Acta Ichthyologica et Piscatoria 53, 2023, 157–162 | DOI 10.3897/aiep.53.111525

PENSOFT

ACTA ICHTHYOLOGICA ET PISCATORIA

First record of two fish species (Actinopterygii) in the Sukhyi Lyman, northwestern Black Sea, Ukraine

Serhii KHUTORNOI[1], Mikhail O. SON[1], Yuriy KVACH[1]

1 *Institute of Marine Biology, National Academy of Sciences of Ukraine, Odesa, Ukraine*

https://zoobank.org/CC623535-18FB-4F07-8B6C-97947217884F

Corresponding author: Yuriy Kvach (yuriy.kvach@gmail.com)

Academic editor: Jan Kotusz ♦ **Received** 27 August 2023 ♦ **Accepted** 22 September 2023 ♦ **Published** 12 October 2023

Citation: Khutornoi S, Son MO, Kvach Y (2023) First record of two fish species (Actinopterygii) in the Sukhyi Lyman, northwestern Black Sea, Ukraine. Acta Ichthyologica et Piscatoria 53: 157–162. https://doi.org/10.3897/aiep.53.111525

Abstract

Two new fish species were recorded while monitoring the fish fauna of Sukhyi Lyman (or Sukhyi Estuary), an estuary in the northwestern Black Sea (Ukraine) close to the marine port of Chornomorsk. A single pumpkinseed, *Lepomis gibbosus* (Linnaeus, 1758), was observed in May 1999, followed by numerous observations in May 2021, while a single peacock blenny, *Salaria pavo* (Risso, 1810), was photographed during snorkeling observations in September 2021. The estuary is a known hub for invasive alien species and other neobionts due to the presence of the marine port. The new population of pumpkinseed, a North American invasive species, in the estuary represents the next stage in the species' ongoing expansion along the Ukrainian Black Sea coast. Likewise, the appearance of the peacock blenny represents the latest stage in the "Mediterranization" of the Black Sea, a process that has been ongoing over the last several thousand years.

Keywords

Blenniidae, Centrarchidae, ichthyofauna, invasive alien species, *Lepomis gibbosus*, Mediterranean species, new records, range extension, *Salaria pavo*

Introduction

Alien species often represent a large fraction of the species in aquatic ecosystems, with fish overrepresented among such aquatic invaders (Strayer 2010). Such biological invasions have the potential to cause ecological changes negatively affecting both biodiversity and ecosystem state (Bax et al. 2003; Chan and Briski 2017). Many of these aquatic species have been introduced either accidentally, alongside commercial stocks, or in shipping ballast water (Panov et al. 2009).

Natural range extension is one of the main mechanisms controlling evolutionary diversification and maintenance of biodiversity (Parmesan and Yohe 2003). Historically, such processes were naturally controlled (e.g., by climatic or physical barriers); hence, long-distance expansion for many aquatic species usually took a very long time (Alexandrov et al. 2007; Polačik et al. 2008). In the modern period, however, human-mediated dispersal, e.g., by attachment to vessel bottoms or transport in ballast waters or tank sediments (Ricciardi 2006; Hänfling et al. 2011; Gruszka et al. 2013; Cupak et al. 2014; Ojaveer et al. 2002, 2017), has played an important role in the geographic spread of numerous aquatic invasive species (Lodge et al. 2016; Bullock et al. 2018).

In Ukraine, the list of non-indigenous fish fauna consists of 27 species (Kvach and Kutsokon 2017). Note that this does not include the so-called neolimnetic group or Mediterranean species, which are not considered non-indigenous to Ukraine as the border between their native and expanded ranges remains unclear (Kvach and Kutsokon 2017). The Sukhyi Lyman (or Sukhyi Estuary), an open water body situated in the northwestern Black Sea, was originally an estuary established by the interfluence of two rivers, the Dalnyk

and Akkarzhanka (Starushenko and Bushuyev 2001). When the Port of Chornomorsk was built in 1957, the estuary was connected to the sea via a 14-m deep navigation canal. At present, the water body is classified as an anthropogenically transformed landform, with its lower part established as a sea bay with the middle and upper parts now oligohaline (Starushenko and Bushuyev 2001; Zaitsev et al. 2006). The salinity of the lower part ranges between 14‰ and 16‰, which is almost equal to that in the adjacent sea.

Recent studies have confirmed up to 58 fish species in the Sukhyi Lyman (Vinogradov and Khutornoy 2013), thanks in large part to the wide range of habitats in the estuary watershed. The presence of the seaport, however, acts as a potential hub for invasive species and, consequently, the waters of the Sukhyi Lyman have been regularly monitored for any change in the local fish fauna since the early 2000s. Here, we present new data on the discovery of two new fish species in the Sukhyi Lyman watershed.

Materials and methods

Fish fauna monitoring at Sukhyi Lyman has taken place regularly over the last two decades. At the same time, data is gathered on bottom-dwelling fauna via snorkeling observations. The snorkeling observations take place at a depth of 0.4 m at a site (46.332944ºN, 30.661555ºE) in the lower part of the estuary. The fish individuals are photographed under natural lighting using an Olympus digital camera. When possible, the fish were caught by a hand with a dipnet. In addition, the catches of both anglers and commercial fishers have been examined in the upper part of the estuary (46.392579ºN, 30.632233ºE) since 2019. A total of 15 fish individuals from the commercial catches were measured: the standard (SL, mm) and total (TL, mm) lengths were indicated. The standard deviation was calculated for mean parameters. Species are identified using the keys provided in Zander (1986) and Movchan (2011), with the taxonomic position, scientific name, and vernacular names provided by FishBase (Froese and Pauly 2023). The water salinity in the estuary was measured in the Hydrochemical Laboratory of the Institute of Marine Biology of the National Academy of Sciences (NAS) of Ukraine.

Results

In May 1999, a single pumpkinseed, *Lepomis gibbosus* (Linnaeus, 1758) (Centrarchiformes: Centrarchidae), was observed in the lower part of the estuary (46.332944ºN, 30.661555ºE) during snorkeling observations and caught by a dipnet. The individual was identified as a male (SL = 62 mm, TL = 75 mm). The salinity at the site was 17‰–18‰ (see Fig. 1). By May 2021, numerous observations were being recorded in angling and fisheries catches in the upper part of the estuary (46.392579ºN, 30.632233ºE), where the salinity was 2.2‰–3.0‰ (Fig. 2). The fish SL varied within 98–143 mm (129.6 ± 12.4 mm), while its

Figure 1. Map of the study area. Red circles are the sampling sites. The salinity parameters (*S*, ‰) are marked for the lower, central, and upper parts of the estuary.

TL within 119–170 mm (152.3 ± 13.6 mm). In September 2021, a single peacock blenny, *Salaria pavo* (Risso, 1810) (Blenniiformes: Blenniidae), was photographed in mussel beds on the rocky bottom of the lower part of the estuary (46.332944ºN, 30.661555ºE) during snorkeling observations. The fish was easily identifiable due to the presence of a high leather crest on the top of the head, which extended from the edge of the eyes to the origin of the dorsal fin (Fig. 3). The individual was identified as a mature male (by well-developed leather crest), but the exact size of the individual could not be identified on photographs.

Discussion

Our data confirm the presence of two new species, the pumpkinseed and peacock blenny, in the Sukhyi Lyman. The pumpkinseed is a North American freshwater centrarchid, currently classified as an invasive alien species of European Union Concern (European Commission 2019). Its presence in Ukrainian waters suggests either range extension through introduction as a "hitchhiker", either with commercially important fishes or through natural spread via coastal waters (Diripasko et al. 2008; Afanasyev et al. 2017; Kvach and Kutsokon 2017). The subsequent catching of multiple fish in the upper part of the estuary confirms the presence of an established population in the water body. Consequently, its original finding in the lower part of the Sukhyi Lyman was most likely an individual spreading from the upper part to the sea.

Nine blennid species (Actinopterygii: Blenniidae) have previously been confirmed in Ukrainian Black Sea waters (Movchan 2011). The peacock blenny, a Mediterranean marine species (Zander 1986), is rarely recorded in the northwestern Black Sea, having only previously been recorded near Cape Tarkhankut and Snake Island (Boltachev and Karpova 2017; Snigirov et al. 2012, 2020). Consequently, our discovery in the Sukhyi Lyman is just the third confirmed case of this species in the northwestern Black Sea. Our finding likely represents an example of the ongoing expansion of Atlanto–Mediterranean blennids into the northwestern Black Sea. The first examples of this expan-

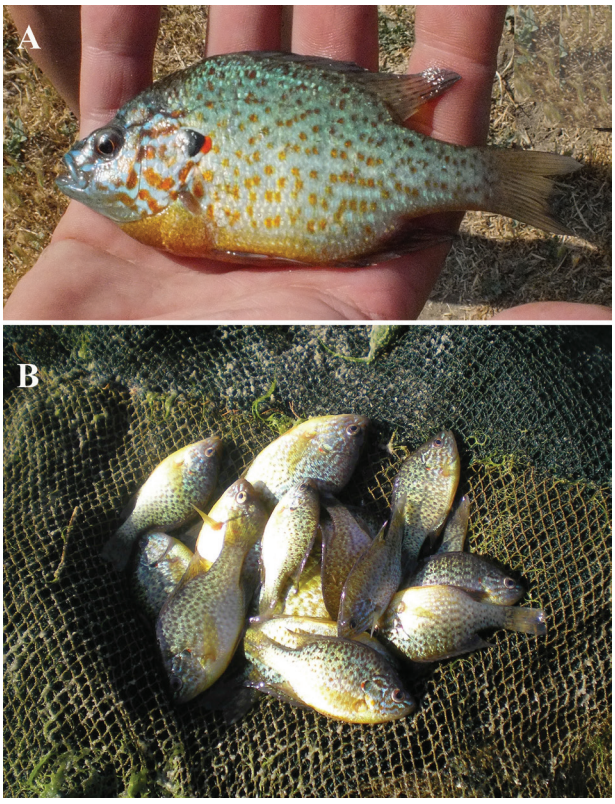

Figure 2. Pumpkinseed (*Lepomis gibbosus*) caught in the Sukhyi Lyman. (**A**) An individual caught while snorkeling (Photo: M. Son); (**B**) Individuals caught with a net by commercial fishers (Photo: Y. Kvach).

Figure 3. Male peacock blenny (*Salaria pavo*) observed by a scuba diver in the Sukhyi Lyman, with views from different angles (Photo: M. Son).

sion were recorded in 1998, when two new blenniid species were recorded in the Gulf of Odessa, i.e., the sphinx blenny, *Aidablennius sphynx* (Valenciennes, 1836), and Zvonimir's blenny, *Parablennius zvonimiri* (Kolombatovic, 1892) (see Khutornoy 1998). In 2019, Montagu's blenny, *Coryphoblennius galerita* (Linnaeus, 1758), was also recorded in the same region (Khutornoy and Kvach 2019).

The presence of the freshwater species, the pumpkinseed (*L. gibbosus*) in the mesohaline estuary is non-typical for this species, but this is not its first record in the brackish waters. Thus, the sporadic findings of this species are known from the Gulf of Odessa (the salinity of 16‰–17‰), gulfs of Yahorlyk and Tendra (up to 18‰) (Shcherbukha 1982; Tkachenko and Khutornoy 2001). The juveniles of this fish are characterized by relatively high tolerance to the natural marine water (Venâncio et al. 2019). The other fish species discovered, the peacock blenny (*S. pavo*), is a typical marine species inhabiting mainly intertidal rocky shores of the Mediterranean Sea and cannot be considered a typical estuarine fish (Steinitz 1954; Fishelson 1963). Nevertheless, this fish species is rather tolerant to the low salinity, which probably originates from its euryhaline ancestors (Plaut 1998).

As one of the largest seaports in the Black Sea, located within a large urban agglomeration, and the focus of both recreational fishing and commercial aquaculture, the Sukhyi Lyman is a high-risk area for biological pollution. Severe fragmentation of the estuary by dams and embayments, as well as its natural morphology, has resulted in the formation of many semi-isolated areas with different hydrological conditions. As a result, many alien species with diverse ecological preferences, including fully marine species, estuarine brackish water species, freshwater species and oligohaline Ponto–Caspian relicts, have become established and/or invasive (Zaitsev et al. 2006; Son 2007, 2008; Krasnovyd et al. 2012; Vinogradov and Khutornoy 2013; Son et al. 2013, 2020; Zhulidov et al. 2021). This diversity in habitat conditions also provides a diversity of invasive species pathways, with marine routes, whether by shipping or naturally through the channel connecting the estuary to the sea, being the most important. Passage through the channel is typical for the many mollusk, worm, and crustacean species now established (Zaitsev et al. 2006; Son et al. 2013; Zhulidov et al. 2021); however, fish stocking in the estuary's desalinated areas and incidental introduction of alien 'hitchhikers' alongside these stocked fish has also had an important impact (Kvach and Kutsokon 2017; Son et al. 2020). Finally, exotic and Ponto–Caspian mollusks have been introduced into small tributaries and the upper parts of the Sukhyi Lyman through natural dispersal, possibly with the additional help of migratory waterfowl (Son 2007, 2008). The most recent invasion registered since 2018–2020 is the now established population of the East Asian river prawn, *Macrobrachium nipponense* (De Haan, 1849) (see Bushuiev et al. 2023), while the Mediterranean Bucchich's goby, *Gobius bucchichi* Steindachner, 1870, is an example of the previous inadvertent introduction of a new component into the fish fauna of the estuary (Khutornoy unpublished*).

According to the standardized classification provided in the Convention on Biological Diversity** (Harrower et al. 2017), introduction pathways for non-native species include fishery in the wild (§ 1.3), contaminant on animals (excluding parasites and species transported by host and vector) (§ 3.4), ship/boat ballast water (§ 4.8), ship/boat hull fouling (§ 4.9), interconnected waterways/basins/seas (§ 5.1) and natural dispersal across borders of invasive alien species that have been introduced through pathways 1 to 5 (§ 6.1). Recent findings of non-native fishes in the northwestern Black Sea have been related to a number of these pathways, with the Chameleon goby, *Tridentiger trigonocephalus* (Gill, 1859), population near the Crimean coast, for example, being confirmed as the result of aquaria releases (Kvach and Kutsokon 2017), while two other species, the pumpkinseed and the Chinese sleeper, *Perccottus glenii* (Dybowski, 1877), were originally introduced due to human activity, but then spread naturally along river courses and eventually along the sea coast (Afanasyev et al. 2017; Kvach et al. 2021, 2022). Our finding of pumpkinseed in the Sukhyi Lyman, therefore, represents a continuation of the spread of this invasive alien species in waterbodies of southern Ukraine.

The second group of neobiota in the northwestern Black Sea are the Mediterranean and Atlanto–Mediterranid species, which have now spread into the northern Black Sea region (Kvach and Kutsokon 2017). This process, commonly termed Mediterranization, began in the early Pleistocene, either during the Earlier Würm or Main Würm interstadial seven to 12 thousand years ago (Slastenenko 1956; Flint 1957; Miller 1965; Zaitsev 1998). The previous findings of Bucchich's goby (*G. bucchichi*) and the chestnut goby, *Chromogobius quadrivittatus* (Steindachner, 1863), the latter near the coast north of Sukhyi Lyman (Vinogradov and Khutornoy 2013), were most likely a result of this process. Our discovery of a peacock blenny in the estuary represents further evidence of this ongoing process in the northwestern Black Sea. Note, however, that the presence of large ports in the region has no doubt supported the natural process of Mediterranization by transporting neobionts via ship/boat ballast water and/or hull fouling.

Acknowledgments

We thank Ruslana Migas (Institute of Marine Biology, National Academy of Sciences of Ukraine) for her help with map preparation. We also thank Dr Kevin Roche for his help in the English proofreading.

* Khutornoy SO (2021) Struktura pribereznih îhtîocenozîv pîvnîčno-zahîdnoï častini Čornogo morâ. [The structure of the offshore ichthyocenoses of the northwestern Black Sea.] PhD Thesis. Institute of Marine Biology of the NAS of Ukraine, Odesa. [In Ukrainian with English summary]

** https://www.cbd.int/

References

Afanasyev SA, Gupalo YA, Manturova OV (2017) Distribution and peculiarities of biology of the pumpkinseed *Lepomis gibbosus* (Perciformes: Centrarchidae) in the water bodies of Kyiv City. Hydrobiological Journal 53(3): 14–25. https://doi.org/10.1615/HydrobJ.v53.i3.20

Alexandrov B, Boltachev A, Kharchenko T, Lyashenko A, Son M, Tsarenko P, Zhukinsky V (2007) Trends of aquatic alien species invasions in Ukraine. Aquatic Invasions 2(3): 215–242. https://doi.org/10.3391/ai.2007.2.3.8

Bax N, Williamson A, Aguero M, Gonzalez E, Geeves W (2003) Marine invasive alien species: A threat to global biodiversity. Marine Policy 27(4): 313–323. https://doi.org/10.1016/S0308-597X(03)00041-1

Boltachev A, Karpova E (2017) Morskie ryby Krymskogo poluostrova. [Marine fishes of the Crimean Peninsula.] 2nd edn. Biznes-Inform, Simferopol, 367 pp. [In Russian]

Bullock JM, Bonte D, Pufal G, Carvalho CS, Chapman DS, Garcia C, Garcia D, Matthysen E, Delgado MM (2018) Human-mediated dispersal and the rewriting of spatial networks. Trends in Ecology and Evolution 33(12): 958–970. https://doi.org/10.1016/j.tree.2018.09.008

Bushuiev S, Snigirov S, Son M, Sokolov I, Kharlov G, Kvach Y (2023) Expansion of the alien East Asian river prawn *Macrobrachium nipponense* (De Haan, 1849) in southwestern Ukraine and assessment of its commercial usage prospects. Aquatic Invasions 18(2): 231–246. https://doi.org/10.3391/ai.2023.18.2.104092

Chan FT, Briski E (2017) An overview of recent research in marine biological invasions. Marine Biology 164(6): 121. https://doi.org/10.1007/s00227-017-3155-4

Cupak J, Hałupka M, Gruszka P (2014) Porastanie kadłubów małych statków jako sposób rozprzestrzeniania się makrozoobentosu. Ship hull fouling as a means of makrozoobenthos dispersal. Inżynieria Ekologiczna 37: 72–79. [In Polish]

Diripasko OA, Demchenko NA, Kulik PV, Zabroda TA (2008) Rasširenie areala solnečnogo okunâ, *Lepomis gibbosus* (Centrarchidae, Perciformes), na vostok Ukrainy. [An expansion of the pumpkinseed, *Lepomis gibbosus* (Centrarchidae, Perciformes), area of distribution into the east of Ukraine.] Vestnik Zoologii 42(3): 269–273. [In Russian with English summary]

European Commission (2019) Commission implementing regulation (EU) 2019/1262 of 25 July 2019 amending Implementing Regulation (EU) 2016/1141 to update the list of invasive alien species of Union concern. Official Journal of the European Union, L 199: 1–4.

Fishelson L (1963) Observations on littoral fishes of Israel I. Behaviour of *Blennius pavo* Risso (Teleostei, Blenniida). Israel Journal of Zoology 12(1–4): 67–80.

Flint RF (1957) Glacial and Pleistocene geology. John Wiley and Sons, New York, 553 pp.

Froese R, Pauly D (Eds) (2023) FishBase. [Version 06/2023] https://www.fishbase.org

Gruszka P, Rokicka-Praxmajer J, Cupak J, Radziejewska T, Wolska M (2013) Unintended "biological cargo" of ships entering the River Odra estuary: Assemblages of organisms in ballast tanks. Scientific Journals of Maritime University of Szczecin 33(105): 22–29.

Hänfling B, Edwards F, Gherardi F (2011) Invasive nonindigenous Crustacea: Dispersal, establishment, impact and control. BioControl 56(4): 573–595. https://doi.org/10.1007/s10526-011-9380-8

Harrower CA, Scalera R, Pagad S, Schönrogge K, Roy HE (2017) Guidance for interpretation of CBD categories on introduction pathways. Technical note prepared by IUCN for the European Commission. https://www.cbd.int/doc/c/9d85/3bc5/d640f059d03acd717602cd76/sbstta-22-inf-09-en.pdf

Khutornoy SA (1998) Ryby pribrežnyh akvatorij g. Odessy. [Fishes of the coastal waters of the City of Odesa.] Naučnye Trudy Zoologičeskogo muzeâ Odesskogo gosudarstvennogo universiteta 3: 42–45. [In Russian]

Khutornoy S, Kvach Y (2019) First record of the Montague's blenny (*Coryphoblennius galerita* (L., 1758) (Actinopterygii: Blenniidae) in the mesohaline waters of the North-Western Black Sea, Ukraine. BioInvasions Records 8(4): 917–923. https://doi.org/10.3391/bir.2019.8.4.20

Krasnovyd V, Kvach Y, Drobiniak O (2012) The parasite fauna of the gobiid fish (Actinopterygii: Gobiidae) in the Sukhyi Lyman, Black Sea. Vestnik Zoologii 46(6): 483–490.

Kvach Y, Kutsokon Y (2017) The non-indigenous fishes in the fauna of Ukraine: A potentia ad actum. BioInvasions Records 6(3): 269–279. https://doi.org/10.3391/bir.2017.6.3.13

Kvach Y, Karavanskyi Y, Tkachenko P, Zamorov V (2021) First record of the invasive Chinese sleeper, *Perccottus glenii* Dybowski, 1877 (Gobiiformes: Odontobutidae) in the Black Sea. BioInvasions Records 10(2): 411–418. https://doi.org/10.3391/bir.2021.10.2.19

Kvach Y, Kutsokon Y, Demchenko V, Yuryshynets V, Kudryashov S, Abramiuk I (2022) Post-invasion spread of Chinese sleeper (*Perccottus glenii*) in the Lower Danube drainage (Budjak region of Ukraine). BioInvasions Records 11(2): 547–559. https://doi.org/10.3391/bir.2022.11.2.27

Lodge DM, Simonin PW, Burgiel SW, Keller RP, Bossenbroek JM, Jerde CL, Kramer AM, Rutherford ES, Barnes MA, Wittmann ME, Chadderton WL, Apriesnig JL, Beletsky D, Cooke RM, Drake JM, Egan SP, Finnoff DC, Gantz CA, Grey EK, Hoff MH, Howeth JG, Jensen RA, Larson ER, Mandrak NE, Mason DM, Martinez FA, Newcomb TJ, Rothlisberger JD, Tucke AJ, Warziniack TW, Zhang H (2016) Risk analysis and bioeconomics of invasive species to inform policy and management. Annual Review of Environment and Resources 41(1): 453–488. https://doi.org/10.1146/annurev-environ-110615-085532

Miller PJ (1965) *Relictogobius kryzhanovskii* and the penetration of Mediterranean gobies into the Black Sea. Nature 208(5009): 474–475. https://doi.org/10.1038/208474a0

Movchan YV (2011) Ribi Ukraïni. [Fishes of Ukraine.] Zoloti Vorota, Kyiv, 444 pp. [In Ukrainian]

Ojaveer H, Leppäkoski E, Olenin S, Ricciardi A (2002) Ecological impacts of Ponto–Caspian invaders in the Baltic Sea. European inland waters and the Great Lakes: an inter-ecosystem comparison. Pp. 412–425. In: Leppäkoski E, Golasch S (Eds.) Invasive aquatic species of Europe: distribution, impacts and management. Kluwer Scientific Publishers, Dorthrecht. https://doi.org/10.1007/978-94-015-9956-6_41

Ojaveer H, Olenin S, Narscius A, Florin AB, Ezhova E, Gollasch S, Jensen KR, Lehtiniemi M, Minchin D, Normant-Saremba M, Strake S (2017) Dynamics of biological invasions and pathways over time: A case study of a temperate coastal sea. Biological Invasions 19(3): 799–813. https://doi.org/10.1007/s10530-016-1316-x

Panov VE, Alexandrov B, Arbačiauskas K, Binimelis R, Copp GH, Grabowski M, Lucy F, Leuven RSEW, Nehring S, Paunović M, Semenchenko V, Son MO (2009) Assessing the risks of aquatic species invasions via European inland waterways: From concepts to environmental indicators. Integrated Environmental Assessment and Management 5(1): 110–126. https://doi.org/10.1897/IEAM_2008-034.1

Parmesan C, Yohe G (2003) A globally coherent fingerprint of climate change impacts across natural systems. Nature 421(6918): 37–42. https://doi.org/10.1038/nature01286

Plaut I (1998) Comparison of salinity tolerance and osmoregulation in two closely related species of blennies from different habitats. Fish Physiology and Biochemistry 19(2): 181–188. https://doi.org/10.1023/A:1007798712727

Polačik M, Janáč M, Trichkova T, Vassilev M, Keckeis H, Jurajda P (2008) The distribution and abundance of the *Neogobius* fishes in their native range (Bulgaria) with notes on the non-native range in the Danube River. River Systems 18(1–2): 193–208. https://doi.org/10.1127/lr/18/2008/193

Ricciardi A (2006) Patterns of invasion in the Laurentian Great Lakes in relation to changes in vector activity. Diversity and Distributions 12(4): 425–433. https://doi.org/10.1111/j.1366-9516.2006.00262.x

Shcherbukha AY (1982) Fauna Ukraïni. [Fauna of Ukraine.] Volume 8, Issue 4. Naukova Dumka, Kyiv, 384 pp. [In Ukrainian]

Slastenenko E (1956) Karadeniz havzasi baliklari. [The fishes of the Black Sea basin.] EBK Yayini, Istanbul, 711 pp. [In Turkish with English summary]

Snigirov S, Goncharov O, Sylantyev S (2012) The fish community in Zmiinyi Island waters: Structure and determinants. Marine Biodiversity 42(2): 225–239. https://doi.org/10.1007/s12526-012-0109-4

Snigirov SM, Zamorov VV, Karavanskyi YV, Pitsyk VZ, Kurakin OP, Abakumov OM, Liumkis PV, Snigirov PM, Morozov YV, Kvach YV, Kutsokon YK (2020) Taksonomîčna ta ekologo-faunîstična harakteristika sučasnoï îhtîofauni Odeskoï zatoki, Dnîstrovskogo peredgirlovogo uzmor'â î priberežnih vod o. Zmîïnij. [Taxonomic and eco-faunistic features of the nowadays fish fauna of the Gulf of Odesa, the Dniester mouth forefront near-shores and coastal waters of the Snake (Zmiinyi) Island.] Odesa National University Herald Biology 25(2): 113–139. https://doi.org/10.18524/2077-1746.2020.2(47).218060 [In Ukrainian with English summary]

Son MO (2007) Native range of the zebra mussel and quagga mussel and new data on their invasions within the Ponto–Caspian region. Aquatic Invasions 2(3): 174–184. https://doi.org/10.3391/ai.2007.2.3.4

Son MO (2008) Rapid expansion of the New Zealand mud snail *Potamopyrgus antipodarum* (Gray, 1843) in the Azov–Black Sea region. Aquatic Invasions 3(3): 335–340. https://doi.org/10.3391/ai.2008.3.3.9

Son MO, Novitsky RA, Dyadichko VG (2013) Recent state and mechanisms of invasions of exotic decapods in Ukrainian rivers. Vestnik Zoologii 47(1): e45–e50.

Son MO, Morhun H, Novitskyi RO, Sidorovskyi S, Kulyk M, Utevsky S (2020) Occurrence of two exotic decapods, *Macrobrachium nipponense* (de Haan, 1849) and *Procambarus virginalis* Lyko, 2017, in Ukrainian waters. Knowledge and Management of Aquatic Ecosystems 421(421): 40. https://doi.org/10.1051/kmae/2020032

Starushenko LI, Bushuyev SG (2001) Pričernomorskie limany Odeŝiny i ih rybohozâjstvennoe značenie. [Black Sea estuaries and lagoons of the Odessa region and their fisheries importance.] Astroprint, Odesa, 151 pp. [In Russian]

Steinitz H (1954) The distribution and evolution of the fishes of Palestine. Istanbul Üniversitesi Fen Fakültesi Hidrobiyoloji (B) 1(4): 225–227.

Strayer DL (2010) Alien species in fresh waters: Ecological effects, interactions with other stressors, and prospects for the future. Freshwater Biology 55(s1): 152–174. https://doi.org/10.1111/j.1365-2427.2009.02380.x

Tkachenko PV, Khutornoy SA (2001) Sovremennyj sostav i tendencii izmeneniâ ihtiofauny pribrežnyh učastkov severo-zapadnoj časti Černogo morâ. [Modern composition and trends of changes in the fish fauna of the costal sites of the northwestern Black Sea.] Pp. 363–369. In: Ivanov IA (Ed.) Ekologičeskaâ bezopaskost' pribrežnoj i šel'fovoj zon i kompleksnoe ispol'zovanie resursov šel'fa. [Ecological safety of the coastal and shelf zones and complex usage of shelf sources.] Issue 2. Ekosi-Gidrofizika, Sevastopol. [In Russian]

Venâncio C, Castro BB, Ribeiro R, Antunes SC, Lopes I (2019) Sensitivity to salinization and acclimation potential of amphibian (*Pelophylax perezi*) and fish (*Lepomis gibbosus*) models. Ecotoxicology and Environmental Safety 172: 348–355. https://doi.org/10.1016/j.ecoenv.2019.01.099

Vinogradov AK, Khutornoy SA (2013) Ihtiofauna Odesskogo regiona severo-zapadnoj časti Černogo morâ (biologičeskie, ekologičeskie, ekologo-morfologičeskie osobennosti). [The fish fauna of Odessa region of the northwestern Black Sea (biological, ecological, eco-morphological features).] Astroprint, Odessa, 224 pp. [In Russian]

Zaitsev YP (1998) Samoe sinee v Mire. [The bluest in the World.] UN Publications, New York, 142 pp. [In Russian]

Zaitsev YP, Aleksandrov BG, Minicheva GG (2006) Severo-zapadnaâ čast Černogo morâ: biologiâ i ekologiâ. [Northwestern Black Sea: biology and ecology.] Naukova Dumka, Kyiv, 703 pp. [In Russian]

Zander CD (1986) Blenniidae. Pp. 1096–1112. In: Whitehead PJP, Bauchot M-L, Hureau J-C, Nielsen J, Tortonese E (Eds) Fishes of the North-eastern Atlantic and the Mediterranean, Volume 3. UNESCO, Paris.

Zhulidov AV, Kozhara AV, Son MO, Morhun H, van der Velde G, Leuven RSEW, Gurtovaya TY, Zhulidov DA, Kalko EA, Kuklina YA, Kosmenko LS, Santiago-Fandino VJR, Nalepa TF (2021) Additional records of the bivalves *Mytilopsis leucophaeata* (Conrad, 1831) (Dreissenidae) and *Arcuatula senhousia* (Benson, 1842) (Mytilidae) in the Ponto–Caspian region. BioInvasions Records 10(1): 119–135. https://doi.org/10.3391/bir.2021.10.1.14