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ICHTHYOFAUNA OF THE BLACK SEA COASTAL ZONE IN THE LASPI BAY AREA (CRIMEA)

© 2021 **E. R. Abliazov[1], A. R. Boltachev[1], E. P. Karpova[1], A. N. Pashkov[2], and O. N. Danilyuk[1]**

[1]A. O. Kovalevsky Institute of Biology of the Southern Seas of RAS, Sevastopol, Russian Federation
[2]Azov – Black Sea branch of the FSBSI "Russian Federal Research Institute of Fisheries and Oceanography" ("AzNIIRKh"), Krasnodar department, Krasnodar, Russian Federation
E-mail: *e_ablyazov@mail.ru*

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The ongoing processes of the Black Sea salinization and fluctuations in mean annual temperature have already caused the natural dispersal of various representatives of the Mediterranean Basin and Indian Ocean fauna and led to a change in species composition and structure of fish communities, inhabiting the coastal zone of the Crimean Peninsula. As a result, it became necessary to study modern composition of fish fauna and indicators of its species richness and diversity. The Laspi Bay was chosen as a model polygon for the following reasons: relatively low level of anthropogenic load; the fact that its part belongs to the specially protected natural areas, as well as the absence of fishing activity with coastal fixed fishing gear; constant free entry of pelagic fish species; biotopes diversity; and smooth change in depth. These peculiarities of the Laspi Bay allow assessing the presence of fish from different ecological groups and provide conditions for monitoring. The study was carried out in the spring-autumn periods of 1990–1994 and 2017–2018. The material was sampled with net fishing gear, hook tackle, and traps. The nets were set at various depths both perpendicular and parallel to the shoreline during the day (10:00 to 18:00) and at nighttime (18:00 to 06:00). Visual observations were also carried out. In total, 70 fish species were registered. Out of them, 14 species were previously not recorded for this area; 5 of them [salema *Sarpa salpa* (Linnaeus, 1758), red-mouthed goby *Gobius cruentatus* Gmelin, 1789, Bath's goby *Pomatoschistus bathi* Miller, 1982, mystery blenny *Parablennius incognitus* (Bath, 1968), and chestnut goby *Chromogobius quadrivittatus* (Steindachner, 1863)] are recent invaders, actively spreading in the Black Sea over the past 15–20 years only. Most of the analyzed species (64) are marine euryhaline fish. The brackish-water group is represented by three species, indigenous to the Black Sea: mushroom goby *Ponticola eurycephalus* (Kessler, 1874), round goby *Neogobius melanostomus* (Pallas, 1814), and knout goby *Mesogobius batrachocephalus* (Pallas, 1814). Out of anadromous fish, starry sturgeon *Acipenser stellatus* Pallas, 1771 is registered, as well as two Clupeidae species: Black Sea shad *Alosa tanaica* (Grimm, 1901) and Pontic shad *Alosa immaculata* Bennett, 1835. As established, the observed seasonal dynamics of species diversity indices within the studied water area is associated with fluctuations in the abundance of horse mackerel *Trachurus mediterraneus* (Steindachner, 1868). In April – May, when this species headed to shallow water for feeding and breeding, the indices have the lowest values; in August, when the abundance of horse mackerel decreases, the maximum values are observed.

Keywords: Black Sea, Laspi Bay, fish fauna, composition, abundance, species richness, diversity, invaders

The Black Sea ichthyofauna is actively investigated (Boltachev & Karpova, 2017 ; Vasil'eva, 2007 ; Zuev et al., 2018). Out of these studies, the analysis of fish communities in the coastal zone stands out, characterized by a higher biological diversity than that of the open sea.

V. A. Vodyanitsky, relying on the distribution of macrozoobenthos, algae, and fish in the coastline and taking into account the peculiarities of separate water areas, identified several zones along the Crimean coast, which were noticeably different from each other (Vodyanitsky, 1949). Later, another zoning of the Crimean coast was proposed – with the allocation of the Sevastopol region, the southern boundary of which is the Laspi Bay (Boltachev & Karpova, 2012).

In the 1980s, A. O. Kovalevsky Institute of Biology of the Southern Seas organized a biological station in the Laspi Bay, which marked the beginning of a comprehensive study of this sea area: its hydrological and hydrochemical conditions, flora, and fauna. The first ichthyological studies in the Laspi area, carried out in 1981–1985 (Salekhova et al., 1987), covered the entire coastal zone up to Sevastopol. As a result, 84 fish species were recorded in the Laspi Bay; the authors noted the ongoing process of the invasion of fish from the East Atlantic complex into the Black Sea, which has been identified in previous works (Oven & Salekhova, 1969 ; Puzanov, 1967, 1965).

In 2005–2011, underwater visual ichthyological observations were carried out (Get'man, 2014); as a result, 23 fish species were recorded, inhabiting the Laspi Bay rocky biotopes. The families Blenniidae and Labridae were represented by the largest number of species.

Part of the bay water area is included in the natural landscape reserve "Cape Aya" and the hydrological nature monument of regional significance "Coastal aquatic complex at Cape Sarych", which determines the high conservation value of ichthyofauna studying in this area.

The Black Sea is characterized by a weak external water exchange and a two-layer hydrological structure of waters, which is a consequence of its inland position. The processes of salinization and fluctuations in mean annual temperature are currently registered (Kazmin et al., 2010 ; Shaltout & Omstedt, 2014).

Salinity in the Black Sea increases by an average of 0.0038 ‰ per 10 years (Belokopytov, 2017), mainly due to a constant influx of the Sea of Marmara water and a reduction in fresh runoff from the mainland. Mean annual water temperature in the Black Sea, based on observations of 1982–2015, increases every decade by an average of 0.64 °C (Sakalli & Basusta, 2018). These processes contribute to natural dispersal of representatives of the Mediterranean Basin fauna (bogue *Boops boops* (Linnaeus, 1758), red-mouthed goby *Gobius cruentatus* Gmelin, 1789, *etc.*) and the Indian Ocean fauna (silver-cheeked toadfish *Lagocephalus sceleratus* (Gmelin, 1789), which has entered through Suez Canal) (Boltachev et al., 2009 ; Vinogradov et al., 2017); species composition and structure of fish communities, inhabiting the coastal zone, are changing. In this regard, it becomes necessary to revise the composition and to analyze the diversity of local fish communities in the coastal zone.

The aim of this work is to study species composition, species richness, and diversity of fish communities in the Laspi Bay.

MATERIAL AND METHODS

The work is based on ichthyological material, sampled in April – July 1990; May – October 1991; August – September 1994; March – August 2017; and August – September 2018. The water body was also fished in August 2006; January and November 2008; May 2009; August – October 2010; October 2012; and May and August 2016.

The material was sampled in the studied water area with net fishing gear, hook tackle, and traps (Fig. 1).

In 1990–1991, 158 nets were set, and 3,735 fish specimens were caught. Three-walled bottom fishing nets with the length of 20–75 m and a mesh size of 20–30 mm were used. They were set at various depths perpendicular to the shoreline at 18:00–20:00 and removed at 08:00–10:00 the next day. In 2017–2018, the material was gathered using fixed single-walled nets with a mesh size of 10–40 mm. The nets were set at different depths both perpendicular and parallel to the shoreline. They were set during the day (10:00 to 18:00) and at nighttime (18:00 to 06:00). Moreover, at nighttime (18:00 to 6:00), bottom traps with mesh size of 6–8 mm were set at depths of 1–2 m. In total, 1,123 fish specimens were caught.

In addition to fishing, visual observations (without quantitative accounting) were carried out. In 2017–2018, monitoring was carried out using photo and video equipment, which made it possible to record small, secretive species. The total duration of visual underwater observations was of 180 h in 1990–1991, 300 h in 1994, and 200 h in 2017–2018.

Data on the presence of rare species in the Laspi Bay in 2014–2017 [green wrasse *Labrus viridis* Linnaeus, 1758 and salema *Sarpa salpa* (Linnaeus, 1758)] were obtained during interviews with members of the Sevastopol Association of Underwater Hunters and analysis of their photographic material, confirming the fact of fish registration.

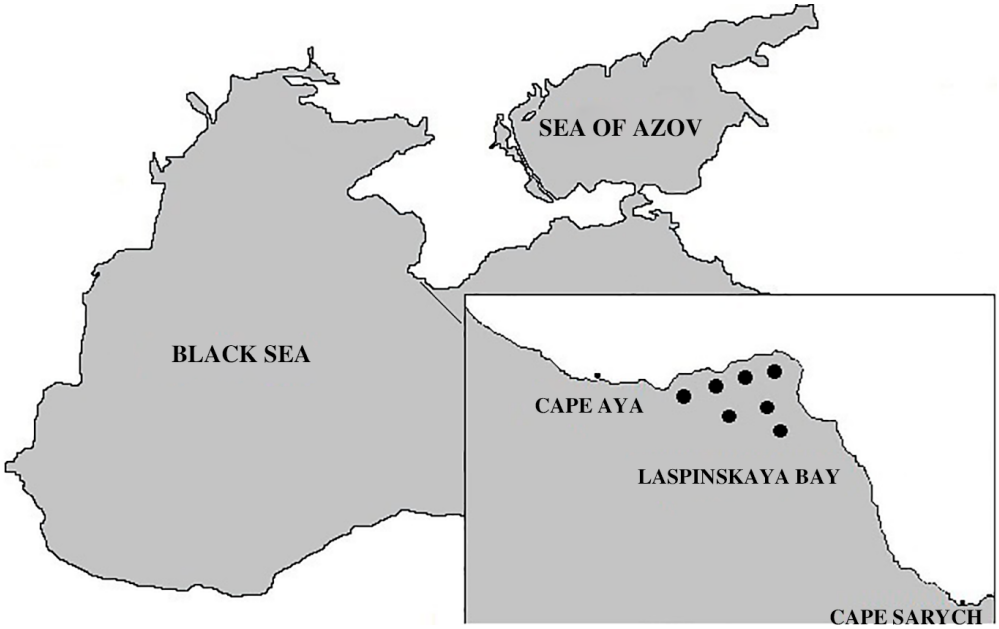

Fig. 1. Map of the Laspi Bay (points indicate sampling locations)

Fish species identification and taxonomic hierarchy are given in accordance with modern concepts (Vasil'eva, 2007 ; World Register of Marine Species, 2019).

To assess the degree of ichthyofauna similarity in different periods, the Sørensen – Czekanowski index was used (Bogolyubov, 1998):

$$K = \frac{2n(A \cap B)}{n(A) + n(B)}, \quad (1)$$

where *n* is the number of species;

A and B are analyzed fish communities.

For 2017–2018, the Margalef species richness index was calculated:

$$D = (S - 1)/\ln(N)\,, \tag{2}$$

where S is the total number of found species;

N is the total number of recorded specimens.

To calculate the uniformity of species distribution over the range, the Simpson diversity index was applied:

$$C = (\sum {p_i}^2)^{-1}\,, \tag{3}$$

where p_i is the ratio of species occurrence (abundance).

The Shannon diversity index was also calculated:

$$H = -\sum pi \times \log 2p_i\,, \tag{4}$$

where p_i is the ratio of specimens of the i-th species in the sample.

To determine the ratio of the dominant species in the catch, the Berger – Parker evenness index was used:

$$IBP = N_i/N_{max}\,, \tag{5}$$

where N_i is the total number of specimens in the sample;

N_{max} is the number of specimens of the dominant species (Pesenko, 1982 ; Rokitskii, 1973).

Indices of species richness and diversity were calculated on the basis of data, obtained in the spring-summer periods of 2017 and 2018. Species richness was estimated by the Margalef index, and species diversity – by the Simpson, Shannon, and Berger – Parker indices. In the calculations, the parameter of abundance was used, which made it possible to avoid the influence on the values of small species with a large biomass.

RESULTS AND DISCUSSION

The Laspi Bay is located between Sarych and Aya capes, the distance between which is about 8000 m. It is protected by mountains from the western, eastern, and northern winds (Atsikhovskaya & Chekmeneva, 2002 ; Klimova et al., 2011). The bay is located at the junction of the continental and subtropical climatic zones. Its depth gradually increases and reaches 60 m. The outer boundary of the bay coincides with the coastal boundary of the Main Black Sea Current, which determines intense water exchange with the open sea (Atsikhovskaya & Chekmeneva, 2002). In the bay water area, the concentration of pollutants is rather low, and the entire water column from the surface to the bottom is well aerated (Kuftarkova et al., 1990).

The coast is composed of volcanic rocks, gradually passing into the Upper Jurassic limestones, due to which the shores are characterized as highly durable (Agarkova-Lyakh, 2007) and are rather weakly subject to abrasion processes. The basis of bay bottom is rocky, boulder, and stony substrates,

interspersed with small pebble areas. At the bay exit, there are small areas of sandy and silty bottom with boulders.

We have registered 70 fish species; in literature (Get'man, 2014 ; Salekhova et al., 1987), 84 species are indicated (Table 1). There were 56 common species, and the Sørensen – Czekanowski faunistic similarity index was 0.73. Totally, 14 species have not been previously recorded in the bay area, and 5 out of them [salema *S. salpa*, red-mouthed goby *G. cruentatus*, Bath's goby *Pomatoschistus bathi* Miller, 1982, mystery blenny *Parablennius incognitus* (Bath, 1968), and chestnut goby *Chromogobius quadrivittatus* (Steindachner, 1863)] are recent invaders, actively spreading in the Black Sea over the past 15–20 years only (Boltachev et al., 2009). Of particular interest is the first record of *Ch. quadrivittatus*. In recent years, an increase in abundance and occurrence of this species was noted along the entire Black Sea coast, and one of its reasons may be climate change (Boltachev & Karpova, 2017 ; Engin et al., 2016).

In literature (Salekhova et al., 1987), 28 species are indicated, which were not found during our studies. Previously (Salekhova et al., 1987), sampling was carried out in an area, including *inter alia* Sevastopol coast and bays. Probably, the list, given by the authors, includes species, that cannot be attributed to the Laspi Bay inhabitants: they are associated with the biotopes of other types, that are not represented in this water area, or do not inhabit the southern and southwestern coast of Crimea at all. These are straightnose pipefish *Nerophis ophidion* (Linnaeus, 1758), as well as syrman goby *Ponticola syrman* (Nordmann, 1840), ratan goby *Neogobius ratan* (Nordmann, 1840), Pinchuk's goby *Ponticola cephalargoides* (Pinchuk, 1976), flatsnout goby *Neogobius platyrostris* (Pallas, 1814), Bucchich's goby *Gobius bucchichi* Steindachner, 1870, grass goby *Zosterisessor ophiocephalus* (Pallas, 1814), and Caucasian dwarf goby *Knipowitschia caucasica* (Berg, 1916). The species, the findings of which in the Black Sea were sporadic, are as follows: grey triggerfish *Balistes capriscus* Gmelin, 1789, thicklip grey mullet *Chelon labrosus* (Risso, 1827), Adriatic blenny *Microlipophrys adriaticus* (Steindachner & Kolombatovič, 1883), and pikeperch *Sander lucioperca* Linnaeus, 1758 (Gudimovich, 1953 ; Oven & Salekhova, 1969 ; Puzanov, 1967). Finally, angler *Lophius piscatorius* Linnaeus, 1758 and John dory *Zeus faber* Linnaeus, 1758 have not been found off the coast of Crimea for more than 30 years. Probably, their local populations have disappeared, which is associated with the intensive trawling on the Crimean shelf (Boltachev & Karpova, 2017 ; Boltachev et al., 2009). The population of Risso's dragonet *Callionymus risso* Lesueur, 1814, inhabiting the biotopes of sandy and silty sediments, also almost disappeared in the 1990s (Boltachev & Karpova, 2017).

We cannot exclude the entry in the bay water area of some rare and numerically small species, which are registered off the coast of Crimea. These are: beluga *Huso huso* (Linnaeus, 1758), Russian sturgeon *Acipenser gueldenstaedtii* Brandt et Ratzeburg, 1833, round sardinella *Sardinella aurita* Valenciennes, 1847, Black Sea salmon *Salmo labrax* Pallas, 1814, European eel *Anguilla anguilla* (Linnaeus, 1758), leaping mullet *Chelon saliens* (Risso, 1810), bogue *Boops boops* (Linnaeus, 1758), shi drum *Umbrina cirrosa* (Linnaeus, 1758), European barracuda *Sphyraena sphyraena* (Linnaeus, 1758), Atlantic bonito *Sarda sarda* (Bloch, 1793), three-spined stickleback *Gasterosteus aculeatus* Linnaeus, 1758, thickly snouted pipefish *Syngnathus variegatus* Pallas, 1814, and Schmidt's pipefish *Syngnathus schmidti* Popov, 1928.

Thus, according to our and published data, the Laspi Bay ichthyofauna accounts for at least 83 species (Table 1).

Table 1. Species composition of the Laspi Bay fish in 1981–2018

No.	Species	Published data	Our data	Origin	Environment
Squalidae – dogfish sharks					
1	*Squalus acanthias* Linnaeus, 1758 – picked dogfish	+	+	As	M, B
Rajidae – skates					
2	*Raja clavata* Linnaeus, 1758 – thornback ray	+	+	As	M
Dasyatidae – stingrays					
3	*Dasyatis pastinaca* (Linnaeus, 1758) – common stingray	+	+	Mm	M, B
Acipenseridae – sturgeons					
4	*Acipenser gueldenstaedtii* Brandt et Ratzeburg, 1833 – Russian sturgeon	+		IPCs	M, B, F
5	*Acipenser stellatus* Pallas, 1771 – starry sturgeon	+	+	IPCs	M, B, F
6	*Huso huso* (Linnaeus, 1758) – beluga	+		IPCs	M, B, F
Engraulidae – anchovies					
7	*Engraulis encrasicolus* (Linnaeus, 1758) – European anchovy	+	+	As	M, B
Clupeidae – herrings, sardines, pilchards, shads, menhadens, and allies					
8	*Alosa tanaica* (Grimm, 1901) – Black Sea shad		+	IPCs	M, B, F
9	*Alosa immaculata* Bennett, 1835 – Pontic shad	+	+	IPCs	M, B, F
10	*Sprattus sprattus* (Linnaeus, 1758) – European sprat	+	+	As	M, B
11	*Sardinella aurita* Valenciennes, 1847 – round sardinella	+		As	M, B
Salmonidae – salmonids					
12	*Salmo labrax* Pallas, 1814 – Black Sea salmon	+		IPCs	M, B, F
Anguillidae – freshwater eels					
13	*Anguilla anguilla* (Linnaeus, 1758) – European eel	+		As	M, B, F
Lotidae – rocklings					
14	*Gaidropsarus mediterraneus* (Linnaeus, 1758) – shore rockling	+	+	As	M
Gadidae – cods					
15	*Merlangius merlangus* (Linnaeus, 1758) – whiting	+	+	As	M
Lophiidae – goosefishes					
16	*Lophius piscatorius* Linnaeus, 1758 – angler	+		As	M
Ophidiidae – cusk-eels					
17	*Ophidion rochei* Muller, 1845 – Roche's snake blenny	+	+	As	M
Mugilidae – mullets					
18	*Chelon auratus* (Risso, 1810) – golden grey mullet	+	+	As	M, B, F
19	*Planiliza haematocheila* (Temminck & Schlegel, 1845) – so-iuy mullet		+	As	M, B, F
20	*Mugil cephalus* Linnaeus, 1758 – flathead grey mullet	+	+	As	M, B, F
21	*Chelon saliens* (Risso, 1810) – leaping mullet	+		As	M, B

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No.	Species	Published data	Our data	Origin	Environment
22	*Chelon labrosus* (Risso, 1827) – thicklip grey mullet	+		Rs	M, B, F
	Atherinidae – Old World silversides				
23	*Atherina boyeri* Risso, 1810 – big-scale sand smelt		+	As	M, B, F
24	*Atherina hepsetus* Linnaeus, 1758 – Mediterranean sand smelt		+	As	M, B, F
	Belonidae – needlefishes				
25	*Belone belone* (Linnaeus, 1760) – garfish	+	+	As	M, B
	Zeidae – true dories				
26	*Zeus faber* Linnaeus, 1758 – John dory	+		Mi	M, B
	Syngnathidae – seahorses, pipefishes, and seadragons				
27	*Syngnathus typhle* Linnaeus, 1758 – broadnosed pipefish	+	+	As	M, B
28	*Syngnathus abaster* Risso, 1827 – black-striped pipefish	+	+	As	M, B, F
29	*Syngnathus variegatus* Pallas, 1814 – thickly snouted pipefish	+		As	M
30	*Syngnathus schmidti* Popov, 1928 – Schmidt's pipefish	+		As	B, F
31	*Nerophis ophidion* (Linnaeus, 1758) – straightnose pipefish	+		As	M, B
32	*Hippocampus hippocampus* (Linnaeus, 1758) – short-snouted seahorse	+	+	As	M
	Scorpaenidae – scorpionfishes				
33	*Scorpaena porcus* Linnaeus, 1758 – black scorpionfish	+	+	As	M
	Triglidae – gurnards				
34	*Chelidonichthys lucerna* Linnaeus, 1758 – tub gurnard	+	+	As	M
	Percidae – perches				
35	*Sander lucioperca* Linnaeus, 1758 – pikeperch	+		Rs	B, F
	Serranidae – sea basses and groupers				
36	*Serranus scriba* (Linnaeus, 1758) – painted comber	+	+	As	M
	Pomatomidae – bluefishes				
37	*Pomatomus saltatrix* (Linnaeus, 1766) – bluefish	+	+	As	M, B
	Carangidae – jacks, pompanos, jack mackerels, runners, and scads				
38	*Trachurus mediterraneus* (Steindachner, 1868) – horse mackerel	+	+	As	M, B
	Sparidae – porgies				
39	*Diplodus annularis* (Linnaeus, 1758) – annular sea bream	+	+	As	M, B
40	*Diplodus puntazzo* (Walbaum, 1792) – sharpsnout sea bream	+	+	As	M, B
41	*Sarpa salpa* (Linnaeus, 1758) – salema		+	Mi	M, B
42	*Boops boops* (Linnaeus, 1758) – bogue	+		As	M
	Centracanthidae – picarels				
43	*Spicara flexuosa* Rafinesque, 1810 – blotched picarel	+	+	As	M

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No.	Species	Published data	Our data	Origin	Environment
44	*Spicara maena* (Linnaeus, 1758) – blotched picarel	+	+	As	M
	Sciaenidae – drums (croakers)				
45	*Sciaena umbra* Linnaeus, 1758 – brown meagre	+	+	As	M, B
46	*Umbrina cirrosa* (Linnaeus, 1758) – shi drum	+		As	M, B
	Mullidae – goatfishes				
47	*Mullus barbatus ponticus* Essipov, 1927 – red mullet	+	+	As	M
	Pomacentridae – damselfishes and clownfishes				
48	*Chromis chromis* (Linnaeus, 1758) – damselfish	+	+	As	M
	Labridae – wrasses				
49	*Symphodus cinereus* (Bonnaterre, 1788) – grey wrasse	+	+	As	M, B
50	*Symphodus ocellatus* Forsskål, 1775 – ocellated wrasse	+	+	As	M
51	*Symphodus roissali* (Risso, 1810) – five-spotted wrasse	+	+	As	M, B
52	*Symphodus tinca* (Linnaeus, 1758) – East Atlantic peacock wrasse	+	+	As	M, B
53	*Symphodus rostratus* (Bloch, 1791) – pointed-snout wrasse	+	+	As	M
54	*Ctenolabrus rupestris* (Linnaeus, 1758) – goldsinny wrasse	+	+	As	M
55	*Labrus viridis* Linnaeus, 1758 – green wrasse	+	+	As	M
	Ammodytidae – sand lances				
56	*Gymnammodytes cicerelus* (Rafinesque, 1810) – Mediterranean sand eel	+	+	As	M
	Trachinidae – weevers				
57	*Trachinus draco* Linnaeus, 1758 – greater weever	+	+	As	M
	Uranoscopidae – stargazers				
58	*Uranoscopus scaber* Linnaeus, 1758 – Atlantic stargazer	+	+	As	M
	Tripterygiidae – triplefin blennies				
59	*Tripterygion tripteronotum* (Risso, 1810) – red-black triplefin	+	+	As	M
	Blenniidae – combtooth blennies				
60	*Aidablennius sphynx* (Valenciennes, 1836) – sphinx blenny	+	+	As	M
61	*Salaria pavo* (Risso, 1810) – peacock blenny	+	+	As	M, B
62	*Parablennius incognitus* (Bath, 1968) – mystery blenny		+	Mi	M
63	*Parablennius sanguinolentus* (Pallas, 1814) – rusty blenny	+	+	As	M
64	*Parablennius tentacularis* (Brünnich, 1768) – tentacled blenny	+	+	As	M, B
65	*Parablennius zvonimiri* (Kolombatovič, 1892) – Zvonimir's blenny	+	+	As	M
66	*Coryphoblennius galerita* (Linnaeus, 1758) – Montagu's blenny	+	+	As	M

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No.	Species	Published data	Our data	Origin	Environment
67	*Microlipophrys adriaticus* (Steindachner & Kolombatovič, 1883) – Adriatic blenny	+		Rs	M
	Gobiesocidae – clingfishes and singleslits				
68	*Diplecogaster bimaculata bimaculata* (Bonnaterre, 1788) – two-spotted clingfish		+	As	M
69	*Lepadogaster candolii* Risso, 1810 – connemarra clingfish	+	+	As	M
70	*Lepadogaster lepadogaster* (Bonnaterre, 1788) – shore clingfish		+	As	M
	Callionymidae – dragonets				
71	*Callionymus pusillus* Delaroche, 1809 – sailfin dragonet	+	+	As	M
72	*Callionymus risso* Lesueur, 1814 – Risso's dragonet	+		As	M
	Gobiidae – gobies				
73	*Aphia minuta* (Risso, 1810) – transparent goby	+	+	As	M, B
74	*Knipowitschia caucasica* (Berg, 1916) – Caucasian dwarf goby	+		As	M, B, F
75	*Zosterisessor ophiocephalus* (Pallas, 1814) – grass goby	+		As	M, B
76	*Chromogobius quadrivittatus* (Steindachner, 1863) – chestnut goby		+	Mi	M
77	*Gobius bucchichi* Steindachner, 1870 – Bucchich's goby	+		As	M
78	*Gobius cobitis* Pallas, 1814 – giant goby	+	+	As	M, B
79	*Gobius cruentatus* Gmelin, 1789 – red-mouthed goby		+	Mi	M
80	*Gobius niger* Linnaeus, 1758 – black goby	+	+	As	M, B
81	*Gobius paganellus* Linnaeus, 1758 – rock goby	+	+	As	M, B, F
82	*Mesogobius batrachocephalus* (Pallas, 1814) – knout goby	+	+	IPCs	M, B
83	*Ponticola eurycephalus* (Kessler, 1874) – mushroom goby		+	IPCs	M, B
84	*Neogobius melanostomus* (Pallas, 1814) – round goby	+	+	IPCs	M, B, F
85	*Neogobius platyrostris* (Pallas, 1814) – flatsnout goby	+		IPCs	M, B
86	*Ponticola cephalargoides* (Pinchuk, 1976) – Pinchuk's goby	+		IPCs	M
87	*Neogobius ratan* (Nordmann, 1840) – ratan goby	+		IPCs	M, B
88	*Ponticola syrman* (Nordmann, 1840) – syrman goby	+		IPCs	M, B, F
89	*Pomatoschistus marmoratus* (Risso, 1810) – marbled goby		+	As	M, B
90	*Pomatoschistus bathi* Miller, 1982 – Bath's goby		+	Mi	M, B
	Gasterosteidae – sticklebacks				
91	*Gasterosteus aculeatus* Linnaeus, 1758 – three-spined stickleback	+		IPCs	M, B, F
	Scombridae – mackerels, tunas, and bonitos				
92	*Sarda sarda* (Bloch, 1793) – Atlantic bonito	+		Mi	M, B

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No.	Species	Published data	Our data	Origin	Environment
Sphyraenidae – barracudas					
93	*Sphyraena sphyraena* (Linnaeus, 1758) – European barracuda	+		As	M
Balistidae – triggerfishes					
94	*Balistes capriscus* Gmelin, 1789 – grey triggerfish	+		Rs	M
Scophthalmidae – turbots					
95	*Scophthalmus maeoticus* (Pallas, 1814) – Black Sea turbot	+	+	As	M
Bothidae – lefteye flounders					
96	*Arnoglossus kessleri* Schmidt, 1915 – scaldback		+	As	M
Pleuronectidae – righteye flounders					
97	*Platichthys flesus* (Linnaeus, 1758) – European flounder	+	+	As	M, B, F
Soleidae – true soles					
98	*Pegusa nasuta* (Pallas, 1814) – blackhand sole	+	+	As	M, B
	In total	**84**	**70**		

Note: As – allochthonous species; IPCs – indigenous Ponto-Caspian species; As – acclimatized species; Rs – random species; Mi – modern invaders; M – marine water; B – brackish water; F – freshwater [according to (World Register of Marine Species, 2019)].

Seventy fish species, recorded and reliably identified for the Laspi Bay coastal zone in 1990–1994 and 2017–2018, belong to 15 orders and 36 families. The family Gobiidae was characterized by the maximum number of species – eleven (Fig. 2). Seven species each were registered for the families Blenniidae and Labridae; three species each were noted for the families Mugilidae, Sparidae, Clupeidae, Gobiesocidae, and Syngnathidae; two species each were recorded for the families Atherinidae and Centracanthidae. Each other family was represented by one species. Thus, representatives of eight families make up 57 % of the Laspi Bay species composition.

In foreign sources (FishBase, 2020), *S. flexuosa* is considered as a junior synonym of *S. maena*. Nevertheless, the presence of significant morphometric and genetic differences between these species was established (Bektas et al., 2018 ; Minos et al., 2013).

The basis of the Laspi Bay ichthyofauna is formed by allochthonous species (58 species, 83 % of the total composition). Ponto-Caspian endemics, that inhabited the Pontian Sea-Lake, are represented by 6 species (9 %). The ratio of modern invaders (spreading since the XX century) is 7 % (5 species). Acclimatized species are represented by so-iuy mullet only, introduced from the Sea of Japan.

In relation to salinity, marine euryhaline fish (64 species, 92 %) prevailed in the bay, mainly migrants from the Mediterranean Sea. The brackish-water group was represented by three species, indigenous to the Black Sea: mushroom goby, round goby, and knout goby. Out of anadromous fish, starry sturgeon was recorded, as well as two species of the family Clupeidae: Black Sea shad and Pontic shad. Since the Black Sea salinity is lower (18–19 ‰) than the oceanic one (32–33 ‰), the marine fauna there is represented by euryhaline species, capable of living in such conditions. It should be noted that most of the species, which we classified as marine, can tolerate strong desalination and sometimes form populations in freshwater bodies (Leonardos, 2001), but high salinity values remain optimal for them.

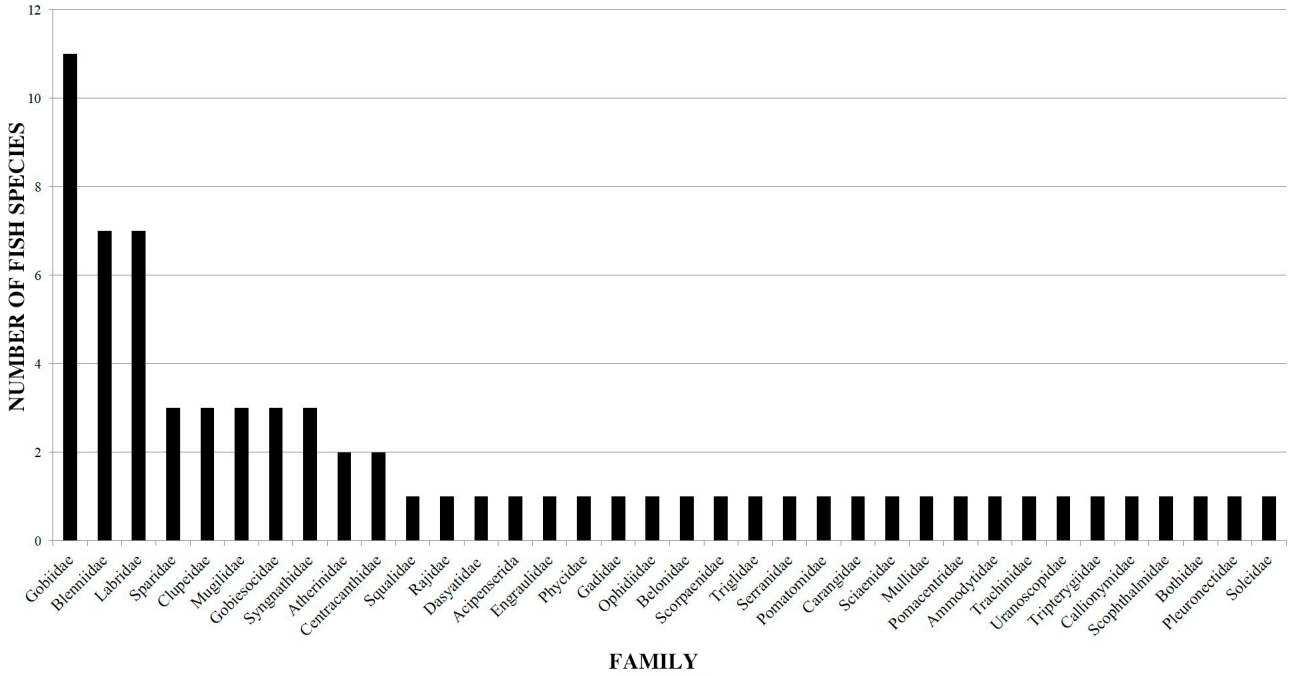

Fig. 2. Taxonomic structure of the Laspi Bay ichthyofauna

The ratio of sedentary fish species (not making significant migrations) accounted for 49 %, and moderately migratory (moving over short distances) – for 20 %. The ratio of highly migratory species (making significant migrations during feeding and spawning) was of 31 %.

Most of ichthyofauna representatives (31 species, 44 %) are rare ones: during the entire period of observations, only sporadic captures or photo and video recordings were registered. Another 26 species (37 %) can be categorized as common; these were sporadic specimens. In total, 13 species (19 %) are regularly found in the bay and are common. Out of them, horse mackerel and black scorpionfish predominate by abundance and biomass, sometimes constituting more than half of the catch. In control catches, 16 species (23 %) were represented by both juvenile and older age groups, and another 12 species (17 %) – by mature individuals only.

Depending on the season, the species diversity indices (Table 2) had values, characteristic of both a well-being community and a depressed one. First of all, criteria of diversity assess the predominance of one species; the lower the value, the higher the well-being of the community. Accordingly, such changes in the values of diversity indices are possibly associated with changes in the abundance of common fish species. The number of species in the spring period was approximately the same as in the summer season. Meanwhile, in spring, horse mackerel approached the shoreline en masse, and values of indices became low; in summer, the values were high.

Table 2. Indicators of species richness and diversity of fish communities in the Laspi Bay coastal zone in 2017–2018

Value	Margalef species richness index (D)	Simpson diversity index (C)	Shannon diversity index (H)	Berger – Parker evenness index (IBP)
Minimum	0.9	1.1	0.3	1.0
Maximum	2.9	9.2	5.5	6.6
Mean	1.7 ± 0.33	4.0 ± 1.37	2.6 ± 0.88	2.8 ± 0.98

Conclusions:

1. In the Laspi Bay during the research period (1991–1994 and 2017–2018), 70 fish species were registered. The family Gobiidae is represented by the maximum number of species (about 16 % of the species recorded). Ichthyofauna is mostly represented by marine euryhaline species (92 %); anadromous and brackish-water species account for 8 %. Of 70 species noted, 14 were recorded in this water area for the first time. Most of them are invaders, which indicates the ongoing acclimatization of representatives of the fauna of other water basins, registered in the first half of the XX century.
2. The total abundance of the Laspi Bay ichthyofauna representatives is subject to seasonal variability, and the main contributor is fluctuations in the abundance of horse mackerel. This variability directly affects the indicators of diversity, causing their significant decrease in the spring period.
3. Out of ichthyofauna representatives, found in the bay water area, 44 % belong to the category of rare: over the entire observation period, they were recorded only sporadically. Common species accounted for 19 %; out of them, horse mackerel was characterized by the highest abundance and biomass in spring, and black scorpionfish – in summer.

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ИХТИОФАУНА ПРИБРЕЖНОЙ ЗОНЫ ЧЁРНОГО МОРЯ В РАЙОНЕ БУХТЫ ЛАСПИНСКАЯ (КРЫМ)

Э. Р. Аблязов[1], А. Р. Болтачев[1], Е. П. Карпова[1], А. Н. Пашков[2], О. Н. Данилюк[1]

[1]ФГБУН ФИЦ «Институт биологии южных морей имени А. О. Ковалевского РАН», Севастополь, Российская Федерация

[2]Азово-Черноморский филиал ФГБНУ «Всероссийский научно-исследовательский институт рыбного хозяйства и океанографии» («АзНИИРХ»), отдел «Краснодарский», Краснодар, Российская Федерация

E-mail: *e_ablyazov@mail.ru*

В настоящее время в Чёрном море протекают процессы осолонения и изменения среднегодовой температуры, которые уже обусловили естественное расселение различных представителей фауны Средиземноморского бассейна и Индийского океана и привели к изменению видового состава и структуры сообществ рыб, населяющих прибрежную зону Крымского полуострова. Вследствие этого возникла необходимость в изучении современного состава ихтиофауны и в оценке показателей её видового богатства и разнообразия. Бухта Ласпинская выбрана в качестве модельного полигона на основании следующих причин: относительно невысокий уровень антропогенной нагрузки; принадлежность части её акватории к особо охраняемым природным территориям и отсутствие рыбопромысловой деятельности прибрежными ставными орудиями лова; постоянный свободный заход пелагических видов рыб; наличие разнообразных биотопов; плавный переход глубин. Вышеперечисленные особенности бухты позволяют оценить наличие рыб разных экологических групп и обеспечивают условия для проведения мониторинга. Исследование выполняли в весенне-осенние периоды 1990–1994 и 2017–2018 гг. Материал собирали сетными орудиями лова, крючковыми снастями и ловушками. Постановку сетей проводили на разных глубинах перпендикулярно и параллельно берегу в дневное (10:00–18:00) и ночное (18:00–06:00) время. Также осуществляли визуальные наблюдения. Всего зарегистрировано 70 видов рыб. Из них 14 ранее не были отмечены в данном районе; пять из них [сальпа *Sarpa salpa* (Linnaeus, 1758), красноротый бычок *Gobius cruentatus* Gmelin, 1789, лысун Бата *Pomatoschistus bathi* Miller, 1982, зелёная морская собачка *Parablennius incognitus* (Bath, 1968) и четырёхполосый хромогобиус *Chromogobius quadrivittatus* (Steindachner, 1863)] являются недавними вселенцами, активно

распространяющимися в Чёрном море только на протяжении последних 15–20 лет. Бóльшая часть проанализированных видов (64) — морские эвригалинные рыбы. Солоноватоводная группа представлена тремя аборигенными для Чёрного моря видами — бычком-рыжиком *Ponticola eurycephalus* (Kessler, 1874), бычком-кругляком *Neogobius melanostomus* (Pallas, 1814) и бычком-мартовиком *Mesogobius batrachocephalus* (Pallas, 1814). Среди проходных рыб зарегистрированы севрюга *Acipenser stellatus* Pallas, 1771 и два вида семейства Сельдевые — черноморский пузанок *Alosa tanaica* (Grimm, 1901) и сельдь черноморско-азовская проходная *Alosa immaculata* Bennett, 1835. Установлено, что сезонная динамика видового разнообразия рыб изучаемой акватории связана с изменением численности локальных скоплений ставриды *Trachurus mediterraneus* (Steindachner, 1868). В апреле — мае, во время подхода данного вида на мелководье для нагула и размножения, индексы имеют наименьшие значения; в августе, когда численность ставрид уменьшается, отмечены максимальные значения.

Ключевые слова: Чёрное море, бухта Ласпинская, ихтиофауна, состав, численность, видовое богатство, разнообразие, вселенцы