BIODIVERSITY OF ICHTHYOFAUNA IN THE DNIESTER DELTA

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The List of current Lower Dniester fishes comprising 65 fish species belonging to 12 orders, 17 families and 52 genera is presented in the paper in a comparative approach. Analysis of the Lower Dniester and the Dniester Liman ichthyofauna structural characteristics has been carried out under conditions of regulated discharge, increasing pollution and spawning grounds degradation. Decrease in fish species composition has been shown, as well as the disappearance of some native reophilic and lithophilous fish species as the result of the Dniester River discharge regulation. Data about rare species found in the Dniester River and the Dniester Liman are presented, including *Benthophiloides brauneri* Beling et Iljin, 1927, which has not been recorded in the Lower Dniester before. The dwindling of catches of the main commercial fish species is also shown.

1. INTRODUCTION

According to current knowledge, the Dniester River and the Dniester Liman are among the most studied water-bodies of Ukraine. The first brief information about the Dniester water-bodies have been presented in papers by D. Kantemir, A.D. Nordman, I.M. Wiedhalm, N.Ya. Danilevskiy (Vinogradov, 1958). More significant information on the Dniester ichthyofauna is contained in the works of K.F. Kessler, was the first to present the fauna list of the Dniester fish, underlining the reophilic character of the river ichthyofauna (Kessler, 1874). It was K.F. Kessler, who divided his Dniester segment studies into parts comparing the ichthyological composition of catches – medium part from Galicia border to Dubossary town and the lower part (from Dubossary to the river mouth). His concepts are valid to this day (Kessler, 1874). The ichthyofauna of the Dniester River was studied and the Dniester Liman fisheries described at the beginning of the 20th century by prominent zoologists and hydrobiologists S.A. Zernov, F.F. Eherman, A.K. Makarov, E.K. Suvorov, A.A. Brauner (Brauner, 1887; Vinogradov, 1958). The full list and important information on the Dniester ichthyofauna were presented by Academician L.S. Berg in the 1920 (Berg, 1949). Systematic comprehensive fish studies in the Dniester were continued in the post-war period by ichthyologists V.L. Grimalskiy, M.S. Burnashev, B.C. Chepurnov, V.N. Dolgiy and many others (Burnashev et al., 1954; Vinogradov, 1958; Yaroshenko, 1957). Important data were reported in papers by I.I. Puzanov, A.R. Prendel, F.S. Zambriborsh (Vinogradov, 1958; Zambriborsch, 1953). At the end of the last century faunisitc lists of fish are found in papers by the hydrobiologists of Kiev gathered in the monograph edited by L.A. Sirenko and N.B. Evtushenko (Sirenko et al., 1992); in publications of ichthyologists V.A. Tkachenko and N.I. Goncharenko (Tkachenko et al., 1998). More recent data on ichthyofauna and fish-husbandry of the Dniester were generalized in the works of E.D. Vasileva (Vasil'eva, 2003), L.I. Starushenko and S.G. Bushuev (Starushenko et al., 2001; Bushuev et al., 2013), I.D. Trombitskiy, V.V. Lobchenko, T.D. Sharpanovskaya (Lobchenko et al., 2001) and many other ichthyologists, hydrobiologists and ecologists, not only Ukrainian or Moldavian, but also Russian.

As can be seen, within a period of 150 years a number of comprehensive surveys were carried out and a significant volume of factual material collected, which enabled researchers to receive

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principally new knowledge on the structural and functional characteristics of the Dniester ichthyofauna.

According to the results of those numerous studies, the decrease in the number of dominant ichthyofauna species, depauperation of fish fauna and changes of ichthyocoenoses are the immediate consequences of a wide range of anthropogenic factors that impact the Dniester River and the Dniester Liman ichthyofauna (Bushuev et al., 2013; Sirenko et al., 1992; Starushenko et al., 2001). The most vivid changes in fauna and biocoenoses were caused by river flow regulation – hydro-engineering transformation of the ecosystem.

After the construction of the Dubăsari dam (1954) and Novodniester Hydroelectric Station (1981) the Dniester River runoff was significantly decreased. In 1965–1971 it made at average of 12 km^3, in 1982–1987 – 10.4–6.5 km^3 (Sirenko et al., 1992). Nowadays, it does not exceed 7.0 km^3. On the other hand, the construction of the navigation channel to Belgorod-Dniester port via Tsaregradskaya Arm (1970) led to increased turnover between the liman and the sea. The annual volume of marine (salty) water, entering the liman, increased from 3.7 km^3 to 4–4.5 km^3 (Sirenko et al., 1992). Decreasing river flow, intensive development of the floodplain, above all bonding of meadows and floodplains for agricultural lands, salinization of the southern part of the liman, have led to the degradation of more than 40 thousand hectares of wetlands, including spawning grounds of phytophilous species of fish (Bushuev et al., 2013).

As a result of the intensification of fishing and frequent cases of poaching the volume of fish catches in the Dniester River and the Dniester Liman was reduced twofold or threefold compared to the 1990s. The number of commercial fish species declined from 21 to 16 (Starushenko et al., 2001; Bushuev et al., 2013). General and local water pollution, anthropogenic eutrophication, accidental or purposeful introduction of aggressive non-indigenous species influenced negatively the ichthyofauna (Bushuev et al., 2013; Sirenko et al., 1992; Starushenko et al., 2001). Changes of structure of the Dniester River and the Dniester Liman fish coenoses, as well as decrease in fish productivity of those watercourses have caused a stringent need to study the ichthyofauna current state comprehensively. The aim of this study is to evaluate the current state of the fish fauna of the Lower Dniester basin reservoirs, the species composition and abundance of the main representatives of the fish fauna, including endangered species.

2. MATERIALS AND METHODS

The results of the author's studies carried out in the Dniester Delta with financial support from the EU TACIS Project «Technical Assistance for the Lower Dniester River Basin Management Planning» in 2006–2007, the data received in the studies of the Dniester River ichthyofauna in the framework of the Research Project of the Ministry of Education and Science of Ukraine (2006–2013), as well as with support from the OSCE / UNECE / UNDP Project «Trans-boundary Cooperation and Sustainable Management of the Dniester River: Phase III – Implementation of Action Programme» («Dniester – III») and the ENVIROGRIDS Project of FP7 programme (2009–2012) were used in the paper. Besides, fishery statistics (Bushuev et al., 2013; Starushenko et al., 2001). and the data collected during analyses of commercial catches of the «Kalkan» private enterprise, as well as anglers' catches in 2007–2013 were used in the work. During the surveys fish was caught using small mesh size fingering trawl (30.0 m long, 1.5 m high, mesh 6–8 mm); fyke-nets (mesh 6–8 mm); research multi-mesh gillnets; gillnets (mesh size 13, 30 and 65–70 mm, length 30, 100 and 750 m, respectively); small mesh size fingering trawl (10 m long, 1.2 m high, mesh size 6.0–8.0 mm), dredge (width 1.1 m, height 0.5 m) and throw net according to standard methodologies (Romanenko et al., 2006; Pryahin et al., 2008). The scheme of research catching is attached (Fig. 1). Altogether 900 different catches have been analysed.

Determination of fish has been done in the field using Keys (Berg, 1949; Kottelat et al., 2007; Movchan et al., 1980–1983; Zambriborsch, 1968). Taxonomy of fishes is presented in accordance with checklist (Kottelat et al., 2007; Bogutskaya et al., 2004). Environmental characteristics of species are presented according to (Movchan et al., 1980–1983). The appurtenance to faunistic complexes is shown in line with (Nikolskiy, 1980).

The following categories have been chosen for quantitative assessment of the values of fish occurrence: rare species (separate specimens of the fish were observed during the entire period of studies), common and dominant species (more than 100 specimens for a year of studies).

To assess the level of species composition similarity between the Middle Dniester and the Lower Dniester in successive associated periods from 1930 to 2013, Sorensen-Chekanovskiy Index *(I_{CS})* and Shimkevich-Simpson Index *($I_{Sz\text{-}S}$)* were used (Pesenko, 1982). Alterations of species composition were assessed from relative occurrence, appurtenance of fish to different ecological groups: by habitats, breeding. Index of changes (Titlyanova et al., 1993) was calculated as ratio of disappeared and emerged species at present time to the number of species found before hydro-engineering transformation of the Dniester (the fish species list was taken from the paper by L.S. Berg (Berg, 1949). Dynamics of commercial catches was presented according to (Starushenko et al., 2001; Bushuev et al., 2013).

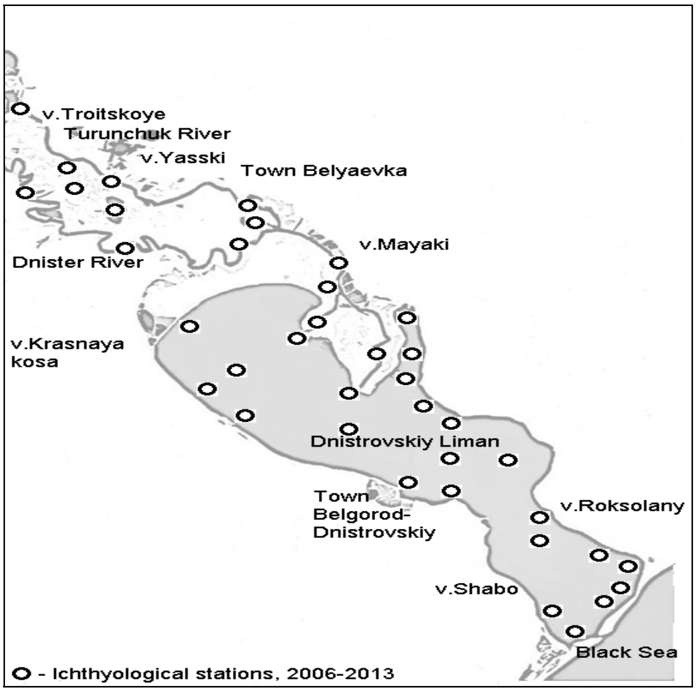

Fig. 1 – Scheme of Ichthyological Stations in the Lower Dniester, 2006–2013.

3. RESULTS AND DISCUSSION

3.1. Dynamics of the Dniester Ichthyofauna Structural Characteristics

Based on generalising the results received by the author from analyses of research catches in the Lower Dniester in 2006–2013, 65 fish species belonging to 12 orders, 17 families and 52 genera were revealed (Table 1).

Table 1

Taxonomic Composition of the Dniester River Ichthyofauna and Occurrence of Species.

Taxa	**Data According to Berg, 1949**	**Data According to Zambriborsch, 1953**	**Data According to Sirenko et al., 1992**	**Data of 2006-2013***	**Protection Status of Species**
1	**3**	**4**	**5**	**6**	**7**
Petromyzontiformes					
Petromyzontidae					
Eudontomyzon mariae (Berg, 1931)	+	-	+	-	RBU, IUCN
Acipenseriformes					
Acipenseridae					
Acipenser gueldenstaedtii Brandt & Ratzeburg, 1833	+	+	+	-	RBU, IUCN, EL, BC
Acipenser nudiventris Lovetsky, 1828	r	r	-	-	RBU, IUCN, EL
Acipenser ruthenus Linnaeus, 1758	+	+	+	-	RBU, IUCN, EL, BC
Acipenser stellatus Pallas, 1771	+	+	+	r	RBU, IUCN, EL, BC
Huso huso (Linnaeus, 1758)	+	+	+	r	RBU, IUCN, EL, BC
Atheriniformes					
Atherinidae					
Atherina boyeri Risso, 1810	+	+	+	+	
Beloniformes					
Belonidae					
Belone belone (Linnaeus, 1761)	-	+	-	-	
Gasterosteiformes					
Gasterosteidae					
Gasterosteus aculeatus Linnaeus, 1758	+	+	+	+	
Pungitius platygaster (Kessler, 1859)	+	+	+	+	
Mugiliformes					
Mugilidae					
Liza aurata (Risso, 1810)	-	+	-	+	
Liza saliens (Risso, 1810)	+	+	-	-	
Liza haematocheila (Temminck & Schlegel, 1845)	-	-	-	i, +	
Mugil cephalus Linnaeus, 1758	+	+	-	-	
Perciformes					
Centrarchidae					
Lepomis gibbosus (Linnaeus, 1758)	-	r	+	+	
Gobiidae					
Benthophiloides brauneri Beling et Iljin, 1927	-	-	-	r	RBU, IUCN
Benthophilus nudus (Berg, 1898)	+	+	-	+	
Gobius niger Linnaeus, 1758	-	-	-	r	
Gobius ophiocephalus Pallas, 1814	r	+	-	-	
Knipowitschia caucasica (Berg, 1916)	-	+	-	-	
Knipowitschia longecaudata (Kessler, 1877)	-	+	-	+	
Mesogobius batrachocephalus (Pallas, 1814)	r	+	+	r	
Neogobius eurycephalus (Kessler, 1874)	-	-	-	r	
Neogobius fluviatilis (Pallas, 1814)	+	+	+	+	
Neogobius gymnotrachelus (Kessler, 1857)	+	+	+	+	
Neogobius kessleri (Gűnther, 1861)	+	+	-	r	
Neogobius melanostomus (Pallas, 1814)	+	+	+	+	
Neogobius syrman (Nordmann, 1840)	-	+	-	-	
Proterorhinus marmoratus (Pallas, 1814)	+	+	-	+	
Percidae					

Table 1 (continued)

Gymnocephalus acerina (Gmelin, 1789)	+	+	+	-	RBU, IUCN
Gymnocephalus cernua (Linnaeus, 1758)	+	+	+	+	
Perca fluviatilis Linnaeus, 1758	+	+	+	+	
Percarina demidoffii Nordmann, 1840	r	+	+	r	RBU, EL
Sander lucioperca (Linnaeus, 1758)	+	+	+	+	
Sander volgensis (Gmelin, 1789)	+	r	-	-	RBU, IUCN, BC
Zingel zingel (Linnaeus, 1766)	+	+	+	r	RBU, IUCN, BC
Pomatomidae					
Pomatomus saltatrix (Linnaeus, 1766)	-	+	-	r	
Sparidae					
Diplodus annularis (Linnaeus, 1758)	-	+	-	-	
Pleuronectiformes					
Pleuronecthidae					
Platichthys flesus (Linnaeus, 1758)	+	+	+	+	
Scophthalmidae					
Psetta maxima maeotica (Pallas, 1811)	-	+	-	-	
Scorpaeniformes					
Cottidae					
Cottus gobio Linnaeus, 1758	+	-	+	-	
Cottus poecilopus Heckel, 1837	+	-	+	-	
Syngnathiformes					
Syngnathidae					
Nerophis ophidion (Linnaeus, 1758)	+	+	-	-	
Syngnathus abaster Risso, 1827	+	+	-	+	
Syngnathus typhle Linnaeus, 1758	r	+	-	r	
Anguilliformes					
Anguillidae					
Anguilla anguilla (Linnaeus, 1758)	r	r	+	r	EL
Clupeiformes					
Clupeidae					
Alosa tanaica (Grimm, 1901)	r	-	+	-	
Alosa maeotica (Grimm, 1901)	+	+	+	+	
Alosa immaculata Bennett, 1835	+	-	-	+	EL
Clupeonella cultriventris (Nordmann, 1840)	+	+	+	+	
Engraulidae					
Engraulis encrasicolus (Linnaeus, 1758)	-	+	-	-	
Cypriniformes					
Balitoridae					
Barbatula barbatula (Linnaeus, 1758)	+	-	+	-	
Catostomidae					
Ictiobus cyprinellus (Valenciennes, 1844)	-	-	+	-	
Cobitidae					
Cobitis rossomeridionalis Vasil'yeva & Vasil'ev, 1998	+	+	+	+	
Misgurnus fossilis (Linnaeus, 1758)	+	+	+	+	
Sabanejewia aurata (De Filippi, 1863)	-	-	+	r	
Cyprinidae					
Abramis ballerus (Linnaeus, 1758)	+	+	-	-	
Abramis brama (Linnaeus, 1758)	+	+	+	+	
Abramis sapa (Pallas, 1814)	+	+	+	r	
Alburnoides bipunctatus (Bloch, 1782)	+	-	+	-	
Alburnus alburnus (Linnaeus, 1758)	+	+	+	+	
Aspius aspius (Linnaeus, 1758)	+	+	+	+	
Barbus barbus (Linnaeus, 1758)	+	r	+	r	RBU, IUCN
*Barbus carpathicus*Kotlik, Tsigenopoulos, Rab et Berrebi, 2002	+	-	-	-	

Table 1 (continued)

Blicca bjoerkna (Linnaeus, 1758)	+	+	+	+	
Carassius gibelio (Bloch, 1782*)*	+	-	+	+	
Carassius carassius (Linnaeus, 1758)	+	+	+	r	RBU, IUCN
Chondrostoma nasus (Linnaeus, 1758)	+	+	+	r	
Ctenopharyngodon idella (Valenciennes, 1844)	-	-	+	+	
Cyprinus carpio Linnaeus, 1758	+	+	+	+	EL
Gobio gobio (Linnaeus, 1758)	+	+	+	r	
Romanogobio kesslerii (Dybowski, 1862)	+	-	+	r	RBU, IUCN, BC
Hypophthalmichthys molitrix (Valenciennes, 1846)	-	-	+	+	
Hypophthalmichthys nobilis (Richardson, 1846)	-	-	+	+	
Leucaspius delineatus (Heckel, 1843)	+	+	+	+	
Leuciscus cephalus (Linnaeus, 1758)	+	+	+	r	
Leuciscus idus (Linnaeus, 1758)	+	+	+	r	
Leuciscus leuciscus (Linnaeus, 1758)	+	+	+	-	RBU, IUCN
Petroleuciscus borysthenicus (Kessler, 1859)	+	r	-	r	
Pelecus cultratus (Linnaeus, 1758)	+	+	+	r	
Phoxinus phoxinus (Linnaeus, 1758)	+	-	+	-	
Pseudorasbora parva (Temminck & Schlegel, 1846)	-	-	+	+	
Rhodeus amarus (Bloch, 1782)	+	+	+	+	
Rutilus frisii (Nordmann, 1840)	+	+	+	r	RBU, IUCN, BC
Rutilus rutilus (Linnaeus, 1758)	+	+	+	+	
Scardinius erythrophthalmus (Linnaeus, 1758)	+	+	+	+	
Tinca tinca (Linnaeus, 1758)	+	+	+	r	
Vimba vimba (Linnaeus, 1758)	+	+	+	r	
Siluriformes					
Siluridae					
Silurus glanis Linnaeus, 1758	+	+	+	+	
Lotidae					
Lota lota (Linnaeus, 1758)	+	-	+	-	RBU
Esociformes					
Esocidae					
Esox lucius Linnaeus, 1758	+	+	+	+	
Umbridae					
Umbra krameri Walbaum, 1792	+	+	+	r	RBU, EL, BC
Salmoniformes					
Salmonidae					
Oncorhynchus mykiss (Walbaum, 1792)	-	-	+	-	
Salmo labrax Pallas, 1814	+	+	+	-	RBU, IUCN
Thymallus thymallus (Linnaeus, 1758)	+	-	+	-	RBU, IUCN, BC
Altogether species:	**74**	**71**	**67**	**65**	**23**

Notes: * – author's own data and results of the Lower Dniester ichthyofauna studies in the framework of the OSCE / UNECE / UNDP Project «Trans-boundary Cooperation and Sustainable Management of the Dniester River: Phase III – Implementation of Action Programme» («Dniester – III»);
- – species not found; + – common species; r – rare species; i – introduced species;
RBU – Read Book of Ukraine (2009); IUCN – List of International Union for Conservation of Nature (2001, 2004); EL – European Red List (IUCN Red List Status – Ex-Nt) (2011); BC – list of fish species from the Protocol of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (1979).

Analysis of taxonomic composition dynamics of the Lower Dniester ichthyofauna from 1930 to 2013 has shown that no significant changes have generally taken place in the taxonomic structure of the Dniester fish coenoses. For example, the number of fish species registered in the river at present is only 1.2 times lower than the number presented in the list of species by L.S. Berg, who had been studying the Lower Dniester ichthyofauna early last century, before artificial regulation of the river flow began.

Reduction of the Dniester ichthyofauna species composition during the period of studies, caused by disappearance of such native species as *A. nudiventris*, *C. chalcoides*, *A. ballerus*, *S. volgensis*, *Z. zingel*, *A. bipunctatus* and some other, was compensated due to the introduction into the Dniester water-bodies of some new species: *C. gibelio*, *H. molitrix*, *C. idella*, *P. parva*, *L. haematocheila*, *L. gibbosus*. As a result, the number of the Dniester fish species stayed relatively stable for the past 70–80 years. Besides comparing the quantity of species, common for the two periods practically no changes, varying from 48 to 61.

Relative similarity of fish populations of the Dniester in different periods of time between 1930 and 2013 is confirmed by the results received from the calculation of the Sorensen-Chekanovskiy and the Shimkevich-Simpson indices of species similarity. The values of these indicators stay practically unchanged not only in cases of comparison between lists of species for successive associated periods, but also in the cases of studies separated by significant periods of time (Table 2).

Table 2

Species similarity indices of the Dniester River Ichthyofauna by Comparison of Different Studies from 1930 to 2013

Period of Studies	**Period of Studies**			
	1930–1940 (Berg, 1949)	1950–1960 (Zambriborsch, 1953)	1983–1989 (Sirenko et al., 1992)	2006–2013 (Our own data)
Sorensen – Chekanovskiy Index of Species Similarity*				
1930–1940 [1]	X	0,47	0.46	0.44
1950–1960 [26]	0.47	X	0.43	0.45
1983–1989 [19]	0.46	0.43	X	0.45
2006–2013 (Our own data)	0.44	0.45	0.45	X
Shimkevich-Simpson Index *				
1930–1940 [1]	X	0.48	0.47	0.46
1950–1960 [26]	0.48	X	0.44	0.46
1983–1989 [19]	0.47	0.44	X	0.45
2006–2013 (Our own data)	0.46	0.46	0.45	X

Note: * calculating similarity indices of lists of the species observed in different segments of the river, specific features of the Lower Dniester ichthyofauna have been taken into account and the species characteristic of the Upper and the Middle Dniester were ignored and so were the marine species found only in the Dniester Liman and difficult to spot, for example: *B. belone*, *B. brauneri*, *K. longecaudata*, *D. annularis*, *P. saltatrix*, *T. thymallus* and other species.

However, it should be pointed out that while the taxonomic structure of ichthyofauna in general stayed relatively stable during the discussed period, the situation with many separate species in the Lower Dniester changed significantly, which evidences more global transformation of the Lower Dniester water-bodies' structural characteristics. For example, the share of species characterised by a high number and included into the category of "common species" has by now shrunk to 33.8% of the total number of species found, while in mid-20th century over 85% of the found species could be referred to as 'common' (Table 3). Besides, the number of rare species grew by now 3–4 times, the number of very rare increased by an order of magnitude, including the extinct species that inhabited the river before its hydro-engineering transformation.

Table 3

Number of Introduced and Native Species (%) of Separate Categories of the Lower Dniester Relative Ichthyofauna Abundance for the Period 1930–2013

No. of Species, %	Period of Studies			
	1930–1940 (Berg, 1949)	1950–1960 (Zambriborsch, 1953)	1983–1989 (Sirenko et al., 1992)	2006–2013 (Our own data)
Common	87.8	85.9	70.2	33.8
Rare	8.1	8.5	10.4	38.5
Very rare and extinct	1.4	4.2	6.0	15.4
Introduced	2.7	1.4	13.4	12.3
Altogether species, absolute units	**74**	**71**	**67**	**65**

So, if we consider the state of ichthyofauna by taking into account the abundance of separate species, significant restructuring of the Lower Dniester ichthyocoenoses' structural elements becomes evident. As a result, more than 1/3 of the species registered at present have the status of increased risk and 1/6 of species are in danger of extinction.

Under ever higher anthropogenic pressure on the Dniester, disturbance of hydrology and flow regulation, destruction of spawning grounds by sand and gravel extraction, as well as floodplain development, the transformation of ichthyofauna will progress, which will end in significant shrinking of the fish species list.

Analysis of the data collected enables us to single out from the current ichthyofauna of the Dniester River and the Dniester Liman representatives of four main faunistic complexes. Introduced species (13.3% of the species found) have been combined for convenience into one general group. Dominant complex is the Ponto-Caspian marine complex (34.0%), which comprises the brackish water and sea species widespread in the lower part of the Dniester Liman that became significantly more saline as a result of the hydro-technical changing of the ecosystem (Table 4).

The significance of limnophilic and reo-limnophilic species within the ecological groups has increased, which is characteristic of a decreased flow speed and increased turbidity.besides the number of reophilic, lithophilous and psammophilous species has decreased. On the contrary, the number of introduced species has increased significantly (index of changes 3.0).

Table 4

Dynamics of Composition of Separate Ecological Groups of Ichthyofauna in the Dniester River in the period 1930 – 2013

Ecological Groups	No. of Species, Absolute Units		Index of Changes
	Data acc. To L.S. Berg, 1949	Data of 2006–2013	
Fresh water	44	42	0.1
Brackish water	25	20	0.2
Marine	5	3	0.4
Migratory	8	5	0.4
Demersal	36	33	0.1
Pelagic	7	7	-
Bottom-pelagic	31	25	0.2
Lithophilous	20	15	0.3
Psammophilous	3	2	0.3
Phytophillous	21	20	0.1
Pelagophyls	13	12	0.1
Ostracophils	1	1	-
Depositing eggs in 'nests'	13	13	-
Carrying eggs	3	2	0.3
Introduced	2	8	3.0

3.2. Dynamics of the Lower Dniester Commercial Ichthyofauna

Against the background of the Lower Dniester ichthyofauna characteristics changes in general, reduction of commercial species composition are also observed, though, as mentioned previously, the Lower Dniester ichthyofauna has been enriched with new commercial species, such as *H. molitrix*, *H. nobilis, C. idella*, *L. haematocheila*. Similarly, from the 1990s till now statistics of catches does not reflect Acipenseridae, *T. tinca*, *R. frisii*, *P. cultratus*, *V. vimba*, *P. demidoffii* and some other species, which evidences that those species either have disappeared completely or occur in the Lower Dniester very seldom.

According to statistics of catches, only 18 commercial species were found in the yields of 2012–2013. Total yield size in the Lower Dniester and the Dniester Liman is relatively stable for the past 5 years and varies between 448.9 and 509.6 tons per year. Catches consist mainly of *A. brama* (31.4% of average annual size of total yield) and *C. gibelio* (23.7%). The share of other fish in commercial catches is smaller: *H. molitrix* (depending on stocking quantities) – 9.8%, *R. rutilus* – 5.9%, *Alosa gen. sp.* – 5.3%, *B. bjoerkna* – 5.1%, *P. fluviatilis* – 4.9%, *S. lucioperca* – 3.9%, Gobiidae – 3.5%, *C. carpio* – 2.7%. Even smaller in the yields are the shares of *E. lucius* (0.7%), *S. glanis* (0.4%), *A. aspius* (0.4%), *S. erythrophthalmus* (0.3%), *L. haematocheila* (0.1%). Average annual yields of *C. cultriventris*, *A. boyeri* and some other species do not exceed 1.6%.

According to the data collected, as well as to commercial statistics (Starushenko et al., 2001; Bushuev S.G. et al., 2013) compared to the 1990s catches from the Dniester River and the Dniester Liman have decreased 2.0–3.0 times (Fig. 2). Keeping in mind that part (40 to 80%) of the catches has always been concealed by fishermen and consequently not included in the statistics of commercial yields, the data on the decrease of commercial catches presented above are, probably, not reliable enough. Taking into consideration oral information from the fishermen of the Dniester River and the Dniester Liman we may conclude that the quantity of fish caught decreased for the past 25 years by 4.0–5.0 times.

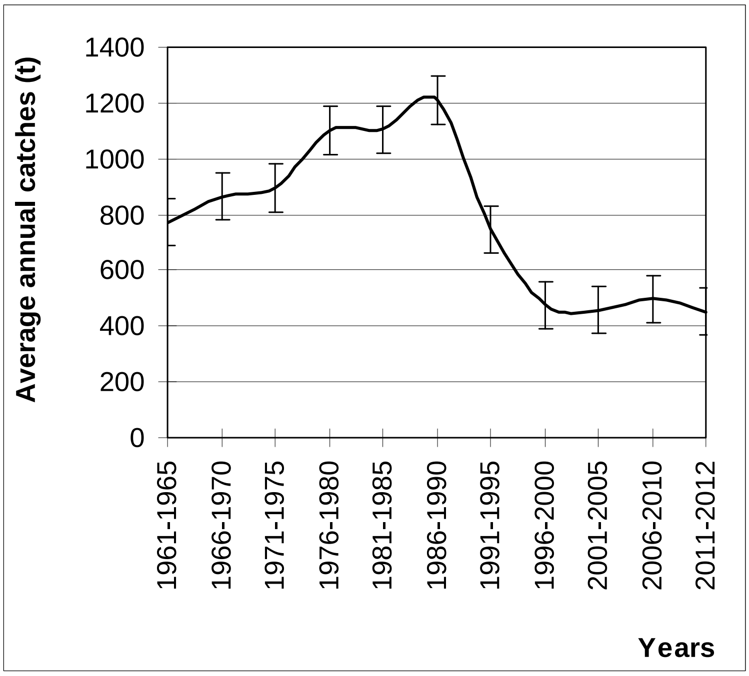

Fig. 2 – Average annual catches (t) of the main commercial fish species in the Lower Dniester, 1961–2012.

Analysis of average annual catches of some species also shows that the decrease in fishery yields in the Dniester Liman is more significant. According to statistics of commercial yields the catches of *S. lucioperca* in the Liman have decreased 9.1 times compared to the 1990s, catches of *R. rutilus* – 8.7 times, *C. carpio* – 6.3 times, *A. brama* and *C. gibelio* – 2.6 and 2.5 times, respectively (Fig. 3). While decrease in the catches of more important species like pike-perch, carp and roach could to a certain extent be connected with the fact that fishermen conceal a greater share of yields, the decrease in catches of *A. brama* and *C. gibelio* is no doubt the result of conditions for fish deteriorating in the Dniester Liman.

At present, more than enough has been said about the reasons for decreasing yields in the Lower Dniester. Noteworthy probably most of it was formulated back in 1887 by A.A. Brauner in his paper «Sketchbook on Fishery in the Dniester River and the Dniester Liman within Odessa Region». According to the observations made by this prominent scientist, over a 20-year period from the 1860s to 1887, catches from the Lower Dniester water-bodies decreased because of fine-meshed fishing gear and, as a result, much fry as by-catches; catching during spawning-run and during spawning; development of riparian land.

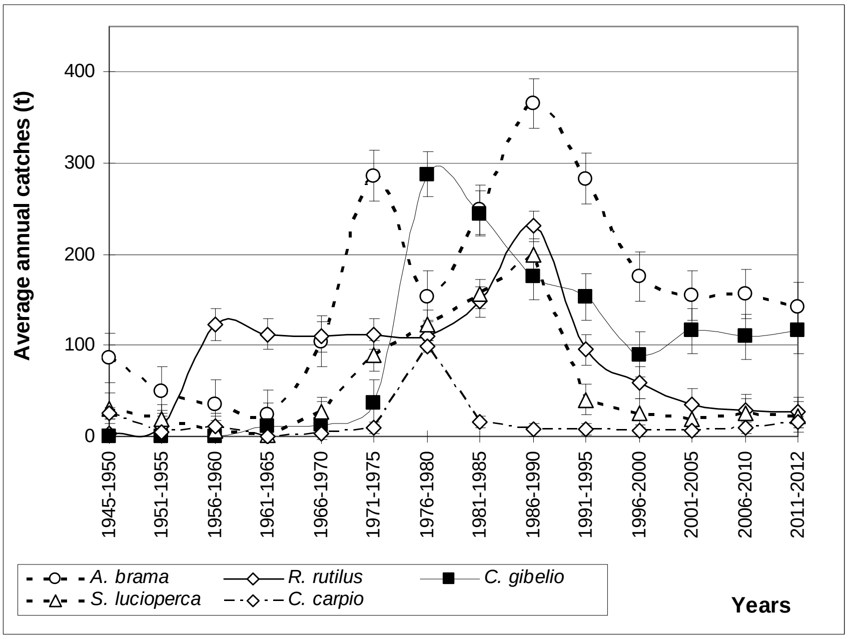

Fig. 3 – Average annual catches (t) of five main commercial fish species in the Lower Dniester in 1961–2012.

At present, with the significant increase of the catching capacity of fishing gear, first of all fine-meshed gillnets of angling line, catching of fry has increased in total to 50–75% of the general yield when nets with mesh size 30–32 mm is used. Illegal fishery, especially with electric rods, is widespread in the Dniester and damages ichthyofauna irreversibly. Uncontrolled fishery during spawning periods goes on. The unsatisfactory hydrological regime of the Lower Dniester, illegal development of riparian land on the banks of the river and the liman, uncontrolled sand and gravel extraction have caused significant shrinking of spawning and feeding areas of most fish species in the Lower Dniester. Under these conditions we have to expect further reduction of species composition and decrease of catches in the Lower Dniester.

Thus, at present in the catches from the Lower Dniester and the Dniester Liman are dominated by such species as *A. brama* and *C. gibelio*, and also, but to a lesser extent, *B. bjoerkna*, *R. rutilus*, *C. carpio*, *H. molitrix*, *S. lucioperca*, *E. lucius*, *S. glanis* and *P. fluviatilis*. Non-commercial fish species, whose size is insignificant, are abundant: *N. fluviatilis*, *N. melanostomus*, *N. gymnotrachelus*, *P. marmoratus*, *A. alburnus*, *R. amarus*, *P. parva*, *L. gibbosus*. Those species are quite widespread in the Lower Dniester and are common.

Other species are found in the Lower Dniester much more seldom. There are many reason for the decrease in their number, among which are, first of all, regulation of the river flow, significant shrinking of spawning grounds, anthropogenic eutrophication and general pollution of the Dniester water-bodies. For example, individual specimens of psammophillous fish (*G. gobio*, *R. kesslerii*) and of almost all the lithophilous species (*A. stellatus*, *H. huso*, *P. demidoffii*, *Z. zingel*, *S. aurata*, *B. barbus*, *C. nasus*, *L. cephalus*, *V. vimba*) are at present registered mainly in the middle part of the river, while before the hydro-engineering changes of the Dniester, *V. vimba*, for example, was one of the main commercial species. Catches of this fish totalled 180 tons per year or around 25% of the total yield in the Dniester Liman. Catches of *P. demidoffii* exceeded 200 tons per year – 42% of the total yield. Average annual catches of Acipenceridae in the Dniester Liman equall 3.8 t (Starushenko et al., 2001). During studies over 2006–2013, some phytophilous species (*A. sapa, C. carassius, R. frisii*, *T. tinca*) were very seldom registered in catches, though before catches of, for example, *C. carassius* and *T. tinca* in the Dniester Liman totalled 10 tons per year (Starushenko et al., 2001). According to the results of studies, significant changes have taken place in the Dniester River from 1930 to the present day. Species composition has decreased 1.2 time. *A. nudiventris*, *S. volgensis*, *Z. streber*, *B. barbatula, A. ballerus, C. chalcoides* have disappeared or are considered extinct. Many fish species that used to be widespread in the Dniester water-bodies and considered common have become rare now. The number of introduced species has increased. Commercial catches have decreased 2–3 times.

4. CONCLUSIONS

1. During studies in the 2006–2013 period, 65 fish species belonging to 12 orders, 17 families and 52 genera were registered in the Dniester River and the Dniester Liman.

2. Out of the 65 species, 11 are listed in the Red Book of Ukraine, 8 – in the IUCN List, 6 – in European Red List, and 6 are protected under the to Bern Convention. In 2007, in the middle part of the Dniester Liman the *B. brauneri* Beling et Iljin, 1927 was found – first registration in the Dniester Liman.

3. Increased anthropogenic pressure on the Dniester River and its water-bodies has resulted in the transformation of ichthyofauna: decrease of fish species composition 1.2 time, 2.3 times decrease of rare indigenous fish species, decrease in the number of reophilic, lithophilous and psammophilous fish species.

4. In connection with species composition negative transformation and a 2.0–3.0 time decrease of commercial catches in the Dniester River and the Dniester Liman calls for urgent measures to strengthen the protection of fish resources, restoration of stock and improvement of the Lower Dniester ecosystem's environmental health in general.

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REFERENCES

Berg, L.S. (1949), *Fishes of fresh water-bodies of the USSR and bordering countries*, Moscow; Leningrad: Publisher of the Academy of Sciences of the USSR, Moscow, 1382 p. (in Russian).

Bogutskaya, N.G., Naseka, A.M. (2004), *Catalog of Agnathastomatous and fish of fresh and brackish waters of Russia with nomenclature and taxonomic comments,* Moscow: Association of Scientific Publishers KMK, Moscow, 389 p. (in Russian).

Brauner, A.A. (1887), *Sketchbook on Fishery in the Dniester River and the Dniester Liman within Odessa Region*, Reports of Kherson Zemstvo (Regional Council), Kherson, pp. 1–20 (in Russian).

Burnashev, M.S., Chepurnov, V.S., Dolgiy, V.N. (1954), *Fish and fishery of the Dniester River*, Collection of papers of Chişinău University, Chişinău, pp. 19–32 (in Russian).

Bushuev, S.G., Chernikov, G.B., Ryjco, V.E., Chaschin, K.A., Snigirov, S.M., Chernicova, S.Yu. (2013), *Report on research work «To assess the state of commercial objects in the internal water-bodies of the North-Western Black Sea area and on the adjacent Black Sea shelf, to study dynamics of their abundance in order to determine possible limits of their extraction and fishery regulation, to develop long-term forecasts for commercial fisher»,* Manuscript of State Enterprise «OdC YugNIRO», Odessa, 124 p. (in Russian).

Convention on the Conservation of European Wildlife and Natural Habitats. Bern, 19.09.1979. http://conventions.coe.int/Treaty/en/Treaties/Word/104.doc.

Freyhof, J., Brooks, E. (2011), *European Red List of Freshwater Fishes,* Luxembourg: Publications Office of the European Union, 62 p.

IUCN Red List Categories and Criteria: Version 3.1. (2001), IUCN Species Survival Commission, Gland, Switzerland and Cambridge, 37 p.

IUCN Red List of Threatened Species. A Global Species Assessment. (2004), Gland and Cambridge, 191 p.

Kessler, K.F. (1874), *Description of fish belonging to families that are common for the Black and Caspian Seas*, Transactions of St. Petersburg society of natural history, St. Petersburg, pp. 191–324 (in Russian).

Kottelat, M., Freyhof, J. (2007), *Handbook of European freshwater fishes,* Kottelat, Cornol, Switzerland and Freyhof, Berlin, 660 p.

Lehmann, A., Giuliani, G., Mancosu, E., Abbaspour, K. C., Sözen, S., Gorgan, D., Beel, A. & Ray, N. (2014), *Filling the gap between Earth observation and policy making in the Black Sea catchment with enviroGRIDS*, Environmental Science & Policy.

Lobchenko, V.V., Trombitskiy, I.D., Tsurkan, A.N. (2001), *Ichthyofauna of the Dniester,* Collection of scientific papers '125th Anniversary of Academician Berg', BIOTICA, Bendery, pp. 73–79 (in Russian).

Movchan, Yu.V., Smirnov, A.I. (1980–1983), *Fauna of Ukraine in 40 volumes. V. 8. Fish*, Editions 1–5, Kiev: Naukova Dumka (in Ukrainian).

Nikolskiy, G.V. (1980), *Structure of species and regularities of fish variability,* Moscow: Pischevaya Promyshlennost, Moscow, 182 p. (in Russian).

Pesenko, Yu.A. (1982), *Principles and methods of quantitative analysis in faunistic studies*Moscow: Nauka, Moskow, 287 p. (in Russian).

Pryahin, Yu.V., Shkitskiy, V.A. (2008), *Methods of studies in fishery*, Publisher of Southern Research Center of Russian Academy of Sciences, Rostov-on-Don, 256 p. (in Russian).

Red Book of Ukraine. Fauna (2009), Kiev: Globalconsulting, Kiev, 600 p. (in Ukrainian).

Romanenko, V.D., Arsan, A.M., Davidov, O.A., Dyachenco, T.M. (2006), *Methods of hydro-ecological studies of surface waters,* Kiev: LOGOS, Kiev, pp. 156–180 (in Ukrainian).

Sirenko, L.A., Evtushenko, N.B., Komarovskiy, F.Ya. (1992), *Hydro-biological regime of the Dniester and its water-bodies,* Kiev: Naukova Dumka, Kiev, 356 p. (in Russian).

Starushenko, L.I., Bushuev, S.G. (2001), *Limans of the Black Sea in Odessa Region and their use for fishery,* Astroprint, Odessa, 151 p. (in Russian).

Titlyanova, A.A., Afanasyev, N.A., Naumova, N.B. (1993), *Successions and biological turnover,* Novosibirsk: Nauka, Novosibirsk, 157 p. (in Russian).

Tkachenko, V.A., Goncharenko, N.I. (1998) *Characteristics of the Dniester basin from the viewpoint of commercial fishery and efficiency of fish reproduction under conditions of waterworks facilities*, Collection of papers 'Environmental State of the Dniester River', Kiev, pp. 106–123 (in Russian).

Vasil'eva, E.D. (2003), *Main alterations in ichthyofauna of the largest rivers of the northern coast of the Black Sea in the last 50 years: a review*, Folia Zool **V**, *52*, No. 4, pp. 337–358.

Vinogradov, K.A. (1958), *Outline of history of domestic hydrobiological studies of the Black Sea*, Kiev: Publisher of the Academy of Sciences of Ukrainian SSR, Kiev, 155 p. (in Russian).

Yaroshenko, M.F. (1957), *Aquatic fauna of the Dniester*, Publisher of the Academy of Science of the USSR. Moldavian Branch, Chicinau, 168 p. (in Russian).

Zambriborsch, F.S. (1953), *State of Stock of the Main Commercial Fishes in the Dniester Delta and the Dniester Liman and the Ways of Their Restoration*, Publisher of Kiev State University, Kiev, pp. 103–135 (in Russian).

Zambriborsch, F.S. (1968), *On systematics of goby-fish of the Black and Azov Seas* (brief keys), Zoological Newsletter **1**, pp. 37–34 (in Russian).

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