the biocoenosis of the Black Sea scallop formed in the water area of one of the sites in Southwestern Crimea (Laspi area).

Material and methods

The work was conducted in October 2020 near the coast of Southwestern Crimea (Laspi area, Mechty Bay). Benthic samples were taken by SCUBA divers using a manual grab sampler (S = 0.04 m^2) at four points of the study area: Station *1* (19 m

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1) Scarlato, O.A. and Starobogatov, Ya.I., 1972. [Bivalvia Class]. In: F. D. Mordukhay-Boltovskoy, ed., 1972. [*Fauna Field Guide for the Black Sea and Sea of Azov*]. Vol. 3. Kiev: Naukova Dumka, pp. 178–249 (in Russian).

2) Revkov, N.K., 2015. [The Black Sea Scallop Flexopecten glaber ponticus Bucquoy, Dautzenberg et Dollfus, 1889]. In: S. P. Ivanov and A. V. Fateryga, eds., 2015. *Red Book of the Republic of Crimea. Animals*. Simferopol: ARIAL, 39 p. (in Russian).

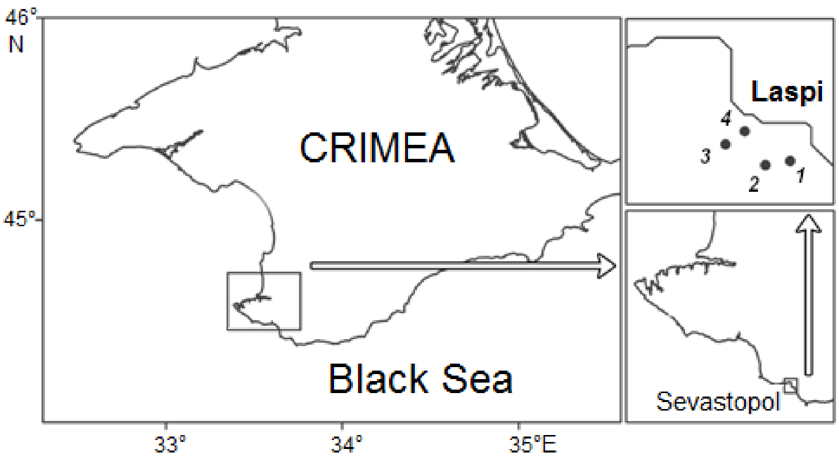
3) Revkov, N.K., 2018. [The Black Sea Scallop Flexopecten glaber (Linnaeus, 1758)]. In: I. V. Dovgal and V. V. Korzhenevskiy, eds., 2018. *The Red Data Book of Sevastopol*. Sevastopol: ROST-DOAFK, 432 p. (in Russian).

deep), Station *2* (34 m), Station *3* (27 m) and Station *4* (13 m) (Fig. 1). The substrate in the sampling area was represented by slightly silty amphioxus sand with shell debris (amphioxus is coarse, well aerated sand typical of the *Branchiostoma* (=*Amphioxus*) *lanceolatum* habitat [2]). It was washed through a 0.5 mm sieve; after washing, the remaining sample was fixed in 4 % neutralised formalin. The material was further processed in the laboratory under a binocular microscope. The organisms were counted and weighed with an accuracy of 0.001 g. Their number and wet biomass were recalculated per 1 m^2 of bottom. The bivalve mass was determined after the removal of mantle cavity fluid. The species-level identification of benthic fauna was made using guides (Fauna Guide [4]) and [11]), and taxa were verified by WoRMS [5]). The average values (from four sampling points) of abundance and biomass of large taxa with an indication of a standard error of measurements are presented in the table.

The faunal homogeneity of zoobenthos was assessed on a transformed (species presence/absence) species abundance matrix using the Bray-Curtis similarity coefficient in the *Cluster* program of PRIMER-6 package. The dominant species of benthic macrofauna was determined based on the density index (DI) value as follows

$$DI_i = N_i^{0.25} \cdot B_i^{0.75} \cdot p_i,$$

where N_i – specific abundance, ind./m^2; B_i – specific biomass, g/m^2; p_i – occurrence frequency of species i (0–1).



F i g . 1 . Schematic map of sampling locations in Laspi area

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[4]) IBSS, 1968–1972. [*Fauna Field Guide for the Black Sea and Sea of Azov. Wild Invertebrata*]. 3 volumes. Kiev: Naukova Dumka, (in Russian).

[5]) WRMS. *An Authoritative Classification and Catalogue of Marine Names*. 2022. [online] Available at: http://www.marinespecies.org [Accessed: 01 December 2022].

The DI_i used in this work is an extension of the lineage of taxa quantification indices using the parameters of their occurrence frequency (p_i), specific abundance (N_i) and specific biomass (B_i) $(N_i \cdot B_i)^{1/2}$ [12]; $(N_i \cdot B_i)^{1/2} \cdot p_i$ [13]; $(N_i \cdot B_i \cdot p_i)^{1/3}$ [6)]; $(B_i \cdot p_i)^{1/2}$ [14–16], collectively known as "density indices" and widely used in benthic studies of the Azov and Black Sea basin in the 1930s–1980s. The modern adjustment of indices came from studies on hydrobiont energy, where respiration costs of the i-th hydrobiont species per specific area are estimated by the formula $Q_i = N_i^{0.25} \cdot B_i^{0.75} \cdot k$ [17, 18]. This gave grounds to speak about the semantic load of the expression $N_i^{0.25} \cdot B_i^{0.75}$ as an estimated (approximate) equivalent of the energy role of hydrobionts and the possibility of using it in studies of structural organization of the benthos [19–21].

When comparing the current macrozoobenthos biomass with similar data from previous years, the biomass in the *Flexopecten* biocoenosis was recalculated taking the mantle cavity fluid of bivalves into account according to [22]. In the text, the names of the biocoenoses are abbreviated to the generic names of their dominant species.

Results

All stations in the study area had a high faunal homogeneity with a Bray – Curtis similarity of over 50 %. This allowed assigning them to a single biocoenosis, *Flexopecten glaber*, due to its dominant DI position. The DI value of *F. glaber* (143.05) was more than six times higher than that of the subdominant species, namely the clams *Bittium reticulatun* (22.76), *Gouldia minima* (20.93) and *Anadara kagoshimensis* (18.33). The DI-ranked range of species in the *Flexopecten* biocoenosis is considered in more detail in the discussion of the obtained material.

In total, 64 representatives of macrozoobenthos were observed in the *Flexopecten* biocoenosis at the level of species taxa. Among them are Crustacea – 12, Mollusca – 21, Polychaeta – 26, mixed group "Miscellaneous" – 5 species (see Appendix). Representatives of Acari, Gromia, Nematoda, Nemertea, Turbellaria as well as some specimens of polychaetes of families Nereididae, Phyllodocidae and Syllidae were not identified to species.

Average abundance and biomass of macrozoobenthos in the scallop biocoenosis were 11,231 ± 2,424 ind./m^2 and 247.7 ± 156.3 g/m^2, respectively (Table). Polychaetes and mollusks were the most abundant (Fig. 2, *a*). Among them mollusks *Bittium reticulatum*, *Caecum armoricum*, *C. trachea*, polychaetes *Pholoe inornata*, *Polygordius neapolitanus* and *Sigambra tentaculata* prevailed (density over 500 ind./m^2). In terms of biomass, the mollusks were the absolute leaders (Fig. 2, *b*), with the subdominant species after the leading biocoenosis species *Flexopecten glaber* being *Anadara kagoshimensis*, the recent (since 1969 [23]) alien species to the Black Sea.

[6)] Arnoldi, L.V., 1949. [Materials for Quantitaive Studies of the Black Sea Zoobenthos. II. Karnikit Bay]. In: IBSS, 1949. *Trudy Sevastopolskoy Biologicheskoy Stantsii* [Proceedings of the Sevastopol Biological Station]. Vol. 7. Moscow, Leningrad: Izd-vo AN SSSR, pp. 127–192 (in Russian).

Mean density (*N*) and biomass (*B*) of the main macrozoobenthos taxa in the *Flexopecten glaber* biocoenosis

Taxon	*N*, ind./m^2	*B*, g/m^2
Annelida	5,131 ± 1,152	4.2 ± 1.3
Crustacea	644 ± 108	2.4 ± 0.6
Mollusca	4,169 ± 1,182	239.2 ± 156.8
Miscellaneous	1,288 ± 491	1.8 ± 0.6
Total	11,231 ± 2,424	247.7 ± 156.3

Note: the mollusk biomass is given exclusive of the mantle cavity fluid mass in bivalves.

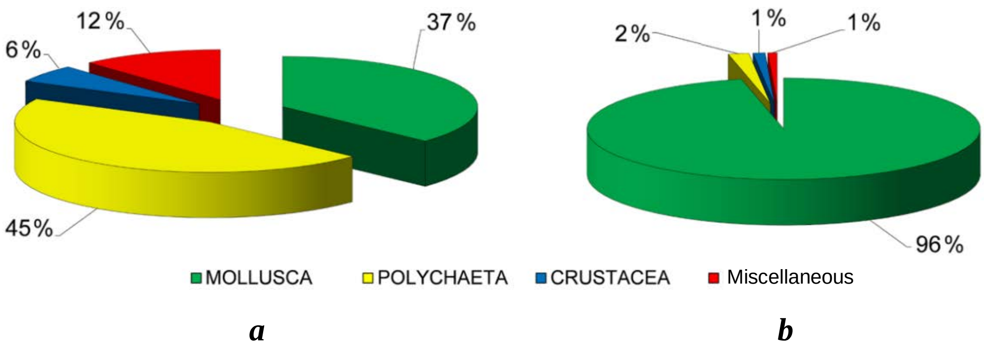


Fig. 2. Relative representation of the basic taxons of macrofauna (*a* – by biomass, *b* – by abundance) in the benthos of the study water area

Ten species in the scallop biocoenosis had an occurrence frequency of 100 % (recorded at all stations). These are the hermit crab *Diogenes pugilator*, the mollusks *Bittium reticulatum*, *Caecum armoricum*, *C. trachea*, *Lucinella divaricata*, *Mytilaster lineatus*, polychaetes *Micronephthys longicornis*, *Pholoe inornata*, *Sigambra tentaculata* (an alien species to the Black Sea [24]) and Nemertea. Two of the species – the index species of the biocoenosis *Flexopecten glaber* itself and the lancelet *Branchiostoma lanceolatum* – are included in the regional Red Data Books (those of Sevastopol and the Republic of Crimea). The former is as a species declining in abundance, the latter is as an rare species [2), 3), 7)].

[7)] Alyomov, S.V., 2018. Branchiostoma lanceolatum (Pallas, 1774). In: I. V. Dovgal and V. V. Korzhenevskiy, eds., 2018. *The Red Data Book of Sevastopol*. Sevastopol: ROST-DOAFK, 356 p. (in Russian).

Discussion

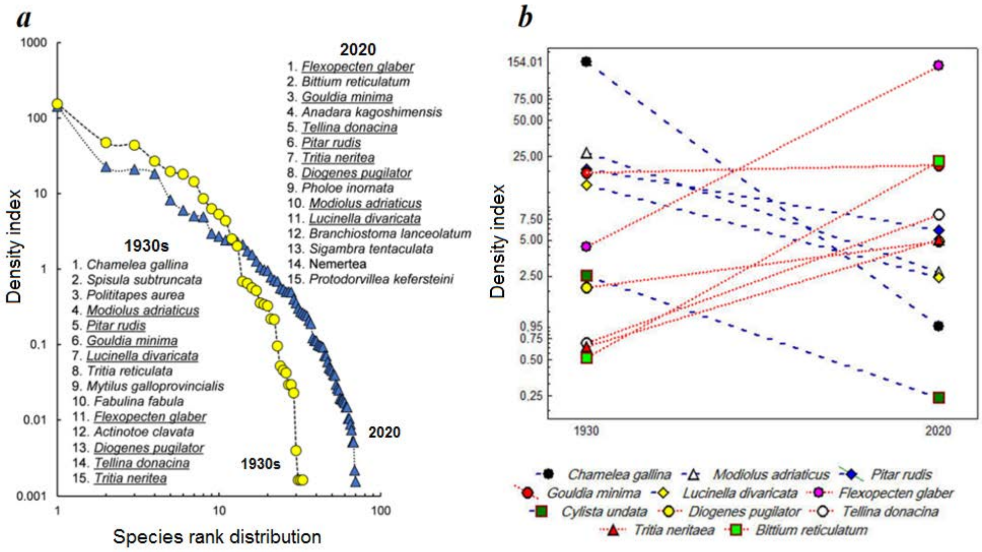
Flexopecten biocoenosis within a benthic biocoenotic classification off the coast of Crimea. As a result of the recovery processes in the population of *F. glaber* off the coast of Crimea after actual depopulation of this mollusk during the Black Sea ecosystem crisis in the second half of the 20th century, the scallop formed its own biocoenosis on the southwestern Crimean shelf area. A similar format of the *F. glaber* domination in benthos was observed in the first half of the 20th century in the oyster beds [1, 2]. In other biotopes near the open coasts of Crimea (silty ground, sand, shell debris, pebbles), *F. glaber* was a member of the characteristic (in biocoenoses *Ostrea – Mytilus*, *Modiolus adriaticus – Mytilus*, *Pitar – Gouldia – Chamelea*) and secondary (in biocoenoses *Loripes – Mytilaster – Modiolus adriaticus*, *Bittium – Mytilaster*, *Chamelea – Polititapes*, *Chamelea – Lucinella*, *Lucinella – Pitar – Chamelea – Gouldia*, *Spisula – Acanthocardia – Pitar*, *Gouldia*, *Parvicardium – Gouldia – Pholoe inornata*) benthos species [1, 3, 4].

Without giving the specifics of the methods of selection of the above biocoenoses, it can be stated that previously the Black Sea scallop was most frequently found in those of them, where the coenosis forming species were *Chamelea gallina* and *Gouldia minima*. These variations in scallop occurrence frequency becomes clear if we refer to a generalised scheme of the biocoenotic subdivision of the Black Sea benthos on the soft bottoms. Within the scallop depths (from 0 down to a depth of 40 m) there are three main biocoenoses: *Mytilus*, *Chamelea* and *Gouldia* [16]. The first two are categorised as regional (or belt), they occur at particular depths and in particular substrates almost along the entire Black Sea coast. The third one belongs to a group of local biocoenoses usually occupying small areas in particular parts of the sea [25]. The *Chamelea* biocoenosis develops in a biotope of sandy sediments (7–30 m depth), the *Gouldia* biocoenosis in sandy-silty sediments (20–50 m) and the *Mytilus* biocoenosis in silty sediments (20–53 m) [16].

It seems quite logical to assume that *F. glaber* population off the coast of Crimea will be recovering in biotopes favourable for the scallop development, and hence in the biocoenoses existing within these biotopes. These biocoenoses are *Mytilus*, *Chamelea* and *Gouldia*.

The observed recovery of *F. glaber* beds and its transformation off the coast of Crimea into a coenosis-forming species is consistent with the current recovery processes (after the 1980–1990s crisis) in the benthos of various parts of the Black Sea shelf associated with the de-etrophication of the Black Sea basin and the improvement in the ecological status of its water areas [22, 26–29].

The biotope of the Gouldia biocoenosis as one of the zones of formation of the modern Flexopecten biocoenosis. In the selected *Flexopecten* biocoenosis, out of the three main coenosis-forming species noted above (within depths up to 40 m) near the coast of Crimea (*M. galloprovincialis*, *Ch. gallina* and *G. minima*), *G. minima*, which ranked third in DI after *F. glaber* and the gastropod *Bittium reticulatum* (Fig. 3), had the greatest development.



F i g . 3 . Curves of the species rank distribution (*a*) and the quantitative representation of the principal macrozoobenthos species (*b*) according to the Density Index (DI) in the *Flexopecten* biocoenosis (Laspi area, depth 13–34 m) in 2020, and in the muddy-sand benthos grouping (area Cape Fiolent – Cape Sarych, depth 12–25 m) in the 1930s (on materials by L. V. Arnoldi [13]). The underlined species are shared by the two study periods

Estimated calculations show that if we exclude *F. glaber* and *A. kagoshimensis* (as an alien species that has recently appeared near the coast of Crimea) from the current benthic structure of the considered study area, the resulting reconstructed *Gouldia* biocoenosis will have a macrozoobenthos biomass of 52 ± 10 g/m^2 (during comparison, the weight of mantle cavity fluid of bivalve mollusks was taken into account), which is comparable to the average benthos biomass (30 g/m^2 [16]) in the *Gouldia* biocoenosis of the 1950s near the coast of Crimea and the Caucasus. Moreover, the relative stability of the *Gouldia* quantitative indices is noticeable when comparing data for Laspi area in 2020 with similar parameters of the 1930s for Southwestern Crimea (Fig. 3).

The *Flexopecten* biocoenosis that we selected is located in a mixed biotope (slightly silty amphioxus sand with shell debris), including components of different sediment fractions that are characteristic of the development biotopes of the main biocoenoses mentioned above. The *Flexopecten* biocoenosis was the closest to the *Gouldia* (32 species shared) and *Chamelea* (30) biocoenoses; the *Mytilus* biocoenosis was more distant (21). Twenty-five species were not previously seen in any of the three biocoenoses near the coast of Crimea, but were present in the scallop biocoenosis. They are seven crustaceans: *Chondrochelia savignyi*, *Elaphognathia bacescoi*, *Eurydice pontica*, *Liocarcinus navigator*,

Melita palmata, *Microdeutopus versiculatus*, *Palaemon elegans*, bryozoans *Cradoscrupocellaria bertholletii*, *Cryptosula pallasiana*, bivalve *Anadara kagoshimensis*, six gastropods: *Caecum armoricum*, *Ebala pointeli*, *Retusa umbilicata*, *Steromphala adriatica*, *Vitreolina incurve*, and six polychaetes: *Lindrilus flavocapitatus*,
Lysidice ninetta, *Lysidice unicornis*, *Nereiphylla pusilla*, *Polyophthalmus pictus* and *Schistomeringos rudolphi*.

Based on the above specific substrate features, species composition and quantitative species development, we believe that the nearest native predecessor of *Flexopecten* biocoenosis in the considered local biotope of silty amphioxus sand with shell debris at 13–34 m depth could be the *Gouldia* biocoenosis. Previously, a mixed representation of psammophilic, pelophilic and euryedaphic forms of benthos was noted for it [16].

In the list of species of the Black Sea *Gouldia* biocoenosis given by M. I. Kiseleva [16], *F. glaber* is absent. However, we note that in earlier publications she indicates the presence of *F. glaber* in this biocoenosis both in the western (Tarkhankut Peninsula, near Cape Uret, a biotope with shell debris, sand and a small admixture of silt at a depth of 10–25 m; species occurrence frequency at the station is 5 %, the abundance being 10 ind./m^2 and the biomass 13.1 g/m^2) [3], and in the southern part of the Crimean shelf (biocoenosis *Parvicardium – Gouldia – Pholoe inornata*) [4]. This discrepancy seems to be caused solely by a technical error of "species dropout" during aggregation of materials. The presence of the scallop in the *Gouldia* biocoenosis of the 1950s and in our data of 2020 indicates the return of the species position (and, as our data show, even its improvement) in a biotope favourable for its development.

Peculiarities of the quantitative development of zoobenthos in the Flexopecten biocoenosis. To assess the level of biomass achieved in the current *Flexopecten* biocoenosis near the coast of Southwestern Crimea, we compare these values with similar data in the *Chamelea* biocoenosis, which forms some of the highest biomass in the benthos of the soft bottoms at depths down to 32 m [30].

The earliest quantitative materials on the region, including the area of interest in Laspi area, are presented in the work of L. V. Arnoldi [13]. Based on biotopic features, he subdivided the benthos of the Southern coast of Crimea (from Cape Fiolent to Cape Sarych) into four main groups: 1) coastal clear sand (depths 1–12 m, *Chamelea – Lucinella – Spisula* group), 2) silt and sand (12–25 m, Chamelea group), 3) mussel muds (26–50 m, *Mytilus* group) and 4) phaseolina muds (51–110 m, *Modiolula – Molgula* group). The group of interest out of the four identified is the second one. The mean macrozoobenthos biomasses of the 1930s *Chamelea* and 2020 *Flexopecten* groups were comparable: 388 g/m^2 vs. 351 g/m^2, respectively. In the current *Flexopecten* biocoenosis, the index form of the 1930s *Chamelea gallina* (DI = 154.01) was placed in the secondary species group

(20^{th} position by DI = 0.95) (see Fig. 3). We note in particular that the level of quantitative development of *Gouldia minima* remained almost unchanged during the compared periods (DI = 18.04 in the 1930s vs. DI = 20.93 in 2020), and in the modern period, *Anadara kagoshimensis* (DI = 18.33), which has successfully established itself near the Crimean coast since the 1990s, joined the leading benthos group along with its native representatives [31].

In 1957, near the open south coast of Crimea in the *Chamelea* biocoenosis (9–25 m; a biotope of fine sand) the macrozoobenthos biomass was low and almost equal to that of the *Flexopecten* biocoenosis (354 g/m^2 vs. 351 g/m^2) [4]. In the second half of the 20^{th} century, during the period of hypereutrophication of the Black Sea basin [32], there was an increase in zoobenthos biomass values in the *Chamelea* biocoenosis associated with a positive response of *Ch. gallina* itself to an increase in available food [35–37]. Accordingly, in 1981–2004 the zoobenthos biomass in the *Chamelea* biocoenosis near the coast of Crimea reached a historical maximum average value of 495 g/m^2 [30].

Thus, in our case, when the formation of the *Flexopecten* biocoenosis in the studied area of the Southwestern Crimea was based on the *Gouldia* biocoenosis, the macrozoobenthos biomass level achieved in the scallop biocoenosis became comparable with that of the main biocoenosis of the sand sublittoral – *Chamelea*. Given the different biotopic relationship between the two biocoenoses (the *Flexopecten* biocoenosis formed on the basis of the silty-sandy *Gouldia* biocoenosis, and the *Chamelea* biocoenosis is located on sandy bottom), the resultant significant expansion of the sublittoral zone with high benthic biomass should be noted.

In this paper we consider one of the possible options for *F. glaber* to realize its biotic potential near the Crimean coast in the process of returning to the regional fauna "through" the *Gouldia* biocoenosis. Other variants may be related to the passage of *F. glaber* through different conditions in other existing biocoenoses.

Conclusion

The paper describes appearance of the Black Sea scallop *Flexopecten glaber* biocoenosis in an area of Southwestern Crimea in a biotope of slightly silty amphioxus sand with shell debris in the depth range 13–34 m. The biocoenosis includes 63 species of benthic macrofauna with a predominance of Polychaeta (26 species) and Mollusca (21 species) groups. It is suggested that the native predecessor of the *Flexopecten glaber* biocoenosis in the area of its detection was the *Gouldia minima* biocoenosis.

With similar weighing methods (taking mantle fluid from bivalves into account), the zoobenthos biomass of the *Flexopecten glaber* biocoenosis (351 g/m^2) was similar to that of the benthos at comparable depths near the southern coasts of Crimea in the 1930s (388 g/m^2), 1957 (354 g/m^2) and 1981–2004 (495 g/m^2) in the *Chamelea gallina* biocenosis, which has one of the highest levels of biomass on the Black Sea shelf.

Appendix

List of macrozoobenthos species in *Flexopecten glaber* biocoenosis

ANNELIDA	
Aonides paucibranchiata Southern, 1914	*Nereiphylla pusilla* (Claparède, 1870)
Capitella capitata (Fabricius, 1780)	*Perinereis cultrifera* (Grube, 1840)
Eunice vittata (Delle Chiaje, 1828)	*Pholoe inornata* Johnston, 1839
Exogone naidina Örsted, 1845	Phyllodocidae g.sp.
Goniadella bobrezkii (Annenkova, 1929)	*Platynereis dumerilii* (Audouin & Milne Edwards, 1834)
Harmothoe imbricata ((Linnaeus, 1767)	*Polygordius neapolitanus* Fraipont, 1887
Harmothoe reticulata (Claparède, 1870)	*Polyophthalmus pictus* (Dujardin, 1839)
Heteromastus filiformis (Claparède, 1864)	*Prionospio cirrifera* Wirén, 1883
Lagis neapolitana (Claparède, 1869)	*Protodorvillea kefersteini* (McIntosh, 1869)
Lindrilus flavocapitatus (Uljanina, 1877)	*Schistomeringos rudolphi* (Delle Chiaje, 1828)
Lysidice ninetta Audouin & Milne-Edwards, 1833	*Sigambra tentaculata* (Treadwell, 1941)
Lysidice unicornis (Grube, 1840)	*Spirobranchus triqueter* (Linnaeus, 1758)
Micronephthys longicornis (Perejaslavtseva, 1891)	Syllidae g.sp.
Mysta picta (Quatrefages, 1866)	*Syllis hyalina* Grube, 1863
Nereididae g.sp.	
CRUSTACEA	
Ampelisca diadema (Costa, 1853)	*Eurydice pontica* (Czerniavsky, 1868)
Apseudopsis ostroumovi Bacescu & Carausu, 1947	*Liocarcinus navigator* (Herbst, 1794)
Athanas nitescens (Leach, 1814 [in Leach, 1813–1815])	*Melita palmata* (Montagu, 1804)
Chondrochelia savignyi (Kroyer, 1842)	*Microdeutopus versiculatus* (Spence Bate, 1857)
Diogenes pugilator (P. Roux, 1829)	*Palaemon elegans* Rathke, 1836
Elaphognathia bacescoi (Kussakin, 1969)	*Pisidia bluteli* (Risso, 1816)
MOLLUSCA	
Anadara kagoshimensis (Tokunaga, 1906)	*Steromphala adriatica* (Philippi, 1844)
Ebala pointeli (de Folin, 1868)	*Gouldia minima* (Montagu, 1803)
Vitreolina incurva (Bucquoy, Dautzenberg & Dollfus, 1883)	*Lepidochitona cinerea* (Linnaeus, 1767)
Bittium reticulatum (da Costa, 1778)	*Lucinella divaricata* (Linnaeus, 1758)
Caecum armoricum de Folin, 1869	*Moerella donacina* (Linnaeus, 1758)
Caecum trachea (Montagu, 1803)	*Mytilaster lineatus* (Gmelin, 1791)
Chamelea gallina (Linnaeus, 1758)	*Mytilus galloprovincialis* Lamarck, 1819
Tritia neritea (Linnaeus, 1758)	*Parvicardium exiguum* (Gmelin, 1791)
Retusa umbilicata (Montagu, 1803)	*Pitar rudis* (Poli, 1795)
***Flexopecten glaber* (Linnaeus, 1758)**	*Rissoa parva* (da Costa, 1778)
Modiolus adriaticus Lamarck, 1819	

Miscellaneous	
Acari	*Leptosynapta inhaerens* (O.F. Müller, 1776)
Cylista undata (Müller, 1778)	Nematoda
Branchiostoma lanceolatum (Pallas, 1774)	Nemertea
Gromia	*Cradoscrupocellaria bertholletii* (Audouin, 1826)
Cryptosula pallasiana (Moll, 1803)	Turbellaria

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