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Ichthyofauna of the Lower Dniester, the Dniester Estuary and the Adjacent Black Sea Area, with Some Ecological Comments

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Abstract: Ichthyological data collected over the last two decades are combined to prepare an inventory of fish species of the Lower Dniester, Dniester Estuary and the adjacent Black Sea area (north-western part of the Black Sea, NWBS). Data from literary sources were also used for the analysis of the ichthyofauna dynamics. Totally, 110 freshwater, anadromous, brackish and marine fish species were detected. They represent 27 orders, 41 families and 92 genera. Possible sources of new arrivals are the settlement of new invasive species and the migration of freshwater fish to the nearshore sea areas. The degree of similarity of fish fauna of the Lower Dniester, Dniester Estuary and the adjacent NWBS was analysed to provide the structural characteristics of fish assemblages of the area under study. The main part of the fish fauna of all three sub-regions is represented by settled, benthic and demersal species of Ponto-Caspian zoogeographical origin. Most species are pelagophiles and phytophiles. The most abundant trophic type is benthophages and fish of a mixed-feeding type. The dynamics of the species composition in the studied area and the species importance as possible subjects for conservation are discussed.

Key words: ichthyofauna, Lower Dniester, Dniester Estuary, North-Western part of the Black Sea

Introduction

The Lower Dniester and Dniester Estuary form one of the largest estuarine ecosystems of the Black Sea coastline with the overall area of c. 580 km^2. Together with the adjacent water area of the north-western part of the Black Sea (NWBS), they attracted substantial ichthyological research efforts during the last 10-15 decades by prominent zoologists and ichthyologists (Vinogradov 1958, Zambriborsch 1953, Chepurnov 1962a, 1962b, Sirenko et al. 1992, Starushenko & Bushuev 2001, Khutornoy 2004). This generated a range of comprehensive studies resulting in the publication of significant factual material and analyses of fish assemblages of the region (Zambriborsch 1953, Sirenko et al. 1992, Starushenko & Bushuev 2001). During the last decade, the main focus of research has been on the structure of fish fauna and the conditions of aquatic biological resources. Apart from this, the biological and ecological characteristics of fish species of industrial significance in the Lower Dniester and

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Dniester Estuary were actively studied (Bushuev et al. 2011; Snigirov 2013, Snigirov et al. 2019, 2020), with considerable attention to the fish fauna of the adjacent part of the NWBS.

It is widely accepted that river deltas, connected estuaries and the adjacent areas of the sea are inhabited by closely-related and actively interchanging fish communities (Feyrer et al. 2015, Snigirov 2020, Snigirov et al. 2020). However, the ichthyological data-sets accumulated for the Lower Dniester, the Dniester Estuary and the adjoining part of the NWBS have not been assessed comprehensively as a whole till now. Such an assessment acquires special urgency due to the strengthening of anthropogenic load on the ecosystems in the area observed during recent decades. The main components of this load are:

- regulation and reducing Dniester River flow (Sirenko et al. 1992, Starushenko & Bushuev 2001, Bushuev et al. 2011, Greben et al. 2019);
- higher rates of anoxic episodes of long duration and wider spatial distribution observed at the NWBS shelf (Zaitsev et al. 2006) as a result of the regulation and reduction of river flow;
- increased frequency of dredging and sand extraction combined with rapid development of recreation areas (Zaitsev et al. 2006);
- pollution of soils and water bodies with a wide range of nutrients and toxicants (Sirenko et al. 1992);
- introduction and mass development of invasive species such as *Mnemiopsis leidyi* A. Agassiz, 1865, *Rapana venosa* Valenciennes, 1846, filamentous algae of the genus *Desmarestia* and others (Alexandrov 2004, Zaitsev et al. 2006).

In view of the obligations of Ukraine in terms of the implementation of EU Directives connected to monitoring biodiversity and quantitative characteristics of fish communities, the aim of this work is to summarize the results of multi-decadal ichthyological surveys in the Lower Dniester, Dniester Estuary and and the adjacent Black Sea area.

Materials and Methods

The work was based on materials collected in the Lower Dniester and the Dniester Estuary for the period 2006-2020 within the national project of the Ministry of Education and Science of Ukraine. It was supported by several international projects: EC-TACIS (2006-2007), OSCE / UNECE / UNEP "Cross-border cooperation and sustainable management in the Dniester basin: Phase III – implementation of the action program" (2011-2012), FP7 ENVIROGRIDS (2011-2012). We used data from commercial catches as well as catches of amateur fishermen in the period 2006-2020. The fish was caught by beach seines (length 30 m, height 1.5 m, 6-8 mm mesh size); fyke-nets (6-8, 16-18 and 30-40 mm mesh size); Neiman gill-nets (12-50 mm mesh size); gill-nets (mesh size 28-32 and 50-70 mm), dredge (width 1.1 m, height 0.5 m, 6-8 mm mesh size) and boat seines (length 600 m, height 2 m, 30-40 mm mesh size). We used standard ichthyological methods (Romanenko et al. 2006, Pryakhin et al. 2008). Identification of fish species was carried out by using field guides (Berg 1948-1949; Kottelat & Freyhof 2007).

During the study in NWBS area adjacent to Dniester Estuary (2017-2020), analyses of commercial catches by gill nets (32-200 mm mesh size) were carried out. For the period 2018-2019, commercial catches of mid water trawls with a length of 28-32 m (6-8 mm mesh size) and beam trawls with a width of 3-4 m (30-65 mm mesh size) were analysed during the implementation of the international project of General Fisheries Commission of Mediterranean (GFCM) *Select Activity Discard Monitoring Program*. Commercial fishery was carried out at a distance of 1.5-10 miles from the shore at depths between 10 to 40 m. Underwater observations were carried out using diving equipment. The scheme of the work area is shown in Fig. 1.

To compare the species groups of the studied areas of NWBS, the Czekanowski-Sorensen Index was used (Sørensen, 1948):

$$ICS = \frac{2c}{a+b},$$

where a and b are the numbers of species in water areas under comparison, and c is the number of common species.

The diversity was evaluated using the Simpson's Complement Index, i.e., 1-D, where

$$D = \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N-1)},$$

Here S is the number of species, N the total number of fishes caught and n is the number of fishes of each species. This index is less sensitive to sample size than other biodiversity indices (Smith & Wilson 1996, Lande et al. 2000). To assess species evenness, we used the Simpson's Evenness Index:

$$E_{1/D} = \frac{1/D}{S},$$

which is independent of species richness (Smith & Wilson 1996).

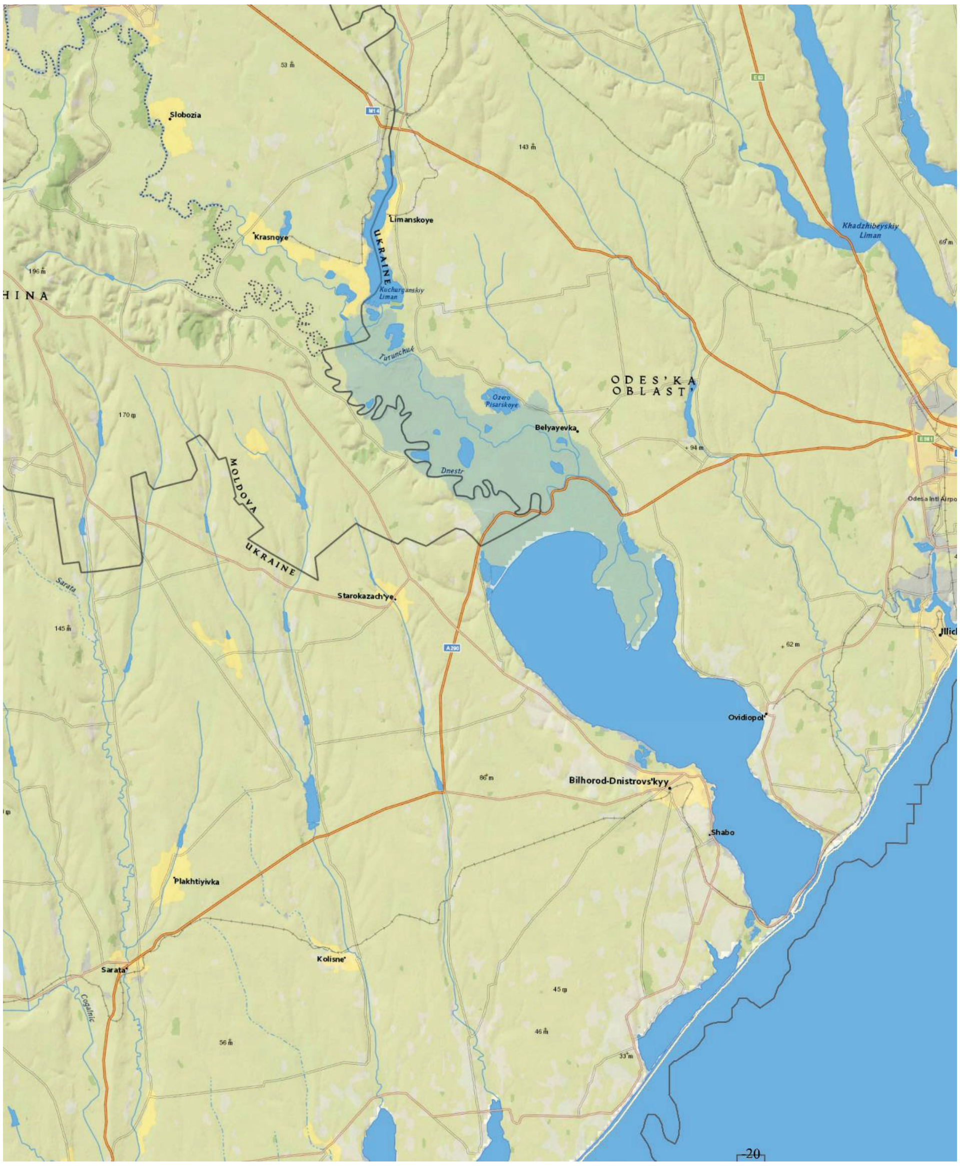

Fig. 1. Scheme of ichthyological research areas

Systematics of fish followed Nelson et al. (2016), including for the family Cyprinidae. The alternative classification of the Cyprinidae (Tan & Arnbruster 2018) was not used. Fish taxa, zoogeographical origin and their scientific names are given after Froese et al. (2021).

Results

In total, we identified 110 freshwater, anadromous, brackish-water and marine fish species belonging to 27 orders, 41 families and 92 genera (Table 1). The fish fauna of the Lower Dniester included 64 species of 11 orders, 16 families and 53 genera; the fish fauna of the Dniester Estuary was poorer, i.e. 59 species of 16 orders, 21 families and 50 genera. The fish community in the adjacent NWBS water area was found to consist of 64 species of 25 orders, 35 families and 56 genera.

The main component of the fish fauna in the Lower Dniester consisted of species of Ponto-Caspian (34.3%), European freshwater (17.2%) and Euro-Siberian zoogeographical origin (15.6%). Ponto-Caspian species dominated in the Dniester Estuary (39.0%) and in the adjacent NWBS water area (28.1%) in terms of the total number of species. In addition, there were numerous species of Boreal-Atlantic origin in the adjacent NWBS, i.e. 21.8%. Most species of the Lower Dniester and the Dniester Estuary were of the freshwater group (70.3% and 42.4%, respectively). The second largest group in the Dniester Estuary was represented by brackish-water species (33.9%). The adjacent NWBS was dominated by marine and brackish-water species (57.8 and 23.4%, respectively).

Table 1. Ichthyofauna of the Lower Dniester (DN, 2004-2020), Dniester Estuary (DNE, 2004-2020) and adjacent NWBS area (aNWBS, 2017-2020): ecological, faunal and zoogeographical characteristics.
Legend: "-" – the species did not occur, "+" – rare species, "++" – common and abundant species, ?+ – the species is marked according to oral reports; 1 – marine, 2 – brackish, 3 – anadromous; 4 – freshwater; O – settled, M – migrating; P – pelagic, B – bottom, D – demersal; I – carnivores, II – benthophages, III – planktophages, IV – detritophages, V – phytophages; Pf – pelagophiles, Ff – phytophiles, Lf – lithophiles, Of – ostracophiles, Psf – psammophiles, LPsf – lithopsammophiles; Dbp – deposits eggs on the brood pouch, Ov – ovoviviparous, Bp – build a nest and protect the eggs. Zoogeographical origin: SBP – Subpolar, BAT – Boreal-Atlantic, PC – Ponto-Caspian, EA – East Asian, EU – European freshwater, BL – Balkan, CR – Carpathian, ES – Euro-Siberian, ATM – Atlantic-Mediterranean, MD – Mediterranean, CB – Circumboreal, CT – Circumtropical, NAR – Non-Arctic, PAR – Palaearctic, CS – Cosmopolitan, AT – Atlantic.

Taxonomic composition of fish	Ecological and faunal characteristics	Zoogeographical origin	DN	DNE	aNWBS
SQUALIFORMES					
Squalidae					
1. *Squalus acanthias* Linnaeus, 1758	1; M; P; I; Ov	SBP	-	-	++
RAJIFORMES					
Rajidae					
2. *Raja clavata* Linnaeus, 1758	1; M; B; I+II; LPsf	BAT	-	-	+
MYLIOBATIFORMES					
Dasyatidae					
3. *Dasyatis pastinaca* (Linnaeus, 1758)	1; M; B; I+II; Ov	BAT	-	+	++
ACIPENSERIFORMES					
Acipenseridae					
4. *Acipenser stellatus* Pallas, 1771	3; M; D; I+II; Lf	PC	+	+	+
5. *Acipenser ruthenus* Linnaeus, 1758	4; O; D; II+I; Lf	PC	+	+	+
6. *Acipenser gueldenstaedtii* Brandt et Ratzeburg, 1833	3; M; D; II+I; Lf	PC	-	-	+
7. *Huso huso* (Linnaeus, 1758)	3; M; D; I; Lf	PC	+	+	+
ANGUILLIFORMES					
Anguillidae					
8 *Anguilla anguilla* (Linnaeus, 1758)	4; M; D; I+II; Pf	BAT	+	+	+
CLUPEIFORMES					
Engraulidae					
9. *Engraulis encrasicolus* (Linnaeus, 1758)	1; M; P; III; Pf	BAT	-	++	++
Clupeidae					
10. *Alosa immaculata* Bennett, 1835	2; M; P; I+III; Pf	PC	++	++	++
11. *Alosa maeotica* (Grimm, 1901)	2; M; P; I+III; Pf	PC	++	++	-
12. *Alosa tanaica* (Grimm, 1901)	2; M; P; III; Pf	PC	-	+	-
13. *Clupeonella cultriventris* (Nordmann, 1840)	2; M; P; III; Pf	PC	++	++	++
14. *Sprattus sprattus* (Linnaeus, 1758)	1; M; P; III; Pf	BAT	-	-	++
CYPRINIFORMES					
Cyprinidae					
15. *Rhodeus amarus* (Bloch, 1782)	4; O; D; II+III+V; Of	EU	++	++	-
16. *Carassius carassius* (Linnaeus, 1758)	4; O; D; II-V; Ff	PAR	+	-	-
17. *Carassius gibelio* (Bloch, 1782)	4; O; D; II-V; Ff	EA	++	++	+
18. *Cyprinus carpio* (Linnaeus, 1758)	4; M; D; II-V; Ff	PC	++	++	+
19. *Barbus barbus* (Linnaeus, 1758)	4; O; B; II; Lf+Psf	EU	+	-	-
20. *Ctenopharyngodon idella* (Valenciennes, 1844)	4; O; P+D; V; Ff	EA	++	++	-
21. *Mylopharyngodon piceus* (Richardson, 1846)	4; O; P+D; II; Pf	EA	+	-	-
22. *Tinca tinca* (Linnaeus, 1758)	4; O; D; II-V; Ff	PAR	+	-	-
23. *Gobio sarmaticus* Berg, 1949	4; O; B+D; II; Psf	PAR	+	-	-
24. *Pseudorasbora parva* (Temminck & Schlegel, 1846)	4; O; B; II+III; Bp	EA	++	++	+

Taxonomic composition of fish	Ecological and faunal characteristics	Zoogeographical origin	DN	DNE	aNWBS
25. *Romanogobio kesslerii* (Dybowski, 1862)	4; O; B; II; Lf+Psf	ES	+	-	-
26. *Abramis brama* (Linnaeus, 1758)	4; O; D; II; Ff	EU	++	++	-
27. *Ballerus sapa* (Pallas, 1814)	4; O; D; II; Ff	PC	+	-	-
28. *Blicca bjoerkna* (Linnaeus, 1758)	4; O; D; II; Ff	EU	++	++	-
29. *Alburnus alburnus* (Linnaeus, 1758)	4; O; P; III; Ff	EU	++	++	-
30. *Leucaspius delineatus* (Heckel, 1843)	4; O; P; III; Ff	EU	+	-	-
31. *Hypophthalmichthys molitrix* (Valenciennes, 1846)	4; M; P; III; Pf	EA	++	++	-
32. *Hypophthalmichthys nobilis* (Richardson, 1845)	4; M; P+D; III; Pf	EA	++	++	-
33. *Aspius aspius* (Linnaeus, 1758)	4; O; D+P; I; Ff	ES	++	++	-
34. *Chondrostoma nasus* (Linnaeus, 1758)	4; O; D+P; II-IV; Lf	EU	+	-	-
35. *Leuciscus leuciscus* (Linnaeus, 1758)	4; O; D+P; II; Ff+Lf	EU	+	-	-
36. *Leuciscus idus* (Linnaeus, 1758)	4; O; D+P; II; Ff+Lf	ES	+	-	-
37. *Petroleuciscus borysthenicus* (Kessler, 1859)	4; O; D+P;II; Ff	PC	+	-	-
38. *Rutilus frisii* (Nordmann, 1840)	4+2; O+M; D+P; II, Lf	PC	?+	?+	-
39. *Rutilus rutilus* (Linnaeus, 1758)	4; O; D; II; Ff	ES	++	++	+
40. *Rutilus heckelii* (Nordmann, 1840)	2; M; D; II; Ff	PC	++	++	-
41. *Scardinius erythrophthalmus* (Linnaeus, 1758)	4; O; D+P; II-V; Ff	EU	++	++	-
42. *Squalius cephalus* (Linnaeus, 1758)	4; O; P+D; I+II; Lf	EU	+	-	-
43. *Vimba vimba* (Linnaeus, 1758)	4+2; O+M; D+P; II+III; Lf	ES	+	-	-
44. *Pelecus cultratus* (Linnaeus, 1758)	4; O; D+P; III; Pf	ES	+	+	-
Cobitidae					
45. *Cobitis tanaitica* Băcescu & Mayer, 1969	4; O; B; II; Ff	ES	++	++	-
46. *Misgurnus fossilis* (Linnaeus, 1758)	4; O; B; II; Ff	ES	++	++	-
47. *Sabanejewia balcanica* (Karaman, 1922)	4; O; B; II; Lf	BL	+	-	-
SILURIFORMES					
Siluridae					
48. *Silurus glanis* (Linnaeus, 1758)	4; O; B; I; Bp	ES	++	++	-
Ictaluridae					
49. *Ictalurus punctatus* (Rafinesque, 1818)	4; O; P+D; I-V; Ff	NAR	?+	-	-
SALMONIFORMES					
Salmonidae					
50. *Salmo labrax* Pallas, 1814	3; M; P; I+II; Lf	PC	-	?+	+
ESOCIFORMES					
Esocidae					
51. *Esox lucius* Linnaeus, 1758	4; O; D+P; I; Ff	PAR	++	++	-
Umbridae					
52. *Umbra krameri* Walbaum, 1792	4; O; D+P; III+II; Bp	PC	+	-	-
GADIFORMES					
Gadidae					
53. *Merlangius merlangus* (Linnaeus, 1758)	1; M; D; I; Pf	BAT	-	+	++
54. *Gaidropsarus mediterraneus* (Linnaeus, 1758)	1; O; B; I+II; Pf	ATM	-	-	+
OPHIDIIFORMES					
Ophidiidae					
55. *Ophidion rochei* Müller, 1845	1; O; B; II+I; Pf	MD	-	-	++
GOBIIFORMES					
Gobiidae					
56. *Aphia minuta* (Risso, 1810)	1; M; P; III; Ff	BAT	-	-	++

Taxonomic composition of fish	**Ecological and faunal characteristics**	**Zoogeographical origin**	**DN**	**DNE**	**aNWBS**
57. *Benthophilus nudus* (Berg, 1898)	2; O; B; II; Bp	PC	++	++	+
58. *Benthophiloides brauneri* BelingetIljin, 1927	2; O; B; II; LPsf	PC	-	+	-
59. *Gobius niger* Linnaeus, 1758	1; O; B; II; Bp	BAT	-	++	++
60. *Knipowitschia longecaudata* (Kessler, 1877)	2; O; D; II; Bp	MD	-	++	-
61. *Mesogobius batrachocephalus* (Pallas, 1814)	2; O; B; I+II; Bp	PC	-	+	++
62. *Neogobius fluviatilis* (Pallas, 1814)	2; O; B; II; Bp	PC	++	++	++
63. *Neogobius melanostomus* (Pallas, 1814)	2; O; B; II; Bp	PC	++	++	++
64. *Ponticola eurycephalus* (Kessler, 1874)	2; O; B; II; Bp	PC	+	-	-
65. *Ponticola ratan* (Nordman,1840)	2; O; B; II; Bp	PC	-	-	+
66. *Ponticola kessleri* (Günther, 1861)	2; O; B; II; Bp	PC	++	++	-
67. *Ponticola syrman* (Nordmann, 1840)	2; O; B; II; Bp	PC	+	+	-
68. *Babka gymnotrachelus* (Kessler, 1857)	2; O; B; II; Bp	PC	++	++	+
69. *Pomatoschistus marmoratus* (Risso, 1810)	1; O; B; II; Bp	MD	-	-	++
70. *Proterorhinus semilunaris* (Heckel, 1837)	2; O; B; II; Bp	PC	++	++	-
71. *Zosterisessor ophiocephalus* (Pallas, 1814)	1; O; B; I+II; Bp	MD	-	+	+
MUGILIFORMES					
Mugilidae					
72. *Mugil cephalus* Linnaeus, 1758	1; M; D; IV; Pf	CT	-	+	+
73. *Planiliza haematocheila* (Temminck & Schlegel, 1845)	2; M; P+D; IV; Pf	EA	-	++	++
74. *Chelon auratus* (Risso, 1810)	1; M; D+P; IV Pf	ATM	-	++	++
75. *Chelon saliens* (Risso, 1810)	1; M; P; IV; Pf	MD	-	-	+
BLENNIIFORMES					
Blenniidae					
76. *Aidablennius sphynx* (Valenciennes, 1836)	1; O; B; II+V; Bp	MD	-	-	+
77. *Parablennius tentacularis* (Brünnich, 1768)	1; O; B; II; Bp	ATM	-	-	+
78. *Parablennius zvonimiri* (Kolombatovic, 1892)	1; O; B; II+V; Bp	MD	-	-	+
GOBIESOCIFORMES					
Gobiesocidae					
79. *Diplecogaster bimaculata* (Bonnaterre, 1788)	1; O; B; II; Bp	ATM	-	-	+
ATHERINIFORMES					
Atherinidae					
80. *Atherina boyeri* Risso, 1810	1; M; P; III; Ff	ATM	++	++	++
BELONIFORMES					
Belonidae					
81. *Belone euxini* Günther,1866	2; M; P; I; Ff	PC	-	-	++
CARANGIFORMES					
Carangidae					
82. *Trachurus mediterraneus* (Steindachner, 1868)	1; M; P; I; Pf	ATM	-	-	++
PLEURONECTIFORMES					
Scophthalmidae					
83. *Scophthalmus maeoticus* (Pallas, 1814)	1; O; B; I; Pf	PC	-	?+	++
Pleuronectidae					
84. *Platichthys flesus* (Pallas, 1814)	2; O; B; II; Pf	BAT	-	++	++
Soleidae					
85. *Pegusa lascaris* (Risso, 1810)	1; O; B; II; Pf	AT	-	-	++
SYNGNATHIFORMES					

Taxonomic composition of fish	Ecological and faunal characteristics	Zoogeographical origin	DN	DNE	aNWBS
Syngnathidae					
86. *Nerophis ophidion* (Linnaeus, 1758)	1; O; D; III+II; Dbp	BAT	-	-	+
87. *Syngnathus abaster* Risso, 1827	2; O; D; III+II; Dbp	ATM	++	++	++
88. *Syngnathus typhle* Linnaeus, 1758	1; O; D; III+II; Dbp	BAT	+	++	+
89. *Syngnathus variegatus* Pallas, 1814	2; O; D; III+II; Dbp	PC	-	-	+
90. *Hippocampus guttulatus* Cuvier, 1829	1; O; D; III+II; Dbp	BAT	-	-	++
CALLIONYMIFORMES					
Callionymidae					
91. *Callionymus risso* Lesueur, 1814	1; O; B; III; Pf	MD	-	-	++
SCOMBRIFORMES					
Scombridae					
92. *Sarda sarda* (Bloch, 1793)	1; M; P; I; Pf	AT	-	-	+
TRACHINIFORMES					
Ammodytidae					
93. *Gymnammodytes cicerellus* (Rafinesque, 1810)	1; O; D; III; Psf	ATM	-	-	++
Trachinidae					
94. *Trachinus draco* Linnaeus, 1758	1; O; B; II+I; Pf	BAT	-	-	+
Uranoscopidae					
95. *Uranoscopus scaber* Linnaeus, 1758	1; O; B; I+II; Pf	ATM	-	-	+
LABRIFORMES					
Labridae					
96. *Symphodus cinereus* (Bonnaterre, 1788)	1; O; D; II; Bp	MD	-	-	++
97. *Symphodus ocellatus* (Forskal, 1775)	1; O; D; II; Bp	MD	-	-	+
PERCIFORMES					
Mullidae					
98. *Mullus barbatus* Linnaeus, 1758	1; O; B; II; Pf	BAT	-	-	++
Centrarchidae					
99. *Lepomis gibbosus* (Linnaeus, 1758)	4; O; D; II; Bp	NAR	++	++	+
Percidae					
100. *Gymnocephalus cernuus* (Linnaeus, 1758)	4; O; B; II; Ff	PAR	++	-	-
101. *Perca fluviatilis* Linnaeus, 1758	4; M; D; I; Ff	PAR	++	++	-
102. *Percarina demidoffii* Nordmann, 1840	4; O; D+P; II+III; Lf	PC	+	+	-
103. *Sander lucioperca* (Linnaeus, 1758)	4; M; D; I; Bp	ES	++	++	+
104. *Zingel zingel* (Linnaeus, 1766)	4; O; B; I+II; Lf	CR	+	-	-
Pomatomidae					
105. *Pomatomus saltatrix* (Linnaeus, 1766)	1; M; P; I+II; Pf	CS	-	+	++
SCORPENIFORMES					
Scorpaenidae					
106. *Scorpaena porcus* Linnaeus, 1758	1; O; B; I+II; (Lf) Pf	ATM	-	-	++
Triglidae					
107. *Chelidonichthys lucernus* (Linnaeus, 1758)	1; O; B; II+I; Pf	ATM	-	-	+
Gasterosteidae					
108. *Gasterosteus aculeatus* Linnaeus, 1758	2; M; D; II; Bp	CB	++	++	+
109. *Pungitius platygaster* (Kessler, 1859)	2; O; D; II; Bp	PC	++	++	+
Cottidae					
110. *Cottus gobio* Linnaeus, 1758	4; O; B; II; Bp	EU	+	-	-

Fish of all three studied areas were mostly non-migrant (Lower Dniester – 78.1%, Dniester Estuary – 61.0%, adjacent NWBS – 59.4%) as well as of benthic and bentho-pelagic cohorts (Lower Dniester – 84.4%, Dniester Estuary – 79.7%, adjacent NWBS – 78.1%).

In terms of the their reproductive pattern, the area under study was dominated by pelagophiles (Lower Dniester – 12.5%, Dniester Estuary – 27.1%, adjacent NWBS – 37.5%), phytophiles (Lower Dniester – 34.4%, Dniester Estuary – 25.4%, adjacent NWBS – 9.4%) and species that build "nests" and protect eggs (Lower Dniester – 25.0%, Dniester Estuary – 28.8%, adjacent NWBS – 31.2%). In terms of trophic status, the fish fauna was dominated by benthophages (Lower Dniester – 42.2%, Dniester Estuary – 32.2%, adjacent NWBS – 59.421.9%) and species with mixed feeding patterns (Lower Dniester – 32.8%, Dniester Estuary – 28.8%, adjacent NWBS – 42.2%). Other groups of fish (predatory, planktophages, detritophages, phytophages, etc.) were represented by single species.

According to catchment analysis, fish fauna of the Lower Dniester and the Dniester Estuary were of high similarity: ICS at species level was 69.9%. The degree of similarity of the species composition of the Dniester Estuary and the adjacent NWBS was lower, i.e. 55.3%. A much lower similarity (32.8%) was found between the fish fauna of the Lower Dniester and the NWBS neighbouring the Dniester Estuary.

The species diversity was found to be high (0.61) in Dniester Estuary, with lower values for Lower Dniester (0.48) and the sea area adjacent to the estuary (0.39). The same pattern was observed for the species evenness: 0.41 for Dniester Estuary, 0.29 for Lower Dniester and 0.24 for the adjacent sea area.

Discussion

Significant transformations of the ecosystems of the Dniester basin and adjacent areas of the Black Sea were associated with several important events. These were the elimination of the Ochakiv duct between Dniester Estuary and the sea (1926), the construction of the Dubossary Reservoir in Moldova (1954-1956), the laying of a navigable canal between the Black Sea to the Dniester Estuary (1970) and the filling of the Dniester reservoirs (1981-1987) (see Greben et al. 2019, Sirenko et al. 1992, Starushenko & Bushuev 2001). During recent decades, significant impacts associated with climate change on the hydrological and biological characteristics of the river–estuary–sea system have been observed. These are, primarily, the decrease in river runoff, the reduction of floodplain meadows and changes in the hydrological regime of the Dniester Estuary (Greben et al. 2019, Snigirov et al. 2019).

According to long-term datasets, the water runoff from the Dniester River has fluctuated interannually, with an overall declining trend (Greben et al. 2019, Sirenko et al. 1992, Starushenko & Bushuev 2001). The average annual runoff from the river in the period 1946-1980 was 10.0 km^3 (Greben et al. 2019, Sirenko et al. 1992, Starushenko & Bushuev 2001), in 1981-2019 – 8.6 km^3 (Greben et al. 2019) and in the driest period of 2011-2019 only 6.7 km^3 (Greben et al. 2019). Under these conditions, the contribution of freshwater runoff to the adjacent NWBS has substantially decreased. On the other hand, the volume of seawater penetrating into the Dniester Estuary has increased. Thus, the annual volume of seawater intrusion in recent decades has reached 4-4.5 km^3, compared to 3.7 km^3 as observed several decades earlier (Sirenko et al. 1992). This resulted in a substantial decrease of the water area within the hydrofront (the line separating freshwater ejected by the estuary from the seawater). After the Dniester runoff was placed under regulation by reservoirs, the area had declined from 30 km along the seashore and over 20 km seawards (Chepurnov 1962a) to 18.5-22.0 km along the seashore and 3.7-5.6 km seawards (Bolshakov 1970, Shuisky 2013). Compared with previous studies, the importance of limnophiles and rheo-limnophiles in the ecological-group composition of the fish fauna of the Lower Dniester has increased, which is associated with the decrease of the flow velocity and the increase of the turbidity of the river water. However, the number of rheophilic, lithophilic and psammophilic species has decreased (Sirenko et al. 1992, Starushenko & Bushuev 2001, Snigirov 2013). Thus, native species as *Acipenser nudiventris*, *Sander volgensis*, *Zingel streber*, *Barbatula barbatula*, *Abramis ballerus* and *Alburnus sarmaticus* were lacking in catches and considered extinct.

Nevertheless, from the middle of the 20th century, the richness of fish species in the Dniester River and Dniester Estuary increased. This was due to the arrival of new alien species such as *Carassius gibelio, Hypophthalmichthys molitrix, H. nobilis, Ctenopharyngodon idella, Pseudorasbora parva, Planiliza haematocheilus, Lepomis gibbosus* and several others. As a result, the total number of species of the fish fauna of the Lower Dniester and the Dniester Estuary has remained relatively constant over recent decades (Sirenko et al. 1992, Starushenko & Bushuev 2001, Snigirov 2013).

Before the construction and filling of the Dniester reservoirs, the fish fauna of the adjacent NWBS included 94 species – 31 freshwater, 18 brackish and 45 marine species (Chepurnov 1962a, 1962b). However, during recent decades, the species number in this water area declined 1.5 times, i.e., to 64 species representing 25 orders, 35 families and 56 genera (Snigirov 2020, Snigirov et al. 2020) whereas 35 previously recorded species were not registered. Starting from the late 80's, marine species such as *Thunnus thynnus*, *Scomber scombrus* and *Trachurus trachurus* vanished completely from the NWBS. Therefore, their occurrence is now unlikely near the mouth of Dniester Estuary. Observations of *Callionymus pusillus* in the Ukrainian part of the Black Sea are rare and, largely, anecdotal. The previously detected *Symphodus roissali* has been observed in the Gulf of Odesa (Snigirov et al. 2020) and potentially can be found in the NWBS area adjacent to the Dniester Estuary. The same is valid about such marine species as *Syngnathus tenuirostris*, *Diplodus annularis*, *Spicara flexuosa* and *Parablennius sanguinolentus* observed in the Gulf of Odesa and in the coastal waters of Snake (Zmiinyi) Island (Snigirov et al. 2020). The brackish-water species *Alosa maeotica* and *A. tanaica* have been recorded in the Dniester Estuary; apparently, they can be expected in the adjacent parts of the NWBS but not recorded there. Other brackish species have been recorded from the estuary and thus can be expected in the adjacent sea area; these are *Rutilus heckelii*, *Ponticola kessleri*, *P. eurycephalus*, *Proterorhinus marmoratus* and *Knipowitschia caucasica*.

Conversely, the artificial regulation of the Dniester runoff and the associated hydrological transformations of the Dniester river basin made freshwater species much less common in the NWBS area adjacent to the mouth of the Dniester Estuary. Several of them such as *Carassius carassius*, *Ballerus sapa*, *Alburnus sarmaticus*, *Petroleuciscus borysthenicus*, *Leuciscus idus*, *Rutilus frisii*, *Vimba vimba*, *Pelecus cultratus* and *Percarina demidoffii* have become rare in the Lower Dniester. Hence, the probability of their presence in the nearshore sea area is very low. More numerous representatives of the freshwater ichthyofauna such as *Abramis brama*, *Blicca bjoerkna*, *Alburnus alburnus*, *Aspius aspius*, *Scardinius erythrophthalmus*, *Cobitis tanaitica*, *Misgurnus fossilis*, *Silurus glanis*, *Gymnocephalus cernuus* and *Perca fluviatilis* are highly likely to be found in the adjacent NWBS, especially during or immediately after spring floods.

There are several species native to the Lower Dniester, which have never been observed in the neighbouring sea area: *Acipenser ruthenus* and the relatively recent arrivals *Pseudorasbora parva* and *Planiliza haematocheila*. However, marine species with no industrial significance such as *Diplecogaster bimaculatus* and *Parablennius zvonimiri* were also recorded. These species are widespread in the Black Sea, including NWBS, thus their presence in seawaters neighbouring the Dniester Estuary does not mean a spread of their distribution.

About one third of fish species detected in all three studied water areas have a special conservation status. The list of the Red Book of Ukraine (Akimov 2009) includes 11 (17.2%) out of 64 species of fish in the Lower Dniester, 7 (8%) out of 59 species of the Dniester Estuary and 11 (17.2%) out of 64 species of the adjacent NWBS. In the lists of the Red Data Book of the Black Sea, there are 8 species of fish (12.5% of all species) from the Lower Dniester, 11 (18.6%) from the Dniester Estuary and 21 species (32.8%) from the adjacent NWBS. Seven species of the Lower Dniester and the Dniester Estuary as well as 10 species of the adjacent NWBS are protected under the Red List of the International Union for Conservation of Nature. Therefore, specific attention should be paid to this area in the context of protecting rare fish species.

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