

## Trends of aquatic alien species invasions in Ukraine

Boris Alexandrov<sup>1\*</sup>, Alexandr Boltachev<sup>2</sup>, Taras Kharchenko<sup>3</sup>, Artiom Lyashenko<sup>3</sup>, Mikhail Son<sup>1</sup>, Piotr Tsarenko<sup>4</sup> and Valeriy Zhukinsky<sup>3</sup>

<sup>1</sup>Odessa Branch, Institute of Biology of the Southern Seas, National Academy of Sciences of Ukraine (NASU); 37, Pushkinska St, 65125 Odessa, Ukraine, E-mail: [alexandrov@paco.net](mailto:alexandrov@paco.net)

<sup>2</sup>Institute of Biology of the Southern Seas NASU; 2, Nakhimova avenue, 99011 Sevastopol, Ukraine, E-mail: [boltach@ibss.iuf.net](mailto:boltach@ibss.iuf.net)

<sup>3</sup>Institute of Hydrobiology NASU; 12, Geroyiv Stalingrada avenue, 04210 Kiyv, Ukraine, E-mail: [hydrobiol@igbirc.com.ua](mailto:hydrobiol@igbirc.com.ua)

<sup>4</sup>Institute of Botany NASU; 2, Tereshchenkivska St, 01601 Kiyv, Ukraine, E-mail: [algae@botany.kiev.ua](mailto:algae@botany.kiev.ua)

\*Corresponding author

Received 13 November 2006; accepted in revised form 2 August 2007

### Abstract

This review is a first attempt to summarize data on the records and distribution of 240 alien species in fresh water, brackish water and marine water areas of Ukraine, from unicellular algae up to fish. A checklist of alien species with their taxonomy, synonymy and with a complete bibliography of their first records is presented. Analysis of the main trends of alien species introduction, present ecological status, origin and pathways is considered.

*Key words:* alien species, ballast water, Black Sea, distribution, invasion, Sea of Azov

### Introduction

The range of organisms of different taxonomic groups varies with time, which can be attributed to general processes of phylogenesis, to changes in the contours of land and sea, forest and deserts, to elevation and isolation of mountains, to changes in water bodies and water flows. These historical activities may be enhanced or slackened under global climate changes. Continental drift, the elevation and lowering of large areas of the Earth, the origin and transformation of oceans, inner lake-seas have led to the formation on the Earth, in the Paleocene and Neocene periods of isolated water bodies with distinct flora and fauna. As a result of active

geological processes and global climate changes (especially in the glacial age) a natural shift and transformation of fauna occurred. However, with the origin of man and with the progress of civilization including extensive travel, the introduction of plants and animals to new areas increased over the ages.

From the beginning of the 19th century, due to rising technical progress, the influence of man on nature has increased in geometrical progression, gradually becoming comparable in dimensions to climate impact.

In the past, even when aquatic 'stepping stones' existed across continents, very often negative environmental factors created natural obstacles hindering the spread of different species of aquatic bacteria, fungi, plants and

animals. For example water salinity serves as a barrier impeding the entry of hydrobionts from the Mediterranean to the Black Sea and Sea of Azov. However, aquatic habitats with salinities of 5-26‰ similar to the Black Sea and therefore suitable for brackish organisms are widely distributed on the Earth (Vinogradov 1986). Thus as these areas are geographically isolated, spread by man can lead to successful colonization of new comers. So the Black Sea has high risk in naturalization of exotic species in comparison with other areas of world ocean.

Once the natural obstacle can be overcome, species can spread over a new territory and expand its range. Often this occurs with the help of intentional or accidental human introductions. As an example of accidental introduction (simultaneously with intentional introduction of valuable species) data can be obtained that of the 36 species brought to the Black Sea from the USA, only 4-6 have been applied in fisheries and in angling and 10 for aquarium fishes. The rest, which penetrated into natural water bodies, are to some degree dangerous for aboriginal fauna (Zaitsev and Ozturk, 2001). The most common way of accidental introduction of new species is via ocean-going ships that transfer organisms through natural barriers. According to the International Marine Organisation (IMO) 80% of world cargoes are transported by shipping. Annually, about 85 000 ships carry 3-10 billion tons of ballast water in which more than 3,000 species of algae, invertebrates and fish have been recorded (IMO Bulletin 1998).

The dispersal of species is accompanied by a simultaneous decrease in native species diversity in the entire biosphere and in separate locations unifying the genetic fund of the planet. The successful invasive species inevitably leads to heavy competition squeezing out weaker often native species, resulting in a decline of biological diversity (Convention on Biological Diversity: June 5, 1992, Rio de Janeiro, Brasil).

The Black Sea – as a brackish water basin, semi-isolated from the Mediterranean Sea has been closely studied for biological invasions. Not only has a high biodiversity of alien species been established – more than 140 – but also their substantial impact on the marine ecosystem (Gomoiu et al. 2002; Alexandrov 2004) is evident. The invasion of the comb jelly *Mnemiopsis leidyi* Agassiz, 1865 was characterized as an ecological disaster (GESAMP 1997). The risk of entry of alien organisms into the Black Sea has been promoted by the dredging of

shipping channels. These include the Danube-Main-Rhine Canal, connecting the Black and North Seas in 1836, and the Volga-Don Canal connecting it with the Caspian Sea in 1952.

An important factor simplifying the naturalization of alien species in the Black Sea is the instability of its ecosystem. Wide scale eutrophication, observed first in the northwestern sea in the early 1970s, spread almost all over the coastal shelf especially close to river estuaries and large cities. These changes in the trophic status of the sea led to a decline in biological diversity (losses of immunity due to a reduction in the number of predators) the freeing of ecological niches and their occupation by highly productive alien species (Alexandrov and Zaitsev 1998).

Of all the lacustrine states in the Black Sea basin, Ukraine, due to its physical-geographic position and economic development, has all the conditions necessary for becoming the main testing area for control the introduction of aquatic alien species.

The aim of this paper is to illustrate, with the help of data from the literature, the chronology of biological invasions of freshwater, brackish and marine species in Ukraine ranging from unicellular algae to fish, with synonyms included.

## Methodology

All species of aliens can be divided into two groups:

- 1) *Distant aliens* – species which never previously inhabited the Black Sea–Azov basin, In other words these have a different origin, and were introduced into the water bodies of Ukraine unintentionally or intentionally with human help.
- 2) *Neighbouring aliens* – inhabitants of the Black Sea – Azov basin, or adjacent areas expanding by chance within Ukrainian waters or with spread accelerated by human activities (this is mostly freshwater species).

Alien species have subsequently been grouped into four categories namely casual, invasive, established and cryptogenic (questionable).

- *Casual*: In this paper alien is used in the sense of CIESM: Alien species are identified as having been recorded only once (no more than twice for fishes) in the scientific

literature: they are presumed to be not established in a river basin. <http://www.ciesm.org/online/atlas/index.htm>

- *Invasive*: These are the introduced species that, having overcome biotic and abiotic barriers, can propagate away from their area of initial introduction through the production of fertile offspring without any reference to impact (Richardson et al. 2000). In many definitions the term invasive is also considered as established species which are agents of change and threaten native biological diversity (IUCN 2002) or as species that threaten the diversity or abundance of native species, the ecological stability of infested ecosystems, economic activities dependent on these ecosystems and/or human health (EPA 2001). It is in this last meaning that the term IAS (Invasive Alien Species is used here).
- *Established* (synonym: *naturalized*): These include an introduced or feral population of a species. Species established in the wild with free-living, self-maintaining and self-perpetuating populations unsupported by and independent of humans (European Commission 2004).
- *Cryptogenic* species are species with no definite evidence of their native or introduced status according to Carlton (1996). Species whose probable introduction has occurred prior to 1800, i.e. has not been witnessed, have also been included in our compiled list. Often these species are excluded from lists of aliens or included among the established ones. In this review we considered it best to separate them.

### *Physical and Geographical Features*

Among the Black Sea countries Ukraine has the longest shoreline – 4,431 km making up 36.7% of the total (Shujskiy 1989).

Ukraine has the greatest shelf area as opposed to its territorial waters (to 200m isobaths), equal to 55,750 km<sup>2</sup> or 57% of the total Black Sea shelf (Zaitsev 1992).

The dense indentations of the shore line and the high number of water body types (lagoons, bays, embayments, limans, lakes) provide various habitats for aquatic organisms. These

aquatic habitats are of varying salinity (0.2-300 ‰), depth (0.8-36.0 m), substrate and vegetation (Zaitsev and Alexandrov 1998). Ukraine has 17 large limans with a total area of 1952 km<sup>2</sup>, 8 bays – 1770 km<sup>2</sup>, 19 coastal wetlands – 6350 km<sup>2</sup> (Conservation... 2003). A liman is the former mouth of a river now covered with sea water. This definition is very close to an estuary, but as a tide-less sea, the Black Sea does not have estuaries.

The largest rivers of the Black Sea (Danube, Dnieper, Dniester) make up more than 50% of the total river runoff into the Black Sea (Nikolaenko and Reshetnikov 1991), and their catchments create a zone of maximum biological productivity in most of the shelf of Ukraine. In total, Ukraine has about 73,000 rivers. The highest number are present in the western mountainous area including the Dniester and Danube basins. The density of the river network there is 1–1.5 km/km<sup>2</sup>. In the Crimea, rivers are relatively rare, with many areas lacking natural water flow. The density of the Crimean river networks is 0.22 km/km<sup>2</sup>.

The continental waters of the Ukraine pertain to two of the largest zoogeographical areas, i.e. Palearctic and Ponto-Caspian brackish areas (Starobogatov 1970). The Palearctic includes North Eurasia and Northwest Africa. Within the boundaries of Ukraine, there are two zoogeographic provinces: the Baltic and Danube-Don. The former includes the rivers of the Visla basin and Shatskie lakes. The Ponto-Caspian area includes the Caspian Sea, limans and the lower reaches of the rivers of the Black and Azov Seas. According to some data a number of relict lakes in Macedonia, Greece, Italy, Iran, Iraq, Central and Western Turkey, i.e. Eastern Mediterranean coast and Asia Minor (Wilke et al. 2007) should be included.

The Crimean peninsula could be included in the Ponto-Caspian area. Up until the 20th century it lacked the relict Ponto-Caspian fauna as zoogeographically it is not a peninsula, but an island and its isolation from the lower basins of the Dnieper and Don occurred before the introduction of Ponto-Caspian fauna. The Crimea can actually be considered to be a faunal isolate of the European-Siberian subarea of Palearctic. However, the Crimean hydrofauna contains a number of Asian elements. The Crimea itself was never considered in large zoogeographical classifications (Figure 1).

## Results and Discussion

On the base of collected information 169 species of distant aliens and 71 neighbouring aliens have been registered in aquatic areas of the Ukraine (Annex). Check-list of aquatic alien species of Ukraine have been compiled according to available data published before May 2007. For this reason some recent data are not included in the results of our investigations. For example, this includes information about distant (mystery blenny *Parablennius incognitus* Bath, 1968, golden goby *Gobius xanthocephalus* Heymer and Zander, 1992; *Syngnathus acus* Linnaeus, 1758; chameleon goby *Tridentiger trionocephalus* Gill, 1859) and neighbouring (bleak *Alburnus alburnus* Linnaeus, 1758; carp *C. carpio*; pike *Esox lucius* Linnaeus, 1758; goby *Gobius ophiocephalus* var. Ninni 1938; black goby *G. niger jozo* Linnaeus, 1758; ruffe *Gymnocephalus cernuus* Linnaeus, 1758; chub *Leuciscus cephalus* Smitt, 1895; sand goby *Neogobius fluviatilis fluviatilis* Pallas, 1814; racer goby *N. gymnotrachelus* Kessler, 1857; round goby *N. melanostomus* Pallas 1811; European perch *Perca fluviatilis* Linnaeus, 1758; tubenose goby *Proterorhinus marmoratus* Pallas, 1814; rodeus *Rhodeus sericeus amarus* Berg, 1949; roach *Rutilus rutilus* Linnaeus, 1758) alien species in coastal and inland water of Crimea that have been firstly registered during 2002-2006 (Boltachev et al. 2007).

### Analysis of distant species registration

In relation to salinity many of the encountered species are brackish organisms encountered both in the sea and in freshwater bodies. However, 59% of the registered species were attributed to the coastal ecosystem of the Black and Azov seas, 29% to brackish and 16% to freshwater areas. Most of the distant alien species (23 species of fish) were registered in the period from the beginning of 1950 to 1975 due to wide scale introduction of valuable varieties of fish in the water bodies of Ukraine and neighboring countries (Russian, Moldova, Belarus). Of the number of aliens observed in that period, 44% relate to introductions. However, of the above mentioned 23 fish species brought to Ukraine, only 4 species became naturalized. These were able to reproduce in new conditions without the help of man. These species include spotted silver carp *A. nobilis*, silver carp *H. molitrix* and grass carp *C. idella* among the freshwater hydrobionts



Figure 1. Ukrainian part of the Black Sea

and haarder *L. haematocheila* in the marine species (see Annex).

The process of successful introduction is linked with a number of biological, physical and chemical factors which at present cannot be accurately forecasted. Of the total number of registered species of distant aliens, only 30% (or 50 species) were naturalized, and today are part of the food web of Ukrainian aquatic ecosystems able to support their populations. Almost half of the species (41% or 69 species) were discovered no more than twice and in small amounts, and that is why they are placed in the casual category (Figure 2).

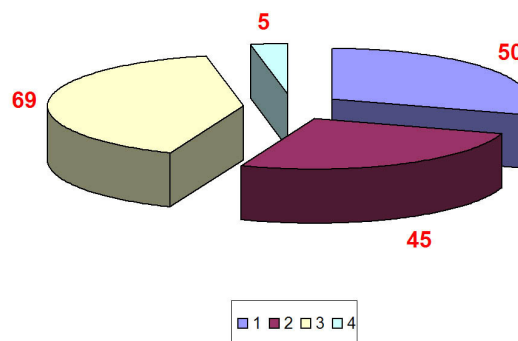
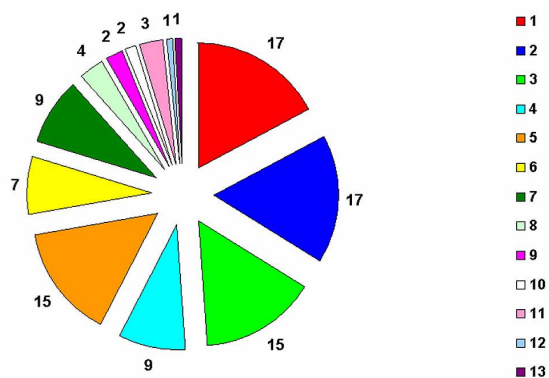
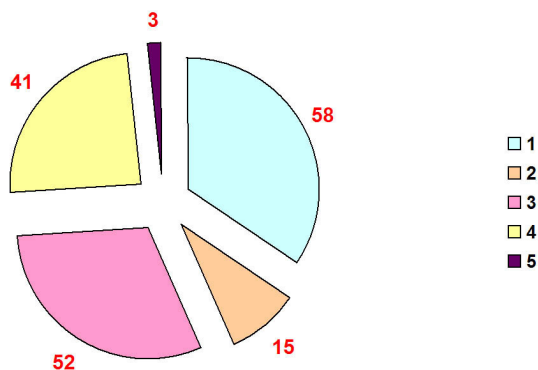


Figure 2. Ratio between main categories of distant alien species: 1 - Established (naturalized), 2 - Invasive, 3 - Casual, 4 - Cryptogenic. Total number of distant alien species is 169

In total, most of the registered number recorded in Ukrainian water bodies are distant aliens (Figure 3), with the majority of the species being either planktonic or fouling organisms (Figure 4).



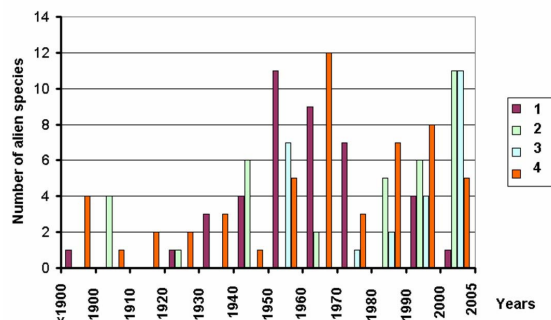
**Figure 3.** Main sources of alien species introduction into Ukrainian waters: 1 – Ponto-Caspian, 2 – Atlantic, 3 – SE Asia, 4 – N America, 5 – Other, 6 – Indo-Pacific, 7 – Europe, 8 – Atlantic, 9 – Indo-pacific, 10 – Atlantic Pacific, 11 – Pacific, 12 – Holarctic



**Figure 4.** Ratio of life forms of distant alien species (biological composition of distant alien species of Ukrainian aquatic ecosystems): 1 – Plankton, 2 – Fouling, 3 – Benthos, 4 – Nekton, 5 – Parasites

This confirms the key role of shipping in transferring aliens. Usually, benthic animals entered Ukrainian water bodies as result of ships’ hull fouling. The maximum number of recorded aliens occurred before the early 1970s (Figure 5). It is possible to explain the subsequent decline due to the widespread introduction of hull antifouling coatings. For example, in the 1970s, the overwhelming majority of ships’ hulls

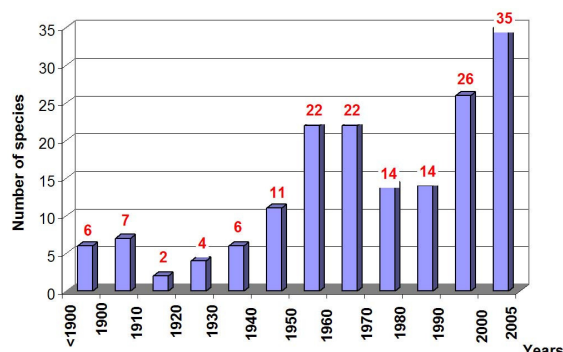
were coated with tributyltin (TBT), which protected the hulls from fouling for 18 to 24 months. Since then the number of cases of recorded planktonic organisms invasions has risen, due to ballast water exchange in tanker fleets (see Figure 5). The total tonnage of tankers in the 1980s made up 42% of the world total and determined their priority in cargo turnover (Marine encyclopedic reference... 1986).



**Figure 5.** Biological structure of distant alien species introduced into Ukrainian aquatic ecosystems: 1 – fish, 2 – phytoplankton, 3 – zooplankton, 4 – zoobenthos

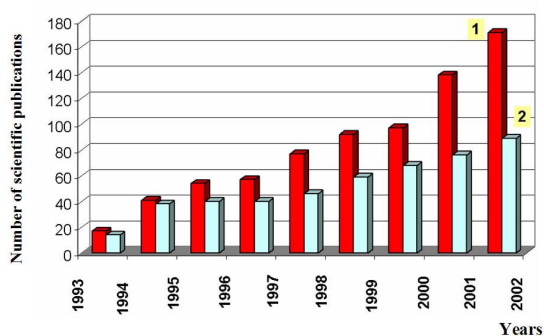
Since 1973, subsequent to the adoption of MARPOL -73/78, a measure to prevent pollution from ships, conditions for survival of hydrobionts in ballast tanks were much better due to isolation from oil products. This was another reason why the probability of transferring planktonic hydrobionts to new ecosystems has increased.

When characterizing the long-term dynamics of alien introduction records into Ukrainian water bodies, two maxima have been noted (Figure 6).



**Figure 6.** Long-term changes in distant alien species introduction

One of them, in the 1960-1970s, is connected with the introduction of fish in freshwater bodies and also with the establishment of new marine ports, increasing the risk of the introduction of aliens into the Black Sea. The second maximum has been recorded since the beginning of the new millenium and can be explained by two factors. On one hand, it can be explained by a large increase in ballast water transportation especially by the oil tanker fleet. On the other hand, there also has been a rise in scientific interest into the problems of biological pollution in the world's oceans resulting in a more comprehensive study of its biological structure. This can be illustrated by the increasing number of publications in the electronic abstract version of ASFA. In the past decade the number of publications on alien species and invasion has increased by 6-7 times (Figure 7).



**Figure 7.** Dynamics of scientific publications on invasive species. Source: Cambridge Scientific Abstract; key words 1 – “invasions”, 2 – “alien species”

Due to more intense biological studies in Ukraine the list of alien species was extended adding marine fungi – 7 species, infusorians – 6, parasites – 3 and unarmored Dynophyta – 11 species (see Annex). Due to the study of new previously un-studied systematic groups, 3% (or 5 species) of the aliens discovered were placed in the category “Cryptogenic” (see Figure 2)

The greatest numbers of distant species of freshwater hydrobionts were introduced and dispersed in the Ponto-Caspian basins. A small part moved up the Dnieper to the mid Dnieper – Danube province. Another fraction was introduced into northwestern Ukraine (Baltic province) and the Crimea. The Annex illustrates some species introduced into the upper Dnieper cascade from North Europe. These species are characteristic of the Baltic province. If the

Ukrainian water bodies of the Baltic basin were closely studied, they would have most likely have been found there. Probably, these species entered the Dnieper basin through a system of channels connecting it with the Baltic. In this case, if borders are not taken into consideration, then the introduction is similar to that in Annex 2 (nearby aliens).

Separate attention is necessary to focus on aquarium species. Subsequent introductions to waterbodies may occur unintentionally when emptying aquariums. One of the famous examples is killer algae *Caulerpa taxifolia* (M. Vahl) C. Agardh, 1817 that penetrated into Mediterranean coastal ecosystems from the aquarium of Monaco Oceanographic Institute.

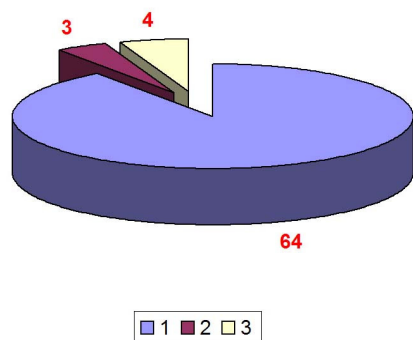
Most of the cultivated species in aquaria are of tropical or subtropical origin. As a rule, they survive in natural conditions of the area under study, being sensitive to lower temperatures. However, in the warm season they are encountered close to populated areas. Examples are aquarium fish like guppies and platies encountered episodically in the Dnieper Basin (Novitskij 2005), and piranha discovered in the summer, 2006, in Lake Kasyanka (Dnieper Basin) near Dnepropetrovsk. At present this invasion is being studied by specialists from Dnepropetrovsk National University (R. Novitskij, personal communication).

However, some of the aquarium species are able to form long-term populations in artificial water bodies (in cooling ponds) – *Ampullaria* sp., *Biomphalaria glabrata* Say, 1818, *Melanoides tuberculata* Müller, 1774; or even in the natural biotopes of most southern regions of Ukraine – *Craspedacusta sowerbyi* Lankester 1880, *Ferrissia fragilis* Tryon, 1863), *Physella heterostropha* (Say, 1817) (Protasov et al. 1981, Son 2007a).

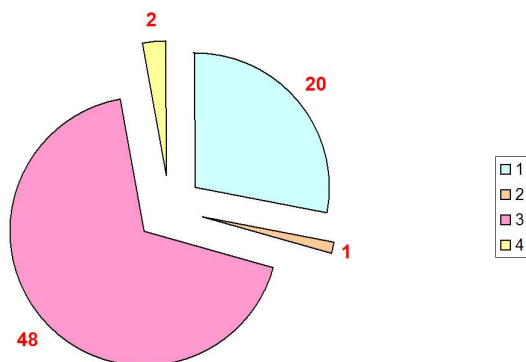
It is evident that most of the aquarium species of the populations formed in open water bodies are functional species (bloodfluke planorb *B. glabrata*, pewter physa *Ph. heterostropha*) and not cultivated decorative species which clean the aquarium of “aquarium weeds“ entering from one aquarium to another with sediments or plants (red-rimmed melania *M. tuberculata*, freshwater jellyfish *C. sowerbyi* Lankester 1880, freshwater limpet *F. fragilis*). All of these species have very a high fertility rate. The aquarium species of gastropods have asexual reproduction (Son 2007a). These specific ecological properties facilitate successful introductions.

*Analysis of neighbouring alien records*

The main feature of neighbouring species, which differentiate them from distant species is the high percentage of naturalized species present – 90% (Figure 8), and also the fact that most of the species records (68%) pertain to benthic organisms (Figure 9). The chronology of introducing species shows that their penetration into the water bodies of the Ukraine was linked with the wide scale melioration in 1950s, due to the withdrawal of runoff from the largest rivers of the Black Sea basins for agriculture purposes.



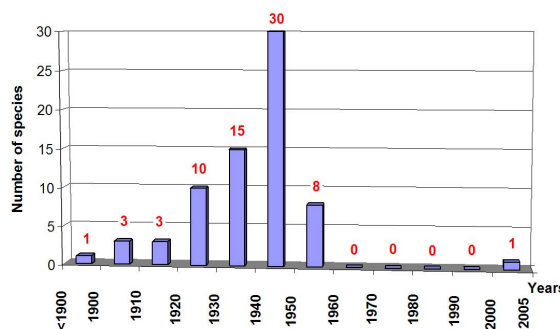
**Figure 8.** Ratio between main categories of neighbouring alien species: 1 - Established (naturalized), 2 - Invasive, 3 - Casual. Total number of nearby alien species is 71



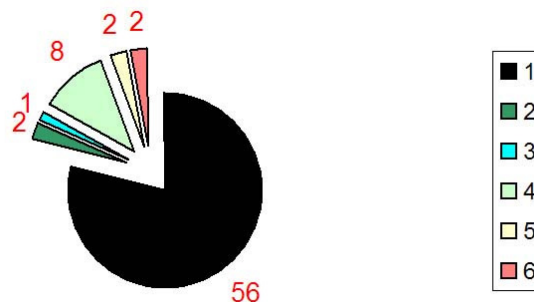
**Figure 9.** Ratio of life forms of neighbouring alien species in Ukrainian aquatic ecosystems: 1 - Plankton, 2 - Fouling, 3 - Benthos, 4 - Nekton

The subsequent introduction of hydrobionts in the late 1950s was not comparable in scale with the previous one (Figure 10). The dominant neighbouring species originated as Ponto-Caspian relicts, which due to the artificial integration of river systems have widespread in the Black – Azov sea basin (Figure 11).

When considering neighbouring aliens, cases of species introduction from adjacent biogeographically areas, such as the Ponto-Caspian into the European - Siberian area through the Dnieper reservoir cascade and inner waters of Crimea, should be of first priority. It is quite clear that first of all many freshwater, brackish Ponto-Caspian relicts were introduced, which were lacking previously from the European – Siberian sub-area. Hydrobionts were able to overcome the zoogeographical border along the Dnieper river bed after the removal of the barrier between Dnipropetrovsk and Zaporozhie following construction of a dam in Kichkas and after activating river shipping, dredging channels, setting up a reservoirs and after intentional introductions. This led to further distribution in the European-Siberian sub area: mid Dnieper (from it to the Don, then into the Volga) and upper Dnieper (from it the Baltic basin, then to West Europe and Britain).



**Figure 10.** Long-term changes of neighbouring alien species introduction into Ukrainian aquatic ecosystems



**Figure 11.** Main donor areas for neighbouring alien species introduction into the Ukrainian part of the Black Sea: 1 - Ponto-Caspian relicts, 2 - Black Sea, 3 - Mediterranean Sea, 4 - European water bodies, 5 - Holarctic, 6 - Cosmopolitan

It is known that separate species of hydrobionts with local areas in Europe as the cladocerans *Cercopagis pengoi* (Ostroumov, 1891), *Limnocletodes behning* (Borutzky, 1926), *Paraleptastacus spinicaudata* (T. Scott et A. Scott, 1895), and the amphipods *Rivulogammarus kischineffensis* (Schell.), *Synurella ambulans* (Müller, 1846) (see Annex) appeared in the Dnieper cascade also at the time of introduction of Ponto-Caspian fauna. These species, which have very wide natural habitat, are made up of several interrupted localities. This is characteristic to Ukraine as in the lower Dniester and Danube where there are many separate relict localities of species, the main ranges of which are in South or West Europe. Possibly, these species were introduced into the Dnieper water reservoir simultaneous with the mass introduction of Ponto-Caspian species as food resource for fish.

Besides being spread along the Dnieper, they penetrated to the Crimea. After the opening of the North-Crimean canal and as a result of introduction of food invertebrates in some water reservoirs in the peninsula, some species with a wide range of dispersal as crustaceans *Daphnia cucullata* Sars, 1862, *Leptodora kindtii* Focke, 1844, *Mesocyclops leucarti* Claus, 1857 and molluscs: river snail *Viviparus viviparus* Linnaeus, 1758; European fingernailclam *Sphaerium corneum* Linnaeus, 1758, *S. rivicola* Lamarck, 1818 were able to enter with representatives of the Ponto-Caspian fauna. Despite this there are some species, with a main range located in the European-Siberian sub area, which also entered the Crimea as Ponto-Caspian fauna, at the southern border of their distribution. The situation differs for three molluscs species *Fagotia danubialis* Bourguignat, 1884; gravel snail *Lithoglyphus naticoides* Pfeiffer, 1828 and freshwater nerite *Th. fluviatilis*. Their dispersal was first noted only in the Crimea but they, together with other species similar to the representatives of Ponto-Caspian fauna, have actively spread in Europe (see Annex). Often they are confused with Ponto-Caspian as most of the areas (lower Dnieper, South Bug, Dniester and Danube) coincide. However, in contrast to representatives of the Ponto-Caspian fauna, they have not been formed in the Sea of the Sarmat, but in rivers and are absolutely freshwater in nature. *L. naticoides* inhabits an isolated part of the area in the Baltic, while *F. danubialis* is found in the eastern tributaries of Pripyat. As for *Th. fluviatilis*, it pertains to a special

zoogeographical group of the most ancient representatives of Ponto-Caspian fauna. It was formed like the zebra mussel *D. polymorpha* in the Eastern Mediterranean basins, but then migrated to the northwestern Black Sea from which many new species emerged - classical Ponto-Caspian. In origin it is like the zebra mussel as it is traditionally classified as a Ponto-Caspian species. However, in Annex this species is noted as European as in the summary table, its affinity as a species is not related to the zoogeographical group, but to its natural range.

The classification of the molluscs in the European species category is attributed to the time of paleoinvasion *Th. fluviatilis* has kept to its localities in the Baltic, as well as in Spain. At present, it is actively spreading in Europe. In the Ukraine it has been inhabiting limans and rivers (in contrast to classical representatives of the Ponto-Caspian fauna it is native in upper stretches of the large rivers) and also in several marine bays (Odessa, Egorlitsky, Tendrovsky) earlier forming the avandelta of the Dnieper (Son 2005).. However, the marine part of its range does not border with the Chernaya River estuary. Evidently, it has been introduced to the Crimea like other species during faunal introductions from the lower Dnieper to mountainous water reservoirs.

#### *Economic prerequisites in biological invasions*

The presence of an indented coastline, deep water bays and limans promoted the establishment of a maximum amount of sea ports following intensive agricultural and industrial development in the Ukraine (see Figure 1), the largest of which are Odessa, Yuzhny, Ilyichovsk. In 2004 their annual turnover was more than a half of the sum total of 19 marine ports of Ukraine and amount to >60 mln. t (M t). By the way it is necessary to stress on the fact that main volum of shipping transportation in the Black Sea comes through Ukraine. For example at the same period (2004) cargo traffic of two main ports of Russian Federation (Novorossisk and Tuapse) was 89.8 M t, largest Black Sea ports in Constanza (Romania) – 50.43 M t, in Georgian ports (Poti, Supsa and Batumi) – 20.55 M t, in Bulgarian ports (Varna and Burgas) – 13.35 M t. Black Sea ports of Turkey (Istanbul, Darince, Zonguldag and Samsun) develop very quickly (Tokman 2005).

In the past 5 years (2001-2006) the total turnover of Ukrainian ports has increased 1.6 fold. Simultaneously, the volume of ballast water exchange increased; this is determined by the numbers of export-import operations. For example, in the port of Odessa in 2001, it increased 17% in comparison to the previous period, while in the port of Ilyichovsk it dropped by 54%. It has been estimated that in 2001 alone, more than 11 M t of ballast waters were discharged in ten of the largest ports of Ukraine (Savusin 2002).

Another pathway for the introduction of alien species are the estuarine ports Ust-Dunaisk (near the Danube), Belgorod-Dnestrovsk (near the Dniester), the ports of Nikolaev and Kherson (near the Dneipro-Bug Liman). Although their cargo turnover is less than those mentioned previously, there is a greater risk of transferring alien species from a more dense marine environment to a less dense freshwater when ballast waters are discharged. This is evident in the high number of acclimatized species discovered in the Danube delta (Alexandrov 2004). It should be noted that most of the above mentioned ports, e.g. Ust-Dunaisk, Belgorod-Dnestrovskiy, Ilyichovsk and Yuzhny have been established in the past 50 years during the period 1958-1980. This should be taken into consideration when analyzing the chronology of invasions.

The Northern Crimean canal has become a powerful man-made source of biological invasions for the freshwater water hydrobionts of the Crimea.

The first Dneiper water came to the Crimean Peninsula in 1963. Having filled up 8 water reservoirs it is supplied to the cities of Kerch, Feodosiya, Simferopol and Sevastopol with maximum consumption of 300 m<sup>3</sup>/sec.

The source of many biological invasions is the intentional introduction by man of valuable fish species for consumption. In addition to spreading naturalized fish e.g. haarder *Liza haematocheila* Temmnick and Schlegel, 1845 (= *Mugil soiuy* Basil and Europeski, 1855) and silver carp *Hypophthalmichthys molitrix* Valenciennes, 1844 which took place in the Black Sea basin, it allowed the simultaneous entry of other undesirable organisms. For example, some parasites, free-living algae, invertebrates and even fish as stone moroko *Pseudorasbora parva* Temminck and Schlegel, 1846 penetrated into the Black Sea. Fish introductions were carried out mostly in freshwater bodies. The existing network of rivers and streams in Ukraine is

closely tied with those in the neighboring Moldova Republic and the Russian Federation, which should be taken into considerations in terms of fish breeding. During the Russian Empire, work for the introduction of species was conducted 150 years ago under the guidance of the Russian Society for Acclimatization founded in 1857. Before the disintegration of the USSR almost 250 introductions of 35 fish and 13 invertebrate species were performed annually. Before 2000 almost 100 introductions of 16 fish and 2 invertebrate species have been carried out in Russia (Stroganov and Zadoenko 2000). As an example, the river nerite *Theodoxus fluviatilis* Linnaeus, 1758, belongs to a special zoogeographical group of the most ancient Ponto-Caspian fauna representatives. Similar to zebra mussel *Dreissena polymorpha* Pallas, 1771 they evolved in the basins of the Eastern Mediterranean, but migrated to the Ponto-Caspian area producing many new classical Ponto-Caspian species (Gelembiuk et al. 2006). Introductions of fish from the Russian Federation were also carried out. In Moldova, the introduction of fish was carried out in three stages. In the first stage in 1950-1961 there were organized introductions of Lake Chud whitefish *Coregonus lavaretus maraenoides* Poljakow 1874, European carp *Cyprinus carpio* Linnaeus 1758, zander (European pike-perch) *Stizostedion lucioperca* Linnaeus 1758, eastern bream *Abramis brama* Linnaeus 1758, roach *Rutilus rutilus heckeli* Nordmann 1840 and various sturgeons (Acipenseridae). In the second stage, 1961-1974, fishes were introduced from Chinese water bodies: silver carp *H. molitrix*, spotted silver carp *Aristichthys nobilis* Richardson 1846, grass carp *Ctenopharyngodon idella* Valenciennes 1844. In the third stage, 1974-1990, valuable varieties of fish from the freshwater bodies of the USA: smallmouth buffalo *Ictiobus bubalus* Rafinesque 1818, bigmouth (common) buffalo *Ictiobus cyprinellus* Valenciennes 1844, black buffalo *Ictiobus niger* Rafinesque 1818, channel catfish *Ictalurus punctatus* Rafinesque 1818, paddlefish (spadefish) *Polyodon spathula* Walbaum 1792 were introduced (Lobchenko 1999).

#### Acknowledgements

We are grateful to Dr. Frances Lucy (Institute of Technology Sligo, Ireland) for her comments and English editing. This study has been supported by the European Commission Sixth Framework

Programme Integrated Project ALARM (Assessing Large scale environmental Risks for biodiversity with tested Methods, contract GOCE-CT-2003-506675), and part of the EC FP6 Strategic Targeted Research Project DAISIE (Delivering Alien Invasive Species Inventories for Europe, contract SSPI-CT-2003-511202).

## References

- Alexandrov BG (2004) Problem of aquatic organisms' transportation by ships and some approaches for risk assessment of the new invasions. *Marine Ecological Journal* 3(1):5-17
- Alexandrov BG and Zaitsev YuP (1998) Black Sea biodiversity in eutrophication conditions In: Conservation of the Biological Diversity as a Prerequisite for Sustainable Development in the Black Sea Region. Kluwer Academic Publishers, Dordrecht: 221-234
- Alimov AF and Bogutskaya NG (eds) (2004) Biological invasions in aquatic and terrestrial ecosystems. KMK Scientific Press Ltd, Moscow, 436 pp
- Anisimova IM and Lavrovskiy VV (1983) *Ichthyology. Vysshaya shkola*, Moscow, 255 pp
- Anistratenko VV (1998) Handbook for identification of Pectinibranch gastropods of the Ukrainian fauna Part 1 Marine and brackishwater. *Vestnik Zoologii Suppl* 8:3-65
- Bacescu M (1954) Animal straine patrunse recent in bazinul Marii Negre, cu referinte speciale asupra prezentei lui *Urnatella gracilis* in Dunare. *Bulletin ICP Bucuresti*: 61-66
- Basilevich VM (1972) Zooplankton and its outflow in the Canal Dnieper-Krivoi Rog. Dissertation, Institute of Zoology, Kiev
- Belmonte G, Mazzocchi MG, Prusova IYu et al (1994) *Acartia tonsa*: a species new for the Black Sea fauna. *Hydrobiologia* 292/293:9-15
- Beshevely LE and Kalyagin VA (1967) On finding of the mollusc *Mya arenaria* L (Bivalvia) in the north-western Black Sea. *Vestnik Zoologii* 3:82-84
- Bodeanu N (1970) Contributions to the systematic and ecology of the benthic diatoms of the Romanian Black Sea littoral. *Revue Roumaine de Biologie Serie de Botanique* 15(1):9-18
- Bodeanu N (1993) Microalgal blooms in the Romanian area of the Black Sea and contemporary eutrophication conditions. *Toxic Phytoplankton Blooms Sea*: 203-209
- Boltachev AR (2006) The Modern state and changes of ichthyofauna in coastal sea water of the Crimea (Black Sea) In: Abstracts of the 1st Biannual Scientific Conference "Black Sea Ecosystem 2005 and Beyond" Istanbul, 8-10 May 2006:114-116
- Boltachev AR and Astakhov DA (2004) An Unusual Finding of Pennant Coralfish *Heniochus acuminatus* (Chaetodontidae) in Balaklava Bay (Sevastopol, Southwestern Crimea. *Voprosy Ichtiologii* 44(6): 853-854
- Boltachev AR and Yurakhno VM (2002) New evidences of the Black Sea ichthyofauna mediterraneanization. *Journal of Ichthyology* 42(9):713-719
- Boltachev AR, Daniluk ON and Is'kiv EP (2007) Active invasion of exotic species of fishes to a sea coastal zone and internal reservoirs of southwestern Crimea In: Abstracts of the International Scientific Conference "Natural and invasive processes of biovariety of water and ground ecosystems formation" Rostov-on-Don, June 5-8, 2007:58-59
- Boltachev AR, Daniluk ON and Pakhorukov NP (2003) About introduction of sunfish *Lepomis macrochirus* (Perciformes, Centrarchidae) into the inner ponds of Crimea. *Journal of Ichthyology* 43(9): 820-822
- Boltachev AR, Gaevskaya AV, Zuev GV et al (1999) The blue whiting (*Micromesistius poutassou* Riss, 1826) (Pisces: Gadidae) is the new species for the Black Sea ichthyofauna. *Ecologiya Morya* 48:79-82
- Boltachev AR, Zuev GV, Kornijchuk YuM et al (2000) Finding of Gilt Pilchard *Sardinella aurita* (Clupeidae) in the Black Sea of Crimea. *Journal of Ichthyology* 40(2):203-204
- Bryantzeva JuV (2005) Morphometry of the microalga *Apedinella spinifera* (Thronsen) Thronsen (Dictyochophyceae) from Sevastopol Bay, the Black Sea. *Morskoy Ekologicheskyy Zhurnal* 4(2):22
- Buchinsky P (1885) Brief sketch of the estuaries fauna of Novorossiysk region. *Zapisky Novorossiyskogo Obschestva Estestvoispytatelej* 10(1):11-23
- Carlton JT (1996) Biological invasions and cryptogenic species. *Ecology* 77:1653-1655
- Chukhchin VD (1961) Development of *Rapana (Rapana bezoar)* L in the Black Sea. *Tr Sevastopol Biol St* 14:163-168
- CONSERVATION OF BIODIVERSITY OF UKRAINE (2003) Second National Report (Eds. Ya Movchan and Yu Sheliag-Sosonko), Kiyv: "Khimdzhest" Publ.:110 pp
- Dediu II (1980) Amphipods of fresh and brackish waters of the southwestern USSR. *Shtiintsa, Kishinev*
- Delamure SL (1964) Fish of freshwater reservoirs. *Krym, Simpheropol*:78 pp
- Diripasko OA, Izergin LV, Yanovskiy EG et al (2001) Key of fishes of the Azov sea. In: Berdyansk: the Azov department of Southern SII of marine fish facilities and oceanography. The Newspaper Azov working, Berdyansk: 107
- Dmitrieva EV (1996) Fauna of Monogenoidea of far-east haarder (*Mugil soiyu*) in the Black Sea. *Vestnik Zoologii* 4-5:95-97
- Dobrynina TI (2001) Distribution of *Eocyzius orientalis* Daday, 1914 (Crustacea, Conchostraca) in Eastern Europe In: Proceedings of the US-Russia invasive species workshop, Borok: 43-44
- Drapkin EI (1953) New mollusc in the Black Sea. *Priroda* 9: 92-95
- Dubyna DV and Protopopova VV (1980) New for the USSR flora species of aquatic fern from the Azollaceae Family. *Ukrainskyi Botanicheskyy Zhurnal* 37(5):20-26
- EPA: United States Environmental Protection Agency (2001) <http://www.epagov/gmpo/nonindightml>
- EUROPEAN COMMISSION (2004) Environment Directorate-General LIFE Focus I Alien species and nature conservation in the EU. The role of the LIFE program, Luxembourg: Office for Official Publications of the European Communities, 2004 ([http://europaeu.int/comm/environment/life/infoproducts/aienspecies\\_enpdf](http://europaeu.int/comm/environment/life/infoproducts/aienspecies_enpdf))
- Gadzhiev DV (1963) Golland Crab in the Caspian Sea. *Priroda* 10:18-19
- Gavrilova NA (2001) Eutintinnus (Ciliophora: Oligotrichida: Tintinnidae) a new genus of Tintinnids for the Black Sea fauna. *Ecologiya Morya* 58:29-31
- Gavrilova NA (2005) New for the Black Sea Tintinnids species. *Ecologiya Morya* 69:5-11

- Gelembiuk GW, May GE and Lee CE (2006) Phylogeography and systematics of zebra mussels and related species. *Molecular Ecology* 15:1033–1050
- GESAMP (1997) (IMO/FAO/UNESCO-IOC/WMO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. *Rep Stud GESAMP* 58: 84 pp
- Gomoiu M-T and Skolka M (1996) Changements recents dans la biodiversité de la Mer Noire dûs aux immigrants In: Danube Delta – Black Sea System under Global Changes Impact, GEO-ECO-MARINA, RCGGM, 1, Bucuresti – Constanta:49–65
- Gomoiu M-T, Alexandrov B, Shadrin N et al (2002) The Black Sea – a recipient, donor and transit area for alien species In: Invasive aquatic species of Europe – distribution, impact and management. In: Leppakoski E, Gollasch S and Olenin S (eds) Kluwer Academic Publishers, Dordrecht: 341-350
- Grigorovich IA, MacIsaac HJ, Shadrin NV et al (2002) Patterns and mechanisms of aquatic invertebrate introductions in the Ponto-Caspian region. *Canadian Journal of Aquatic and Fisheries Sciences* 59:1189–1208
- Grinjevskiy MV, Tretiyak OM, Alimov SI et al (2001) Peculiar object of fisheries in aquaculture of Ukraine. *Svit, Kiev*, 164 pp
- Grossu AV (1951) *Potamopyrgus jenkinsi*, gastropod nou pentru apele continentale ale Republicii Populare Romine. *Comuniculare Academie R P R* 1(7):593–596
- Gubanova AD (1997) To the question on occurrence of *Acartia tonsa* Dana in the Black sea. In: Second Congr Ukr Hydroecolog Soc, Kiev 27-31 Octob. 1997:24-25
- Guslyakov NE and Gerasemiuk VP (1984) About some new and interesting species of diatom algae of the Black Sea. *Novosti Sistematiki Nizshikh Rastenij* 21:14–17
- Gusynskaya SL and Zhdanova GA (1978) Distribution of northern and estuarine-Caspian planktonic crustaceans in the Dnieper reservoirs. *Hydrobiologicheskij Zhurnal* 14(6):25–27
- IMO Bulletin (1998) To put an end to invasion of alien organisms as a result of their transportation with ballast water. October: 21 pp.
- Ioffe TsI (1968) Review of works performed in reservoirs for acclimatization of fish food invertebrates. *Izvestiya Gosudarstvennogo Nauchno-Issledovatel'skogo Instituta Ozerogo i Rechnogo Rybnogo Khozajstva* 67:7–29
- IUCN: International Union for the Conservation of Nature and Natural Resources <http://www.iucn.org>
- Ivoilov AA (1986) Classification and nomenclature of *Tribus tilapiini* (Cichlidae) – new subjects of fish industry on warm waters in USSR. *Voprosy Ihtologii* 26(3):355–366
- Karpevich AF (1975) Theory and practice of acclimatization of aquatic organisms. *Pishevaya promyshlennost, Moscow*:427 pp
- Karpevich AR and Bokova EI (1963) Transfer of fishes and aquatics invertebrate, held in USSR for 1960-1961. *Problems of Ichthyology* 2(27):366–395
- Kiseleva MI (2004) Polychaetes (Polychaeta) of the Azov and Black Sea. *Kola Sci Centre RAS, Apatity*: 409 pp
- Kolesnikova EA (2003) Harpacticoida species diversity change in the Black Sea Crimean coast. In: Ereemeev VN and Gaevskaya AV (eds) Modern condition of biological diversity in near-shore zone of Crimea (the Black Sea sector) *Ekosi-Gidrophizika, Sevastopol*: 267-270
- Konsulov AS and Kamburska LT (1998) Ecological determination of the new Ctenophora – *Beroe ovata* invasion in the Black Sea. *Trudove na Instituta po okeanologiya* 2:195–198
- Kopytina NI (2002) Comparative characteristic of marine cellulose decompose micobiota of some limans of north-western part of the Black Sea In: The Black Sea ecological problems: collected papers, SCSEIO, Odessa:99-102
- Kopytina NI (2004) Distribution of marine fungi in north-western part of the Black Sea In: X Congress of Ukrainian microbiologists, Odessa: 15-17 September 2004:218
- Kopytina NI (2006) New species of marine higher fungi for the Black Sea In: Problems of biological oceanography in the XXI century, International scientific conference, devoted to 135-th anniversary of IBSS, Sevastopol: 19-21 September 2006: in press
- Koshelev AV (2003) Introduction of *Cordylophora inkermanica* Marfenin (Hydrozoa, Clavidae) into the sea lagoons of the north-west part of the Black Sea In: Evolution of marine ecosystems impacted by introducers and artificial mortality of fauna, Azov, June 15-18, 2003:94-96
- Kozlov VI and Abramovich LC (1980) The fishermen reference book. *Rossselhozizdat, Moscow*:220 pp
- Krakhmalnyi OF (2001) *Gymnodinium radiatum* Kofoid & Swezy (Gymnodiniales, Dinophyta) – new species for Black Sea flora. *Ukainsky Botanicheskij Zhurnal* 58(5):593–595
- Kruglova VM (1961) The prospects for the acclimatization of some species of the Caspian fauna. *Trudy Vsesoyuznogo Gidrobiologicheskogo Obschestvava* 11:345–353
- Liakhov SM and Mordukhai-Boltovskoi FD (1973) On the distribution of *Jaera sarsi* Valkanov, 1936 (Crustacea, Isopoda) in the Volga basin. *Informatsionnyi Byulleten Biologia Vnutrennikh Vod* 20:29–33
- Lobchenko VV (1999) Introduction, acclimatization and biodiversity problem in Dniester river In: Biodiversity Conservation of the Dniester River Basin. Proceedings of the International Conference. Chisinau, October 7-9 1999:130-131
- Lyashenko AV, Sinitzina OO and Voloshkevich EV (2005) Exotic benthic invertebrates in the water bodies of the lower reaches of the Danube. *Hydrobiologicheskij Zhurnal* 41(4):46–56
- Makarov Yu. N. (2004) Fauna of Ukraine, T. 26, Vol. 1-2, Decapodes. *Naukova Dumka, Kiev*: 429 pp
- Maltsev VI (1997) Some parasitologic aspects of far-east haarder (*Mugil soiyuy*) introduction into the Azov and Black Sea basin. In: Proceeding the reports on Yang Sciences, Vladivostok: 49-54
- Marfenin NN (1983) A new species of the genus *Cordylophora* (Hydrozoa, Clavidae) from the Black Sea. *Zoologicheskij Zhurnal* 62(11):1732–1734 [in Russian]
- MARINE ENCYCLOPAEDIC REFERENCE BOOK. Vol 2 (O-Ya): (1986): Sudostroenie, Leningrad: 304-305
- Markovskij YuM (1954) Fauna of invertebrates of lower river's stretches of UkrSSR conditions of its occurring and ways ofutilization Part 2 Dniepr-Bug Liman. *Naukova Dumka, Kiev*: 208 pp
- Maslov II, Sarkina IS, Belich TV and Sadogurskiy SE (1998) Annotated catalogue of algae and fungi of Mys Martiyan reserve. *Yalta*:31 pp
- Mavrodiadi P (1908) Black Sea cirripedes and gregarines that are parasitic on them. *Zapisky Novorossijskogo Obschestva Estestvoispytatelej* 32:101–128
- Melnikov GB (1961) Zooplankton of the Simpheropol Reservoir in connection with specific conditions of occurring. *Trudy Vsesoyuznogo Gidrobiologicheskogo Obschestvava* 11:44–53

- Merezhkovsky KS (1902-1903) List of diatom algae of the Black Sea. *Botanicheskie Zapisky* 19:51–89
- Minicheva GG and Eremenko TI (1993) Algological discoveries in the north-western Black Sea. *Algologiya* 3(4):83–86
- Mironov SS, Shadrin NV and Grintsov VA (2002) New molluscs species in marine and continental waters of Crimea, the Black Sea. *Ekologiya Morya* 61:43
- Monchenko VI (1995) Harpacticoids (Copepoda, Harpacticoida) of the Dnieper River: Summary of faunistic investigations. *Hydrobiologicheskiy Zhurnal* 31(5):33–37
- Mordukhay-Boltovskoy FD (ed) (1972) Guide of the Black Sea and the Sea of Azov Fauna. V. 3. Naukova Dumka, Kiev:340 pp
- Mordukhay-Boltovskoy FD and Galinskii VT (1974) About further spread of Caspian polyphemids in the reservoirs of Ponto-Caspian rivers. *Informatsionnyi Byulleten Biologia Vnutrennikh Vod*, 21:40–44
- Morozova-Vodianitskaya NV (1948) Phytoplankton of the Black Sea Part I. *Sov Bot* 7:39–172
- Murina VV and Skulyari MA (2000) On finding of a new polychaete species (*Magelina mirabilis*, Polychaeta, Magelonidae) larva in the Black Sea. *Zoologicheskiy Zhurnal* 79(7):859–860
- Nabozhenko MV (2004) Bivalve molluscs (Mollusca, Bivalvia) of Taganrog Bay. In: *Materialy XXII konferentsii molodykh uchenykh*. Murmansk:69–74
- Nevrova EL (2003) Species abundance of the bottom diatom algae at the Crimean coast. In: Eremeev VN and Gaevskaya AV (eds) *Modern condition of biological diversity in near-shore zone of Crimea (the Black Sea sector)*. Ekosi-Gidrophizika, Sevastopol:271–277
- Nikolaenko AV and Reshetnikov VI (1991) Investigation of long-term changes of the freshwater balance in the Black Sea. *Vodnie Resursy* 1:20–28
- Novitskij RA (2005) To the question about invasion of alien species into fauna of Dnieper reservoirs In: *Alien species in Holarctic (Borok-2) Book of abstracts*. Rybinsk:35–36
- Ostroumov AA (1892) On the occasion of American Balanus in Sevastopol Bay. *Vestnik Estestvoispytateley*
- Parin NV (2003) *Liza haematocheila* – correct species name of haarder (Mugilidae). *Voprosy Ikhtiologii* 43(3):418–419
- Pereladov MV (1988) Some observations for biocenosis changes in Sudak Bay of the Black Sea / III All-Union konf on marine biology. V. 1. Naukova Dumka, Kiev:237–238
- Pligin YV and Yemelyanova LV (1989) Acclimatization of Caspian invertebrates in the Dnieper Reservoirs. *Hydrobiologicheskiy Zhurnal* 25(1):1–9
- Prokopov GA (2003) Fresh water fauna of the Chiornaya river basin. In: *Voprosy razvitiya Kryma* 5. Tavria plus, Simpheropol:151–174
- Protasov AA, Starodub KD and Afanas'ev SA (1981) A polyp of *Craspedacusta sowerbii* in the cooling reservoir of Chernobyl' Nuclear power station Ukrainian-SSR. *Vestnik Zoologii* 15:67–68
- Radashevsky VI and Pankova VV (2006) The morphology of two sibling sympatric *Polydora* species (Polychaeta: Spionidae) from the Sea of Japan. *Journal of Marine Biological Association of UK* 86:245–252
- Reingardt L (1909) Phytoplankton of the Black Sea, Kerch, Bosphorus, and Marmora Sea. *Trudy Obschestva Ispytateley Prirody pri Kharkovskom Universitete* 18:295–324
- Richardson DM, Pysek P, Rejmanek M et al (2000) Naturalization and invasion of alien plants: concepts and definitions. *Diversity and Distributions* 6:93–107
- Roginskaya IS and Grintsov VA (1990) Sea slug *Doridella obscura* Verill – new invader in the Black Sea. *Okeanologiya* 30 (5): 855–857
- Romanenko VD, Afanasiev SA, Petuhov VE et al (2003) Influencing of fish farming on biodiversity in basin the Dnieper: definition of gaps and problems. *Academy periodicals*, Kiev:187 pp
- Romanova ZA, Finenko GA and Shadrin NA (1999) First record of alien species *Beroe ovata* (Ctenophora) near the Crimea coast. *Vestnik Zoologii* 33(6):99
- Roschin AM, Chepurnov BA and Kostenko NG (1992) Diatom algae. Algae, fungi and muscoid of Karadag reserve In: *Flora and fauna of USSR reserves*. IEMEZH RAN, Moscow:7–17
- Salekhova LP, Kostenko NS, Bogdanchek TA et al (1987) Ichtyofauna composition in Karadag state reserve (Black Sea). *Voprosy Ikhtiologii* 27(6):898–905
- Savusin VP (2002) Ballast waters – the source of pollution of the sea environment In: *Protection of environment from anthropogenic impacts*. Ekspert, Kharkov-Kremenchug, T. 6(8):57–67
- Senicheva MI (1971) Composition and quantitative development of phytoplankton of neritic zone in Sevastopol area during autumn-winter 1968-1969. *Biologia moria* 24:3–12
- Senicheva MI (2002) New and rear diatom and dinoflagellate species of alga for the Black Sea. *Ekologia Morya* 62:25–29
- Senichkina LG (1983) Phytoplankton of the north-western part of the Black Sea in winter period In: *Sezonnie izmeneniya Chernomorskogo planktona*. Nauka, Moscow:55–65
- Shadrin NV (1999) Ecosystem functioning and economics: interrelations on global and local scales In: *Sevastopol aquatory and coast: ecosystem processes and services for human society*. Aquavita, Sevastopol:10–24
- Shadrin NV (2000) The species introducers in the Black Sea and in the Sea of Azov: the causes and consequences In: *Species introducers in the European seas in Russia*. Apatity:79–90
- Shadrin NV, Mironov SS and Golicov AN (2002) A finding of the alive *Neptunea arthritica* (Bernardi, 1857) (Gastropoda, Buccinidae) in the Black Sea. *Ekologiya Morya* 62:29
- Shcherbak GI (ed) (1989) *Invertebrates and fishes of the River Dnieper and its reservoirs*. Naukova Dumka, Kiev
- Shujskiy YuD (1989) Coastal zone of the sea. *Geographic encyclopedia of Ukraine*. V. 1. URE, Kiev:83
- Simkina RG (1963) To the ecology of *Perigonimus megas* Kinne (Hydroidea, Athecata) – a new species in the fauna of the USSR. *Trudy Instituta Oceanologii* 70:216–224
- Sinegub IA (1994) About spread of range of sea slug *Doridella obscura* Verrill in the Black Sea. *Hydrobiologicheskiy Zhurnal* 30(3):107–109
- Son MO (2005) Molluscs of genus *Theodoxus* Montfort, 1810 (Gastropoda, Neritidae) of Ukrainian Black Sea coast and hypothesis of its descent in Black Sea bays. In: *Molluscs, Quaternary, faunal changes and environmental dynamics* Symposium on occasion of 80th birthdays of Vojen Lozek. Prague
- Son MO (2006) Exotic molluscs (Mollusca: Bivalvia, Gastropoda) in fresh and brackish waters of Ukraine In: *Ekologo-funktsionalni ta faunistychni doslidzhennya molyuskiv, yih rol' u bioindykatsii navkolyshnyogo seredovystcha* Vypusk 2. Zhytomir State University, Zhytomir

- Son MO (2007a) Invasive molluscs in fresh and brackish waters of the Northern Black Sea Region. Druk LTD, Odessa:132 pp
- Son MO (2007b) North American freshwater limpet *Ferrissia fragilis* Tryon, 1863 – the cryptic invader in the Northern Black Sea Region. Aquatic invasions. 2(1): 55-58
- Starobogatov Yal (1970) The molluscan fauna and zoogeographical zoning of the continental water bodies of the world. Nauka, Leningrad: 372 pp
- Stemninskij L (1909) History of distribution of *Elodea canadensis* Mich in Russia. Trudy Botanicheskogo Sada Yurievskogo universiteta 10 (5):214–229
- Sroganova NZ and Zadoenko IN (2000) The artificial introduction of hydrobionts and its results. In: Species introducers in the European seas in Russia. Apatity:51-57
- Svetovidov AN (1964) Fishes of Black Sea. Nauka, Moscow
- Suchoivan PG and Vjatchanina LI (1989) Fishes. In: Invertebrates and fishes of Dnieper and its reservoirs. Naukova dumka, Kiev:136-173
- Suprunovich AV and Makarov YuN (1990) Food invertebrates: mussels, oysters, scallops, crawfishes and shrimps. Naukova Dumka, Kiev:263 pp
- Terenko LM (2003) Dinoflagellates as monitoring object in the urban area of the port of Odessa (Black Sea, Ukraine). In: Proc the 4th European Congress of Protistology and 10th European Conference on Ciliate Biology. San Benedetto del Tronto, 31 August – 5 September, 2003:126-127
- Terenko LM and Terenko GV (2000) Species diversity of the plankton phytocenosis in the Odessa Bay of the Black Sea. Ekologia Morya 52:56–59
- Terenko L and Terenko G (2005) Harmful dinoflagellates blooms off the Ukrainian Black Sea coast as effect eutrophication. In: International Conference “Hazardous algae – a problem for modern ecology. Gdansk, 18 – 19 May 2005:29–30
- Therriault TW, Docker MF, Orlova MI et al (2004) Molecular resolution of the family Dreissenidae (Mollusca: Bivalvia) with emphasis on Ponto-Caspian species, including first report of *Mytilopsis leucophaeata* in the Black Sea basin. Molecular and Phylogenetic Evolution 30 (3):479–489
- Tkachenko PV (2005) A Find of the Sparus aurata (Perciformes, Sparidae) in the northwestern part of the Black Sea. Vestnik Zoologii 39(2):89–90
- Tokman G (2005) From Europe to Asia by Sea. BLACK SEA TRANS, International transport journal, № 2, <http://www.blackseatrans.com/bst/eng/2005-2/05.php>
- Tretyak OM (1996) Biological fundamentals of breeding and cultivation bigmouth Buffalo on the basis of cooling pools of Energy Power Stations (on an example of pooling pools of Burshtyn EPS). Dissertation. Kiev:28 pp
- Tseeb YaYa (1965) Ivan Ivanovitch Puzanov. Hydrobiologicheskyy Zhurnal 1(3):66–68 [in Russian]
- Tseeb YaYa (Editor) (1964) Kakhovka reservoir Hydrobiological survey. Naukova Dumka, Kiev
- Tseeb YaYa and Olivari GA (1958) Introducing food invertebrates into the Kakhovka reservoir. Dopovidi Akademii Nauk Ukrajinjskoji RSR 3:330–334
- Turanov VF and Turanova YaV (2003) Breeding and rearing of the fresh water shrimp *Macrobrachium rosenbergii* on the South of Ukraine. Rybnoe Khozyajstvo Ukrainy 3(4):47–48
- Usachev PI (1928) On the phytoplankton of the Sea of Azov. Dnevnik Vsesoyuznogo S'ezda Botanikov:64–70
- Vinogradov AK (1986) Toxicity of highly mineralized industrial wastes on the marine hydrobionts. Naukova Dumka, Kiev:160 pp
- Voloshkevich EV and Son MO (2002) *Corbicula fluminalis* – a new species of bivalve molluscs in the fauna of Ukraine. Vestnik Zoologii 36(6):94
- Volovik SP and Dubinina VG and Semenov AD (1993) Hydrobiology and dynamics of fisheries in the Azov Sea. Studies and Reviews General Fisheries Council for the Mediterranean 64 (2):1–58
- Vorobyova LV (1977) About interstitial fauna of sandy beaches. Hydrobiologicheskyy Zhurnal 13(3):65–67
- Vovk PS (1963) Results and perspectives of working on enrichment of Ukrainian inland water by valuable species of fish. In: Akklimatizatsiya zhivotnyh v SSSR. Alma-Ata:225-228
- Vovk PS (1976) Biology of Far Eastern phytophagous fishes and theirs economical usage in Ukrainian water bodies. Naukova Dumka, Kiev:245 pp
- Wilke T, Albrecht C, Anistratenko VV, Sahin SK and Yildirim MZ (2007) Testing biogeographical hypotheses in space and time: Faunal relationships of the putative ancient lake Egirdir in Asia Minor. Journal of Biogeography (in print).
- Yanushevich AI (ed) (1966) Acclimatization of animals in the USSR. Israel Program for Sci Translations, Jerusalem
- Yurishinets BI and Korniyushin AV (2001) New species of bivalve mollusk for Ukraine *Sinanadonta woodiana* (Bivalvia, Unionidae), its diagnostic and possible paths of introduction. Vestnik Zoologii. 35(1):79–84
- Zagorodnyaya YuA (2002) *Oithona brevicornis* in the Sevastopol Bay: is it a single event or a new invader in the Black Sea fauna? Ekologiya Morya 61:43
- Zagorodnyaya YuA and Kolesnikova EA (2003) To the problem of the alien copepod species introduction into the Black Sea In: Evolution of marine ecosystems impacted by introducers and artificial mortality of fauna. Azov, June 15-18, 2003:80-82
- Zagorovskiy N and Rubinshtein D (1916) Materials to systems of biocenosis of Odessa Bay. Zapiski Imperatorskogo Obschestva Sel'skogo Khozyajstva Yuzhnoj Rossii 86(1):203–241
- Zaika VE, Kiseleva MI, Mikhailova TV et al (1992) Long-term changes in the Black Sea zoobenthos. Naukova Dumka, Kiev:248 pp
- Zaitsev YuP (1992) Ecological state of the Black Sea shelf zone near the Ukrainian coast (a review). Hydrobiologicheskyy Zhurnal 28 (4):3–18
- Zaitsev Yu (1998) Marine hydrobiological investigations of National Academy of Sciences of Ukraine in 1990s of XX century: shelf and coastal water bodies. Hydrobiologicheskyy Zhurnal 34(6):3–21
- Zaitsev YuP and Alexandrov BG (Compilers) (1998) Black Sea Biological Diversity: Ukraine Black Sea Environmental Series, Volume 7, United Nations Publications, New-York:351 pp
- Zaitsev Yu, Alexandrov B, Berlinsky N et al (2004) Basic biological investigations of Odessa maritime port (August-December, 2001): final report. GloBallast Monograph Series, N 7. IMO, Odessa:171 pp
- Zaitsev Yu and Mamaev V (1997) Marine Biological Diversity in the Black Sea: A study of Change and Decline Black sea Environmental Series, Volume 3. United Nations Publications, New-York: 208 pp
- Zaitsev Yu and Ozturk B (2001) Exotic species in the Aegean, Marmara, Black, Azov and Caspian seas. Turkish Marine Research Foundation, Istanbul:265 pp
- Zaitsev YuP, Vorobyova LV and Alexandrov BG (1988) A northern source of replenishment of the Black Sea fauna. Doklady AN UkrSSR 11:61–63

- Zambriborsch FS (1958) Representative of a new Class of invertebrate, Kamptozoa, in USSR fresh waters. *Zoologicheskij Zhurnal* 37, 11:1741
- Zhukinskyi BN (1959) Acclimatization of new fish species in the Ukrainian water bodies. The report of a military hunter and fisher 1(13):47–50
- Zhuravel PA (1950) About forming of biological conditions of reservoirs of South-East Ukraine and ways of enrichment of its native forage (for fish) resources. Dissertation, Dnepropetrovsk State University:28 pp
- Zhuravel PA (1961) Some consideration of introducing new species of fish forage fauna into the Crimean reservoirs. *Trudy Vsesoyuznogo Gidrobiologicheskogo Obschestvava* 11:338–344
- Zhuravel PA (1965) About acclimatization of fauna of Caspian type in water bodies of Ukraine. *Hydrobiologicheskij Zhurnal* 1(3):59–65
- Zhuravel PA (1967) On *Dreissena bugensis* spread in man-made water bodies. *Hydrobiologicheskij Zhurnal* 3(2):87–90
- Zhuravel PA (1969) On the range extension of some estuarine-Caspian invertebrates. *Hydrobiologicheskij Zhurnal* 5:1152–1162
- Zhuravel PA (1974) Acclimatization of forage estuarine-Caspian fauna into the reservoirs and lakes of USSR. *Izdatelstvo Dnepropetrovskogo Universiteta, Dnepropetrovsk*:124 pp
- Zolotarev V (1996) The Black Sea ecosystem changes related to the introduction of new mollusc species. *Marine Ecology* 17 (1–3):227–236
- Zolotarev VN and Zolotarev PN (1987) Bivalve *Cunearca cornea* a new element of the fauna in the Black Sea. *Doklady Akademii Nauk SSSR* 297:501–503
- Zuev GV and Boltachev AR (1998) The life history characters of the haarder (*Mugil so-iuy* Basilewsky, 1855) at the Crimean western coast. *Ekologiya Morya* 47:29–33

**Annex**

## Check-list of aquatic alien species of Ukraine

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<b>Fungi, ANAMORPHIC</b>								
<i>Cirrenalia basiminuta</i> (Kaghu-Kumar and Zainal, 1988)	2001	-	-	Indo-Pacific	Unintentional	Ships	Unknown	Kopytina 2002
<i>Cumulospora marina</i> (Schmidt, 1985) = <i>Vesicularia marina</i> (Schmidt, 1974); <i>Basramyces marinus</i> (Abdullah, Abdulkadder and Goos, 1989)	2001	-	-	Indo-Pacific	Unintentional	Ships	Unknown	Kopytina 2006
<i>Cumulospora varia</i> (Chatmata and Somrithipol, 2004)	2004	-	-	SE Asia	Unintentional	Ships	Unknown	Kopytina 2006
<b>Fungi, ASCOMYCOTA</b>								
<i>Lulworthia uniseptata</i> (Nakagiri, 1984)	2001	-	-	SE Asia	Unintentional	Ships	Unknown	Kopytina 2002
<i>Savoryella lignicola</i> (Jones and Eaton, 1969)	2001	-	-	Cosmopolitan	Unintentional	Ships	Unknown	Kopytina 2004
<i>Zopfiella latipes</i> (Malloch and Cain, 1971)	2001	-	-	Indo-Pacific	Unintentional	Ships	Unknown	Zaitsev et al. 2004, Kopytina 2006
<i>Glioniella clavatispora</i> (Steinke and Hyde, 1997)	2002	-	-	Indo-Pacific	Unintentional	Ships	Unknown	Kopytina 2004
<b>Microalgae, BACILLARIOPHYTA</b>								
<i>Toxonidea insignis</i> (Donkin, 1858)	1902	-	-	N Atlantic	Unintentional	Ships	Unknown	Merezhkowsky 1902-1903
<i>Cocconeis britannica</i> (Naegeli, 1849)	1902	-	-	N Atlantic	Unintentional	Ships	Unknown	Merezhkowsky 1902-1903
<i>Pinnularia trevelyana</i> ((Donkin) Rabenh., 1861)	1902	-	-	N Atlantic	Unintentional	Ships	Unknown	Merezhkowsky 1902-1903
<i>Bacteriastrum hyalinum</i> (Lauder, 1864)	1907	-	-	Atlantic	Unintentional	Ships	Unknown	Reingardt 1909
<i>Pseudosolenia calcaravis</i> (Sundström, 1986)	1924	-	-	Atlantic, Indo-Pacific	Unintentional	Ships	Unknown	Usachev 1928
<i>Asterionellopsis glacialis</i> (Round, 1990)	1967	-	-	Atlantic	Unintentional	Ships	Unknown	Senicheva 1971
<i>Navicula finmarchica</i> (Cleve and Grunow, 1880)	1970	-	-	N Atlantic, Pacific	Unintentional	Ships	Unknown	Bodeanu 1970
<i>Achnanthes pseudogroenlandica</i> (Hendey, 1964)	1984	-	-	Atlantic	Unintentional	Ships	Unknown	Guslyakov and Gerasemiuk 1984, Nevrova 2003
<i>Undatella quadrata</i> ((Brebisson) Paddock and Sims, 1980)	1985	-	-	N Atlantic	Unintentional	Ships	Unknown	Roschin et al. 1992
<i>Nitzschia sigmoidea</i> (Nitzsch, 1817), (Smith, 1853)	1986	-	-	N Atlantic	Unintentional	Ships	Unknown	Roschin et al. 1992

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Thalassiosira nordenskiöldii</i> (Cleve, 1873)	1986 2000	-	-	N Atlantic	Unintentional	Ships	Unknown	Shadrin 2000, Terenko and Terenko 2000
<i>Skeletonema subsalsum</i> (Bethge, 1928)	1993	-	-	N Atlantic	Unintentional	Ships	Unknown	Bodeanu 1993
<i>Lioloma pacificum</i> (Hasle, 1996)	1999	-	-	Indo-Pacific	Unintentional	Ships	Unknown	Terenko and Terenko 2000
<i>Chaetoceros diversus</i> var. <i>papilionis</i> (Senicheva, 2002)	1999	-	-	Pacific	Unintentional	Ships	Unknown	Senicheva 2002
<i>Chaetoceros tortissimus</i> (Gran, 1900)	2001	-	-	N Atlantic	Unintentional	Ships	Unknown	Senicheva 2002
<b>Microalgae, CHLOROPHYTA</b>								
<i>Hillea fusiformis</i> (Schiller, 1925)	1948	-	-	Mediterranean	Unintentional	Ships	Unknown	Morozova-Vodyanitskaya 1948
<i>Pterosperma cristatum</i> (Schiller, 1925)	1948	-	-	Mediterranean, Pacific	Unintentional	Ships	Unknown	Morozova-Vodyanitskaya 1948
<i>Pterosperma joergenseni</i> (Schiller, 1925)	1948	-	-	Mediterranean	Unintentional	Ships	Unknown	Morozova-Vodyanitskaya 1948
<i>Poropila dubia</i> (Schiller, 1925)	1948	-	-	Mediterranean	Unintentional	Ships	Unknown	Morozova-Vodyanitskaya 1948
<i>Pyramimonas longicauda</i> (Van Meel, 1984)	2001	-	-	Pacific	Unintentional	Ships	Unknown	Zaitsev et al. 2004
<b>Microalgae, CHRYSOPHYTA</b>								
<i>Octactis octonaria</i> (Hovasse, 1946)	1948	-	-	Mediterranean	Unintentional	Ships	Unknown	Morozova-Vodyanitskaya 1948
<i>Apedinella spinifera</i> (Thronsen, 1971)	1999	-	-	Atlantic Mediterranean Pacific	Unintentional	Ships	Unknown	Terenko and Terenko 2000, Bryantzeva 2005
<b>Microalgae, DYNOPHYTA</b>								
<i>Prorocentrum minimum</i> (Schiller, 1933)	1948	-	-	Cosmopolitan	Unintentional	Ships	Unknown	Morozova-Vodyanitskaya 1948
<i>Pronoctiluca pelagica</i> (Fabre-Domergue, 1889)	1983	-	-	Atlantic, Mediterranean	Unintentional	Ships	Unknown	Senichkina 1983
<i>Gymnodinium radiatum</i> (Kofoid and Swezy, 1921)	1998	-	-	Pacific	Unintentional	Ships	Unknown	Krakhmalnyi 2001
<i>Gymnodinium uberrimum</i> (Kofoid and Swezy 1921)	1999	-	-	Europe	Unintentional	Ships	Unknown	Terenko and Terenko 2000
<i>Alexandrium acatenella</i> ((Whed. and Kof.) Balech, 1985)	2001	-	-	Pacific	Unintentional	Ships	Unknown	Zaitsev et al. 2004
<i>Alexandrium affine</i> (Balech, 1985)	2001	-	-	SE Asia	Unintentional	Ships	Unknown	Zaitsev et al. 2004
<i>Spatulodinium pseudonoclituca</i> (Cachon and Cachon, 1967)	2001	-	-	N America, Atlantic, Mediterranean	Unintentional	Ships	Unknown	Terenko 2003

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Gyrodinium impudicum</i> (Fraga and Bravo, 1995)	2001	-	-	Atlantic, Mediterranean, Pacific	Unintentional	Ships	Unknown	Terenko 2003
<i>Alexandrium tamarense</i> (Balech, 1995)	2001	-	-	Cosmopolitan	Unintentional	Ships	Unknown	Zaitsev et al. 2004
<i>Cochlodinium polykrikoides</i> (Margelef, 1961)	2001	-	-	N America Indo-Pacific	Unintentional	Ships	Unknown	Terenko 2003
<i>Alexandrium pseudogonyaulax</i> (Horiguchi ex Yuki and Fukuyo, 1992)	2002	-	-	SE Asia	Unintentional	Ships	Unknown	Terenko 2003
<i>Gymnodinium aureolum</i> (Hansen, 2000)	2002	-	-	N America	Unintentional	Ships	Unknown	Terenko 2003
<i>Gyrodinium instriatum</i> (Freudental and Lee 1963)	2003	-	-	Atlantic Pacific	Unintentional	Ships	Unknown	Terenko and Terenko 2005
<b>Macroalgae, PHAEOPHYTA</b>								
<i>Desmarestia viridis</i> (Lamouroux, 1813)	1992	-	-	Atlantic	Unintentional	Ships	Unknown	Minicheva and Eryomenko 1993
<b>Macroalgae, FUCOPHYCEAE</b>								
<i>Ectocarpus caspicus</i> (Henckel, 1909)	1980	-	-	Caspian	Unintentional	Ships	Unknown	Maslov et al. 1998
<b>Higher plants, POLYPHODIOPHYTA</b>								
<i>Azolla filiculoides</i> (Lamarck, 1783)	-	1970s	1970s	N America	Unknown	Ornamental trade	Unknown	Dubyna and Protopopova 1980
<i>Azolla caroliniana</i> (Willdenow, 1810)	-	1970s	1970s	N America	Unknown	Ornamental trade	Unknown	Dubyna and Protopopova 1980
<b>Higher plants, MAGNOLIOPHYTA</b>								
<i>Elodea canadensis</i> (Michaux, 1791)	-	1890s	-	N America	Unknown	Ornamental trade	Competition, habitat modification	Stemninskij 1909
<b>Ciliata, OLIGOTRICHA</b>								
<i>Eutimninus lusus-undae</i> (Entz, 1885)	2001	-	-	Indo-Pacific Mediterranean	Unintentional	Ships	Unknown	Gavrilova 2001
<i>Eutimninus tubulosus</i> (Kofoid and Campbell, 1939)	2001	-	-	Atlantic, Indo-Pacific	Unintentional	Ships	Unknown	Gavrilova 2005
<i>Eutimninus apertus</i> (Kofoid and Campbell, 1929)	2002	-	-	Pacific	Unintentional	Ships	Unknown	Gavrilova 2005
<i>Eutimninus hastae</i> (Taniguchi and Hada, 1981)	2002	-	-	Pacific	Unintentional	Ships	Unknown	Gavrilova 2005
<i>Salpingella</i> sp. ( <i>rotundata</i> ?) (Kofoid and Campbell, 1929)	2002	-	-	Pacific	Unintentional	Ships	Unknown	Gavrilova 2005
<i>Favella brevis</i> (Jørgensen, 1924)	2002	-	-	Mediterranean	Unintentional	Ships	Unknown	Gavrilova 2005
<b>Coelenterata, HYDROZOA</b>								
<i>Craspedacusta sowerbii</i> (Lankester, 1880)	-	1950s	-	S America	Unintentional	Ornamental trade	Unknown	Protasov et al. 1981
<i>Cordylophora caspia</i> (Pallas, 1771)*	-	1950s	-	Ponto-Caspian	Unintentional	Ships	Fouling	Zhuravel 1965

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Blackfordia virginica</i> (Mayer, 1910)	1960s	-	-	N America	Unintentional	Ships	Unknown	Zaitsev et al. 2004
<i>Bougainvillia muscus</i> (Van Beneden, 1844)	1960	-	-	Atlantic	Unintentional	Ships	Unknown	Simkina 1960
<i>Tiaropsis multicirrata</i> (Sars, 1835)	1990	-	-	N Atlantic	Unintentional	Ships	Unknown	Shadrin 1999
<i>Eudendrium vaginatum</i> (Allman, 1863)	1990	-	-	N Atlantic	Unintentional	Ships	Unknown	Shadrin 1999
<i>Eudendrium capillare</i> (Allman, 1856)	1990	-	-	N Atlantic	Unintentional	Ships	Unknown	Shadrin 1999
<i>Cordylophora inkermanica</i> (Marfenin, 1983)*	2002	-	-	BS	Unintentional	Ships	Fouling	Marfenin 1983, Koshelev 2003
<b>Ctenophora, CTENOPHORA</b>								
<i>Mnemiopsis leidyi</i> (Agassiz, 1865)	1982	-	-	Atlantic	Unintentional	Ships	Predation	Pereladov 1988, Zaitsev et al. 1988, Volovik et al. 1993
<i>Beroe ovata</i> (Bruguère, 1789)	1997	-	-	Atlantic (Mediterranean)	Unintentional	Ships	Predation	Konsulov and Kamburska 1998, Zaitsev 1998, Romanova et al. 1999
<b>Plathelminthes, MONOGENOIDEA</b>								
<i>Ligophorus kaohsianghsieni</i> (Gussev, 1962)	1994	-	-	SE Asia	Unintentional	Acclimatization of fish	parasite	Dmitrieva 1996
<i>Gyrodactylus mugili</i> (Zhukov, 1970)	1995	-	-	SE Asia	Unintentional	Acclimatization of fish	parasite	Maltsev 1997
<i>Gyrodactylus zhukovi</i> (Ling, 1962)	1995	-	-	SE Asia	Unintentional	Acclimatization of fish	parasite	Maltsev 1997
<b>Annelida, POLYCHAETA</b>								
<i>Hypania invalida</i> (Grube, 1860)*	-	1950s	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1974
<i>Hypaniola kowalewskii</i> (Grimm, 1877)*	-	1956	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1974
<i>Hesionides arenarius</i> (Friedrich, 1937)	1960s	-	-	Atlantic, Mediterranean, Pacific	Unintentional	Ships	Unknown	Vorobyova 1977
<i>Ancistrosyllis tentaculata</i> (Treadwell, 1941)	1960s	-	-	Atlantic	Unintentional	Ships	Unknown	Shadrin 1999
<i>Ficopomatus enigmaticus</i> (Fauvel, 1923) = <i>Mercierella enigmatica</i> (Fauvel, 1923)	1961	-	-	SE Asia	Unintentional	Ships	Fouling	Zaitsev et al. 2004
<i>Polydora cornuta</i> (Bosk, 1802) first identified as <i>Polydora ciliata</i> (Johnston, 1838)	1962	-	-	Cosmopolitan	Unintentional	Ships	Fouling	Radashevsky and Pankova 2006
<i>Manayunkia caspica</i> (Annenkova, 1929)*	-	1963	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Glycera capitata</i> (Oersted, 1843)	1970s	-	-	Atlantic, Pacific	Unintentional	Ships	Unknown	Mordukhay-Boltovskoy 1972, Kiseleva 2004

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Nephtys ciliata</i> (Muller, 1776)	After 1975	-	-	Atlantic, Pacific	Unintentional	Ships	Unknown	Mordukhay-Boltovskoy 1972
<i>Magelona mirabilis</i> (Johnston, 1845) = <i>M. papillicornis</i> (Muller 1858)	1997	-	-	Mediterranean N Atlantic	Unintentional	Ships	Unknown	Murina Skulyari 2000
<b>Annelida, OLIGOCHAETA</b>								
<i>Tubificoides benedii</i> (Udekem, 1855)	1916	-	-	N America	Unintentional	Ships	Fouling	Zagorovskiy and Rubinshtein 1916
<i>Limnodrilus newaensis</i> (Michaelsen, 1902) = <i>Tubifex newaensis</i> (Brinkhurst, 1963)*	-	1955	-	Ponto-Caspian	Unintentional	Ships	Unknown	Zhuravel 1974
<i>Psammoryctes deserticola</i> (Grimm, 1876) = <i>Ilyodrilus raduli</i> (Jaroschenko, 1948); <i>Tubifex deserticola</i> (Ostroumov, 1897)*	-	1989	-	Ponto-Caspian	Unintentional	Canals	Unknown	Grigorovich et al. 2002
<b>Annelida, HIRUDINEA</b>								
<i>Cystobranchus fasciatus</i> (Kollar, 1842)*	-	1974	-	Ponto-Caspian	Unintentional	Ships	Parasite	Pligin and Yemelyanova 1989
<b>Crustacea, CONCHOSTRACA</b>								
<i>Eocyzicus orientalis</i> (Daday, 1914)	-	1981	-	Asia	Unintentional	Unknown	Habitat modification	Dobrynina 2001
<b>Crustacea, CLADOCERA</b>								
<i>Bosmina coregoni</i> (Muller, 1867)	-	1950s	-	North Europe	Unintentional	Ships	Unknown	Alimov and Bogutskaya 2004
<i>Bosmina crassicornis</i> (Lillieborg, 1887)	-	1950s	-	North Europe	Unintentional	Canals	Unknown	Shcherbak 1989
<i>Bosmina kessleri</i> (Uljanin, 1875)	-	1950s	-	North Europe	Unintentional	Canals	Unknown	Alimov and Bogutskaya 2004
<i>Eubosmina longispina</i> (Leydig, 1860)	-	1950s	-	North Europe	Unintentional	Canals	Unknown	Shcherbak 1989
<i>Daphnia cucullata</i> (Sars, 1862)*	-	1955	-	Holarctic	Intentional	Acclimatization of forage fauna for fish	Unknown	Melnikov 1961
<i>Leptodora kindtii</i> (Focke, 1844)*	-	1955	-	Holarctic	Intentional	Acclimatization of forage fauna for fish	Predation	Melnikov 1961
<i>Cercopagis pengoi</i> (Ostroumov, 1891) = <i>C. tenera</i> (Sars, 1897)*	-	1959	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Predation	Gusynskaya and Zhdanova 1978
<i>Cornigerius maeoticus maeoticus</i> (Pengo, 1879) = <i>Evadne cornigera</i> (Sars, 1902)*	-	1959	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Mordukhai-Boltovskoi and Galinskii 1974
<i>Podonevadne trigona</i> (Sars, 1897)*	-	1960s	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1969
<i>Cornigerius bicornis</i> (Zernov, 1901)*	-	1966	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Basilevich 1972
<i>Cornigerius lacustris</i> (Spandl, 1923)*	-	1970s	-	Ponto-Caspian	Unknown	Unknown	Unknown	Basilevich 1972

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<b>Crustacea, COPEPODA</b>								
<i>Eudiaptomus gracilis</i> (Sars, 1862)	-	1950s	-	North Europe	Unintentional	Canals	Unknown	Grigorovich et al. 2002
<i>Eudiaptomus graciloides</i> (Sars, 1886)	-	1955	-	North Europe	Unintentional	Canals	Unknown	Tseeb 1964
<i>Mesocyclops leucarti</i> (Claus, 1857)*	-	1955	-	Cosmopolitan	Intentional	Acclimatization of forage fauna for fish	Unknown	Melnikov 1961
<i>Heterocope appendiculata</i> (Sars, 1863)	-	1957	-	North Europe	Unintentional	Canals	Unknown	Gusynskaya and Zhdanova 1978
<i>Calanipeda aquaedulcis</i> (Kritschagin, 1873) = <i>Popella guernei</i> (Richard, 1888)*	-	1960s	-	Ponto-Caspian	Unintentional	Acclimatization of forage fauna for fish	Unknown	Karpevich 1975
<i>Heterocope caspia</i> (Sars, 1897)*	-	1962	-	Ponto-Caspian	Unintentional	Canals	Unknown	Zhuravel 1969
<i>Acartia tonsa</i> (Dana, 1849) = <i>Acanthacartia tonsa</i> (Dana, 1849)	1976	-	-	Indo-Pacific Atlantic	Unintentional	Ships	Competition	Belmonte et al. 1994, Gubanova 1997
<i>Rhincalanus</i> sp.	1997	-	-	unknown	Unintentional	Ships	Unknown	Zagorodnyaya and Kolesnikova 2003
<i>Clausocalanus arcuicornis</i> (Dana 1849)	2001	-	-	Atlantic Indo-Pacific	Unintentional	Ships	Unknown	Zagorodnyaya and Kolesnikova 2003
<i>Scolecetrix</i> sp.	2001	-	-	unknown	Unintentional	Ships	Unknown	Zagorodnyaya and Kolesnikova 2003
<b>Crustacea, CYCLOPOIDA</b>								
<i>Oncaea minuta</i> (Giesbrecht, 1892)	1997	-	-	Indo-Pacific	Unintentional	Ships	Unknown	Zagorodnyaya and Kolesnikova 2003
<i>Oithona plumifera</i> (Baird, 1843)	2001	-	-	Atlantic Indo-Pacific	Unintentional	Ships	Unknown	Zagorodnyaya and Kolesnikova 2003
<i>Oithona setigera</i> (Dana, 1852)	2001	-	-	Atlantic Indo-Pacific	Unintentional	Ships	Unknown	Zagorodnyaya and Kolesnikova 2003
<i>Oithona brevicornis</i> (Giesbrecht, 1891)	2001	-	-	Atlantic Indo-Pacific	Unintentional	Ships	Unknown	Zagorodnyaya 2002
<b>Crustacea, HARPACTICOIDA</b>								
<i>Robertgurneya rostrata</i> (Gurney, 1927)	1964	-	-	Atlantic, Pacific	Unintentional	Ships	Unknown	Kolesnikova 2003
<i>Paramphiascella vararensis</i> (Scott, 1903)	1964	-	-	Atlantic, Pacific	Unintentional	Ships	Unknown	Kolesnikova 2003
<i>Idyella pallidula</i> (Sars, 1905)	1964	-	-	Atlantic, Pacific	Unintentional	Ships	Unknown	Zagorodnyaya and Kolesnikova 2003
<i>Proameira simplex</i> (Norman and Scott, 1905)	1964	-	-	Atlantic, Mediterranean, Pacific	Unintentional	Ships	Unknown	Zagorodnyaya and Kolesnikova 2003
<i>Ectinosoma abrau</i> (Kritschagin, 1873)*	-	1970s	-	Ponto-Caspian	Unintentional	Unknown	Unknown	Monchenko 1995
<i>Limnocletodes behning</i> (Borutzky, 1926)*	-	1970s	-	Mediterranean	Unintentional	Unknown	Unknown	Monchenko 1995
<i>Nitocra incerta</i> (Richard, 1893)*	-	1970s	-	Ponto-Caspian	Unintentional	Unknown	Unknown	Monchenko 1995

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Paraleptastacus spinicaudata</i> (T. Scott et A. Scott, 1895)*	-	1970s	-	Europe	Unintentional	Unknown	Unknown	Monchenko 1995
<i>Schizopera bobrutzkyi</i> *	-	1970s	-	Ponto-Caspian	Unintentional	Unknown	Unknown	Monchenko 1995
<i>Onychocampus mohammed</i> (Blanch and Richard, 1891)	-	1970s	-	Atlantic	Unintentional	Unknown	Unknown	Monchenko 1995
<i>Amphiascus tenuiremis</i> (Brady and Robertson, 1880)	1996	-	-	Atlantic, Pacific	Unintentional	Ships	Unknown	Zagorodnyaya and Kolesnikova 2003
<b>Crustacea, CIRRIPIEDIA</b>								
<i>Balanus improvisus</i> (Darwin, 1854)	1844	-	-	Atlantic	Unintentional	Ships	Fouling, habitat modification	Buchinsky 1885
<i>Balanus eburneus</i> (Gould, 1841)	1892	-	-	Atlantic	Unintentional	Ships	Fouling, habitat modification	Ostroumov 1892
<i>Balanus amphitrite</i> (Darwin, 1854)	1905	-	-	Atlantic	Unintentional	Ships	Fouling, habitat modification	Mavrodiadi 1908
<b>Crustacea, MYSIDACEA</b>								
<i>Paramysis lacustris</i> (Czerniawsky, 1882)*	-	1949	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1950
<i>Limnomysis benedeni</i> (Czerniawsky, 1882)*	-	1949	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1950
<i>Paramysis intermedia</i> * (Czerniawsky, 1882)	-	1955	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1961
<i>Hemimysis anomala</i> (Sars, 1907)*	-	1955	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1961
<i>Mesomysis kowalevskii</i> (Grimm, 1877)*	-	1955	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1961
<i>Paramysis baeri</i> (Martynov, 1924)*	-	1956	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1974
<i>Katamysis warpachowskyi</i> (Sars, 1893)*	-	1960s	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Ioffe 1968
<b>Crustacea, CUMACEA</b>								
<i>Stenocuma cercaroides</i> (Sars, 1894) = <i>Pseudocuma cercaroides</i> *	-	1945	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1965
<i>Pterocuma pectinata</i> (Sowinsky, 1893)*	-	1956	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Kruglova 1961
<i>Pterocuma rostrata</i> (Sars, 1894)*	-	1965	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1965
<b>Crustacea, ISOPODA</b>								
<i>Jaera sarsi</i> (Valkanov, 1936)*	-	1960s	-	Ponto-Caspian	Unintentional	Canals	Unknown	Lyakhov and Mordukhai-Boltovskoi 1973

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<b>Crustacea, AMPHIPODA</b>								
<i>Corophium curvispinum</i> (Sars, 1895) = <i>C. devium</i> (Wundsch, 1912); <i>C. curvispinum devium</i> (Bening, 1914); <i>C. curvispinum</i> (Sowinskyi prn. <i>devium</i> Martynov, 1924)*	-	1890s	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Dediu 1980
<i>Pontogammarus robustoides</i> (Sars, 1894)*	-	1950	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Obesogammarus obesus</i> (Sars, 1894) = <i>Pontogammarus obesus</i> *	-	1950	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Turcogammarus aralensis</i> (Uljanin, 1875) = <i>Pontogammarus aralensis</i> *	-	1950s	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Chaetogammarus warpachowskyi</i> (Sars, 1894)*	-	1953	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Dikerogammarus vilosus</i> (Sowinsky, 1894)*	-	1955	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Grigorovich et al. 2002
<i>Chaetogammarus ischnus</i> (Stebbing, 1898) = <i>Gammarus tenellus</i> (Sars, 1896); <i>G. sowinskyi</i> (Bening, 1914)*	-	1955	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Tseeb and Olivari 1958
<i>Dikerogammarus haemobaphes</i> (Eichwald, 1841)*	-	1955	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Obessogammarus crassus</i> (Sars, 1894)*	-	1955	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1961
<i>Pontogammarus maeoticus</i> (Sowinsky, 1894)*	-	1955	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1961
<i>Lanceogammarus andrussovi</i> (Sars, 1896) = <i>Iphiginella andrussovi</i> *	-	1956	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Tseeb and Olivari 1958
<i>Amathilina cristata</i> (Sars, 1894)*	-	1956	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Corophium robustum</i> (Sars, 1895) = <i>C. bidentatum</i> (Sars, 1895)*	-	1956	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Gusynskaya and Zhdanova 1978
<i>Corophium chelicorne</i> (Sars, 1895)*	-	1956	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Corophium nobile</i> (Sars, 1895)*	-	1956	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Gmelina costata</i> (Sars, 1863)*	-	1965	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Dediu 1980

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Gmelina pusilla</i> (Sars, 1863)*	-	1965	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Dediu 1980
<i>Corophium mucronatum</i> (Sars, 1895)*	-	1969	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Zhuravel 1965
<i>Corophium maoticum</i> (Sowinskyi, 1898)*	-	1969	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Dediu 1980
<i>Stenogammarus carausui</i> (Derzhavin and Pjatakova, 1962)*	-	1977	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Shcherbak 1989
<i>Shablogammarus subnudus</i> (Sars, 1896) = <i>Pontogammarus subnudus</i> *	-	1981	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Pligin and Yemelyanova 1989
<i>Kuzmelina kusnetzowi</i> (Sars, 1894) = <i>Gmelina kusnezowi</i> *	-	1982	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Shcherbak 1989
<i>Echinogammarus trichiatus</i> (Martynov, 1932)*	-	1998	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Competition	Grigorovich et al. 2002
<i>Synurella ambulans</i> (Müller, 1846)*	-	2000	-	Europe	Unintentional	Unknown	Unknown	Novitskij 2005
<i>Rivulogammarus kischineffensis</i> (Schell.)*	-	2002	-	Europe	Unintentional	Unknown	Unknown	Novitskij 2005
<b>Crustacea, DECAPODA</b>								
<i>Rhithropanopeus harrisi</i> (Gould, 1841)	1948	-	1937	N America	Unintentional	Ships	Competition, predation	Gadzhiiev 1963, Makarov 2004
<i>Pandalus kessleri</i> (Czerniavsky, 1878)	-	-	1959	Pacific, SE Asia	Intentional	Aquaculture	Unknown	Makarov 2004
<i>Astacus leptodactylus</i> (Eschscholtz, 1832) = <i>A. leptodactylus</i> (Rathke, 1837)*	-	1963	-	Ponto-Caspian	Intentional	Aquaculture	Unknown	Yanushevich 1966
<i>Callinectes sapidus</i> (Rathbun, 1896)	1970s	-	-	N America	Unintentional	Ships	Unknown	Zaitsev and Ozturk 2001
<i>Marsupenaeus japonicus</i> (Bate, 1888)	-	1977	-	Indo-Pacific	Intentional	Aquaculture	Unknown	Suprunovich and Makarov 1990, Zaitsev and Mamaev 1997
<i>Macrobrachium rosenbergii</i> (De Man, 1879)	1990-1992	1980s	-	Indo-Pacific	Intentional	Aquaculture	Unknown	Turanov and Turanova 2003, Makarov 2004
<i>Eriocheir sinensis</i> (Milne-Edwards, 1853)	1998	2002	-	SE Asia	Unintentional	Ships	Habitat modification	Zaitsev 1998, Novitskij 2005
<b>Mollusca, GASTROPODA</b>								
<i>Ferrissia fragilis</i> (Tryon, 1863) = <i>Ferrissia clessiniana</i> (Jickeli, 1882), <i>Ancylus lacustris brevis</i> Puzanov 1925	-	1919	-	N America	Unintentional	Ornamental trade	Unknown	Son 2007, 2007b

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Viviparus viviparus</i> (Linnaeus, 1758)*	-	1949	-	Cosmopolitan	Intentional	Acclimatization of forage fauna for fish	Unknown	Tseeb 1965
<i>Potamopyrgus jenkinsi</i> (Smith, 1889)	-	2005	1951	Australia	Unintentional	Unknown	Habitat modification	Grossu 1951, Markovskij 1954, Son 2006
<i>Rapana venosa</i> (Valenciennes, 1846) = <i>Rapana thomasiana thomasiana</i> (Crosse, 1861)	1954	-	-	SE Asia	Unintentional	Ships	Predation	Chukhchin 1961
<i>Theodoxus fluviatilis</i> (Linnaeus, 1758)*	-	1955	-	Europe	Unintentional	Unknown	Unknown	Zhuravel 1961
<i>Lithoglyphus naticoides</i> (Pfeiffer, 1828)*	-	1955	-	Europe	Unintentional	Unknown	Unknown	Zhuravel 1974
<i>Aporrhais pespelecani</i> (Linne, 1758)	1987	-	-	Mediterranean	Unintentional	Ships	Unknown	Anistratenko 1998
<i>Corambe obscura</i> (Verrill, 1870)	1989	-	-	Atlantic	Unintentional	Ships	Predation	Sinegub 1994, Roginskaya and Grintsov 1990
<i>Ampullaria</i> sp.	-	1999	-	Africa	Unknown	Ornamental trade	Unknown	Son 2007a
<i>Neptunea arthritica</i> (Bernardi, 1857) first identified as <i>Purpura pacifica</i> )	2000	-	-	Pacific IO	Unintentional	Ships	Unknown	Mironov et al. 2002, Shadrin et al. 2002
<i>Fagotia danubialis</i> (Pfeiffer, 1828)*	-	2000	-	Europe	Unintentional	Unknown	Unknown	Mironov et al. 2002
<i>Melanoidea tuberculata</i> (Müller, 1774)	-	2000	-	Africa, SE Asia	Unknown	Ornamental trade	Unknown	Grigorovich et al. 2002
<i>Biomphalaria glabrata</i> (Say, 1818)	-	2000	-	Africa	Unknown	Ornamental trade	Unknown	Son 2007a
<i>Ercolania viridis</i> (Costa, 1866) = <i>E. funerea</i> (Costa, 1867)	2001	-	-	Atlantic	Unintentional	Ships	Predation	Zaitsev et al. 2004
<i>Physella heterostropha</i> (Say, 1817)	-	2004	2004	N America	Unknown	Ornamental trade	Unknown	Son 2006, 2007a
<b>Mollusca, BIVALVIA</b>								
<i>Teredo navalis</i> (Linne, 1758)	750-500 BC	-	-	Atlantic, Pacific	Unintentional	Ships	Habitat modification	Gomoiu et al. 1996
<i>Crassostrea gigas</i> (Thunberg, 1793)	1900s	-	-	SE Asia	Intentional	Aquaculture	Unknown	Zolotarev 1996
<i>Dreissena bugensis</i> (Andrusov, 1897)*	-	1941	-	Ponto-Caspian	Unintentional	Canals	Habitat modification	Zhuravel 1967
<i>Hypanis colorata</i> (Eichwald, 1829) = <i>Monodacna colorata</i> *	-	1948	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1950
<i>Sphaerium corneum</i> (Linnaeus, 1758)*	-	1955	-	Europe	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1961
<i>Sphaerium rivicola</i> (Lamarck, 1818)*	-	1955	-	Europe	Intentional	Acclimatization of forage fauna for fish	Unknown	Zhuravel 1961
<i>Hypanis pontica</i> (Eichwald, 1838); = <i>Monodacna pontica</i> *	-	1961	-	Ponto-Caspian	Intentional	Acclimatization of forage fauna for fish	Unknown	Pligin and Yemelyanova 1989

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Mya arenaria</i> (Linne, 1758)	1966	-	-	N America	Unintentional	Ships	Competition	Beshevly and Kalyagin 1967
<i>Anadara inaequalis</i> (Bruguère, 1789)	1987	-	-	Indo-Pacific	Unintentional	Ships	Unknown	Zaika et al. 1992, Zolotarev and Zolotarev 1987, Zolotarev 1996
<i>Corbicula fluminea</i> (Müller, 1774)	-	1995	2000	SE Asia	Unintentional	Canals	Competition	Lyashenko et al. 2005, Son 2006, 2007a
<i>Sinanodonta woodiana</i> (Lea, 1834) = <i>Anodonta woodiana</i>	-	1999	2002	SE Asia	Unintentional	Parasite carrier	Habitat modification	Yurishinets and Korniyushin 2001, Son 2006
<i>Mytilopsis leucophaeata</i> (Conrad, 1831) = <i>Congerina leucophaeta</i>	-	-	2000	N America	Unintentional	Ships	Unknown	Therriault et al. 2004
<i>Corbicula fluminalis</i> (Müller, 1774)	-	2003	2000	SE Asia	Unintentional	Canals	Competition	Voloshkevich and Son 2002, Son 2007a
<i>Mytilus edulis</i> (Linnaeus, 1758)	2001	-	-	Atlantic	Unintentional	Ships	Fouling, hybridisation	Zaitsev et al. 2004
<i>Mytilus trossulus</i> (Gould, 1850)	2001	-	-	Pacific	Unintentional	Ships	Fouling, hybridisation	Zaitsev et al. 2004
<i>Hypanis glabra</i> (Ostroumoff, 1905) = <i>Adacna glabra</i> (Ostroumoff, 1905)	-	-	2004	Caspian	Unintentional	Ships	Competition	Nabozhenko 2004, Son 2007a
<b>Tentaculata, ENTOPROCTA</b>								
<i>Urnatella gracilis</i> (Leidy, 1851) = <i>U. dniestriensis</i> (Zambriborsch, 1958)	-	1954	1954	N America	Unintentional	Ships	Unknown	Bacescu 1954, Zambriborsch 1958
<b>PISCES</b>								
<i>Carassius auratus gibelio</i> (Bloch, 1782)	-	1900s	-	SE Asia	Intentional	Aquaculture	Unknown	Salekhova et al. 1987, Boltachev et al 2006
<i>Micropterus salmoides</i> (Lacepede, 1802)	-	end of XIX	-	N America	Intentional	Aquaculture	Unknown	Zhukinskyi 1959
<i>Ictalurus nebulosus</i> (Le Sueur, 1819)	-	1935	-	N America	Intentional	Aquaculture	Competition	Zhukinskyi 1959
<i>Ictalurus punctatus</i> (Rafinesque, 1818)	-	1935	-	N America	Intentional	Aquaculture	Competition	Grinjevskiy et al. 2001
<i>Oncorhynchus mykiss</i> (Walbaum, 1792) = <i>Salmo gairdneri iridea</i> (Gibbons, 1855); <i>Salmo irideus</i> (Gibbons 1885)	1965	1938	-	N America	Intentional	Aquaculture	Competition, predation	Zhukinskyi 1959 Karpevich and Bokova 1963, Zaitsev and Mamaev 1997
<i>Percottus glehni</i> (Dybowsky, 1877)	-	1948	-	SE Asia	Intentional	Aquarium trade	predation	Anisimova and Lavrovskiy 1983, Romanenko et al. 2003

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Syngnathus abaster nigrolineatus</i> (Eichwald, 1831)*	-	1956	-	Black Sea	Unintentional	Canals	Unknown	Suchoivan and Vjatchanina 1989
<i>Rutilus frisii kutum</i> (Kamensky, 1899)*	-	1959	-	Ponto-Caspian	Intentional	Canals	Unknown	Vovk 1963
<i>Lepomis gibbosus</i> (Linnaeus, 1758) = <i>Perca gibbosa</i> (Linne); <i>Eupomotis gibbosus</i> (Jordan and Evermann); <i>L. macrochirus</i> (Rafinesgue, 1815)	-	2002	1949	N America	Intentional	Aquaculture	Competition, predation	Svetovidov 1964, Boltachev et al. 2003
<i>Gambusia holbrooki</i> (Girard, 1859)	-	1950s	-	N America	Intentional	Aquaculture	Predation	Zaitsev and Mamaev 1997, Delamure 1964 Boltachev 2006
<i>Channa argus argus</i> (Cantor, 1842)	-	1950s	-	SE Asia	Intentional	Aquaculture	Unknown	Zhukinskyi 1959
<i>Coregonus albula ladogensis</i> (Pravdin and Berg, 1948) = <i>Coregonus albula</i> (Linnaeus, 1758); <i>Coregonus ladogae</i> (Pravdin, Golubev and Belyaeva, 1938)	-	1950s	-	Holarctic	Intentional	Aquaculture	Predation	Zhukinskyi 1959 Karpevich and Bokova 1963, Prokopov 2003
<i>Tribolodon brandtii</i> (Dybowski, 1872)	1950s	-	-	Pacific	Unintentional	Ships	Unknown	Diripasko et al. 2001
<i>Aristichthys nobilis</i> (Richardson, 1845)	-	1953	-	SE Asia	Intentional	Aquaculture	Unknown	Vovk 1963
<i>Hypophthalmichthys molitrix</i> (Valenciennes, 1844)	2001	1953	-	SE Asia	Intentional	Aquaculture	Unknown	Vovk 1963, Vovk 1976, Diripasko et al. 2001
<i>Coregonus nasus</i> (Pallas, 1776)	-	1954	-	Holarctic	Intentional	Aquaculture	Predation	Zhukinskyi 1959, Karpevich and Bokova 1963
<i>Coregonus peled</i> (Gmelin, 1788)	-	1954	-	Holarctic	Intentional	Aquaculture	Predation	Zhukinskyi 1959, Karpevich and Bokova 1963, Prokopov 2003
<i>Ctenopharyngodon idella</i> (Valenciennes, 1844)	2001	1954	-	SE Asia	Intentional	Aquaculture	Unknown	Vovk 1963, Vovk 1976, Diripasko et al. 2001
<i>Coregonus autumnalis migratorius</i> (Georgi, 1775)	-	1957	-	Holarctic	Intentional	Aquaculture	Predation	Zhukinskyi 1959, Karpevich and Bokova 1963
<i>Rutilus frisii kutum</i> (Kamensky, 1899)	-	1959	-	Ponto-Caspian	Intentional	Aquaculture	Unknown	Vovk 1963
<i>Coregonus lavaretus ladoga</i> (Poljakow and Berg, 1916) = <i>Coregonus lavaretus</i> (Linnaeus, 1758)	-	1960s	-	Holarctic	Intentional	Aquaculture	Predation	Zhukinskyi 1959, Karpevich and Bokova 1963, Prokopov 2003

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Lateolabrax japonicus</i> (Cuvier, 1828) = <i>Labrax japonicus</i> (Cuvier, 1828)	1960-1970s	-	-	Pacific, SE Asia	Intentional	Aquaculture	Unknown	Zaitsev and Ozturk 2001,
<i>Plecoglossus altivelis altivelis</i> (Temminck and Schlegel, 1846)	1960-1970s	-	-	Pacific, SE Asia	Intentional	Aquaculture	Unknown	Zaitsev and Ozturk 2001
<i>Salmo ischchan aestivalis</i> (Fortunatov, 1926)	-	1960	-	Sevan Lake	Intentional	Aquaculture	Unknown	Karpevich and Bokova 1963, Prokopov 2003
<i>Salmo ischchan gegorkuni</i> (Kessler, 1877)	-	1960	-	Sevan Lake	Intentional	Aquaculture	Unknown	Karpevich and Bokova 1963, Prokopov 2003
<i>Mylopharyngodon piceus</i> (Richardson, 1846)	-	1961	-	SE Asia	Intentional	Aquaculture	Unknown	Grinjevskiy et al. 2001
<i>Oncorhynchus gorbuscha</i> (Walbaum, 1792)	1961	-	-	Pacific, SE Asia	Intentional	Aquaculture	Competition, predation	Zaitsev and Ozturk 2001, Alimov and Bogutskaya 2004
<i>Pseudorasbora parva</i> (Temminck and Schlegel, 1846)	1990s	1980s	1961	SE Asia	Unintentional	Unknown	Competition	Dediu 1989
<i>Oreochromis mossambicus</i> (Ortega and Vari, 1856)	-	1961; 1996	-	Africa	Intentional	Aquaculture	Predation	Grinjevskiy et al. 2001, Novitskij 2005
<i>Coregonus lavaretus maracnoedes</i> , (Poljakow, 1874)	-	1965	-	Holarctic	Intentional	Aquaculture	Predation	Prokopov 2003
<i>Morone saxatilis</i> (Walbaum, 1792) = <i>Roccus saxatilis</i>	-	-	1965	N America	Intentional	Aquaculture	Unknown	Kozlov and Abramovich 1980
<i>Oreochromis aureus</i> (Steingachner, 1864)	-	1970s	-	Africa	Intentional	Aquaculture	Predation	Ivoilov 1986
<i>Oreochromis niloticus</i> (Linnaeus, 1758)	-	1970s	-	Africa	Intentional	Aquaculture	Predation	Ivoilov 1986
<i>Tilapia zillii</i> (Gervais, 1848)	-	1970s	-	Africa	Intentional	Aquaculture	Predation	Ivoilov 1986
<i>Liza haematocheila</i> (Temminck and Schlegel, 1845) = <i>Mugil so-iuy</i> (Basil and Europeski, 1855)	-	1996	1972	SE Asia	Intentional	Aquaculture	Unknown	Zuev and Boltachev 1998, Parin 2003
<i>Ictiobus bubalus</i> (Rafinesgue, 1819)	-	1975	-	N America	Intentional	Aquaculture	Unknown	Grinjevskiy et al. 2001
<i>Ictiobus cyprinellus</i> (Valenciennes, 1844)	-	1975	-	N America	Intentional	Aquaculture	Unknown	Tretyak 1996
<i>Ictiobus niger</i> (Rafinesgue, 1820)	-	1975	-	N America	Intentional	Aquaculture	Unknown	Grinjevskiy et al. 2001
<i>Sparus aurata</i> (Linnaeus, 1758)	1987	2004	-	Atlantic, Mediterranean	Unintentional	Ships	Unknown	Boltachev and Yurachno 2002, Tkachenco 2005
<i>Micromesistius poutassou</i> (Risso, 1827)	1999	-	-	N Atlantic, Mediterranean	Unintentional	Ships	Unknown	Boltachev et al. 1999
<i>Chelon labrosus</i> (Risso, 1826)	1999	-	-	N Atlantic, Mediterranean	Unintentional	Ships	Unknown	Boltachev and Yurachno 2002

Species	Year of first record and recipient region			Origin / donor area	Vector	Pathway	Impact or potential impact / invasiveness	References
	Sea and inland saline waters	Fresh waters	Inland brackish waters or waters with salinity variation					
<i>Sardinella aurita</i> (Valenciennes, 1847)	1999	-	-	Atlantic Pacific	Unintentional	Ships	Unknown	Boltachev et al. 2000
<i>Sarpa salpa</i> (Linnaeus, 1758)	1999	-	-	Atlantic	Unintentional	Ships	Unknown	Boltachev and Yurachno 2002
<i>Sphyraena obtusata</i> Cuvier, 1829 = <i>Sphyraena chrysotaenia</i> non (Klunzinger, 1884)	1999	-	-	Pacific IO	Unintentional	Ships	Unknown	Boltachev and Yurachno 2002
<i>Heniochus acuminatus</i> (Linnaeus, 1758)	2003	-	-	Indo-Pacific	Unintentional	Ships	Unknown	Boltachev and Astakhov 2004

\*Neighbouring alien species. (Species that not mark with star are distant aliens).