EXOTIC SPECIES IN THE AEGEAN, MARMARA, BLACK, AZOV AND CASPIAN SEAS

Edited by Yuvenaly ZAITSEV and Bayram ÖZTÜRK

EXOTIC SPECIES IN
THE AEGEAN, MARMARA,
BLACK, AZOV
AND
CASPIAN SEAS

ISBN :975-97132-2-5

This publication should be cited as follows: Zaitsev Yu. and Öztürk B.(Eds) **Exotic Species in the Aegean, Marmara, Black, Azov and Caspian Seas**. Published by Turkish Marine Research Foundation, Istanbul, TURKEY, 2001, 267 pp.

Türk Deniz Araştırmaları Vakfı (TÜDAV)
P.K 10 Beykoz-İSTANBUL-TURKEY
Tel:0216 424 07 72
Fax:0216 424 07 71
E-mail :tudav@superonline.com
http://www.tudav.org

Printed by Ofis Grafik Matbaa A.Ş. / İstanbul -Tel: 0212 266 54 56

Contributors

Prof. Abdul Guseinali Kasymov, Caspian Biological Station, Institute of Zoology, Azerbaijan Academy of Sciences. Baku, Azerbaijan
Dr. Ahmet Kıdeys, Middle East Technical University, Erdemli.İçel, Turkey
Dr. Ahmet . N. Tarkan, University of Istanbul, Faculty of Fisheries. Istanbul, Turkey.
Prof. Bayram Ozturk, University of Istanbul, Faculty of Fisheries and Turkish Marine Research Foundation, Istanbul, Turkey.
Dr. Boris Alexandrov, Odessa Branch, Institute of Biology of Southern Seas, National Academy of Ukraine. Odessa, Ukraine.
Dr. Firdauz Shakirova, National Institute of Deserts, Flora and Fauna, Ministry of Nature Use and Environmental Protection of Turkmenistan. Ashgabat, Turkmenistan.
Dr. Galina Minicheva, Odessa Branch, Institute of Biology of Southern Seas, National Academy of Ukraine. Odessa, Ukraine.
Mrs. Ludmila Terenko, Odessa Branch, Institute of Biology of Southern Seas, National Academy of Ukraine. Odessa, Ukraine.
Dr. Ludmila Vorobyova, Odessa Branch, Institute of Biology of Southern Seas, National Academy of Ukraine. Odessa, Ukraine.
Dr. Nuri Basusta, Mustafa Kemal University, Faculty of Fisheries . Hatay, Turkey.
Dr. Veysel Aysel, Aegean University, Science Faculty. İzmir, Turkey.
Prof. Yuvenaly Zaitsev, Odessa Branch, Institute of Biology of Southern Seas, National Academy of Ukraine. Odessa, Ukraine.

Acknowledgments

We are very grateful to all our colleagues and friends, marine biologists, whose materials have been used in this book. We are grateful to Dr. Ayaka Amaha Öztürk for her valuable comments and to Ann Alexandrova for the coloured cover page.

C O N T E N T S

Executive Summary

The geographic chain of intercontinental Eurasian seas, namely the Aegean Sea, the Sea of Marmara, the Black Sea, the Sea of Azov, and the Caspian Sea (the abbreviation AMBACS for this system of seas is proposed), bordering on one side the South-Eastern Europe, on the other side the Asia Minor and the Middle Asia, was investigated in the aspect of man-induced exotic (non-native) species. Some part of these species (the most of them) were introduced accidentally by ships or other kinds of human activities, and others were purposely released commercially important species.

The majority of the Aegean Sea exotics are originated from the Indo-Pacific-and penetrated into the Eastern Mediterranean Sea and the Aegean Sea through the Suez Canal. Since it is an artificial canal, the species migrating by this way are considered as accidentally man-induced organisms.

The Sea of Marmara is under a strong influence of water current from the Black Sea and its exotics are basically of Black Sea origin. The Black and Azov Seas are populated by exotics of different origins, but the main donor area is the Boreal Atlantic Ocean. For the Caspian Sea, which was connected to the Sea of Azov by the Volga-Don Canal opened in 1952, practically the only source of accidental introduction of exotic species, the origins of its exotic species are the Sea of Azov and the Black Sea.

By the year 2000, the total number of exotic organisms, accidentally and intentionally introduced into the considered system of seas and its coastal wetlands is 18 species of plants, 79 species of invertebrates, 43 species of fish, and 6 species of marine mammals.

As to phyletic diversity, out of 22 divisions (phyla) of plants, representatives of 8 divisions are in the list of exotic species in the AMBACS system, and out of 35 marine animal phyla, representatives of 9 phyla were introduced in to the same seas.

Behavioral changes of exotics in new habitats are discussed. It is underlined that the food chains of introduced species in new habitats are, as a rule, shorter and simpler than in original areas. It especially concerns the last links-secondary and tertiary consumers, which are lacking in new habitats. Therefore newly introduced species are commonly free for unlimited growth of population as long as an antagonistic species does appear. So, *a priori*, the impact of a potential settler on native species is unknown and unpredictable, because its behavior in a new habitat can change for worse. On account of this, a concept like " not to allow the penetration of exotic harmful species" is, in essence, scientifically incorrect with the exception of pathogenics, there are no harmful plant or animal species *a priori*. The only thing to do is to put an end to the introduction of *all* non- native species.

The entry mechanisms of exotic species, connected with human activities, are diverse. Among them there are shipping activities concerned with ballast waters, sediments, and hull's fouling, construction of shipping canals, introduction of non-target species with deliberately released commercial invertebrates and fish, and escaping from aquaria.

As to the chronology of introductions, it is noted, that the oldest settler can be to be considered the shipworm *Teredo navalis*, which was introduced anciently by navigators, but the peak of the introduction of exotics was the 20th century, and especially in the second half.

The analysis of existing data shows that the sensitivity of different seas to exotics' invasions is functions of its biological diversity. A high biological diversity corresponds to a low share (percent) of introduced exotic species and vice versa, an area with low biological diversity, inhabited by many relic and endemic species, has a high share of introduced species. The reason of this is the biotic environment in each specific area.

The impact of exotics on native species is analysed. It is stressed that it is rather complicated to appreciate all biological consequences of introduction of a foreign species into an area where it does not naturally occur and to give an integral estimation. Practically each settler can be, on one hand, positive for native species, on the other hand, negative. However, in some cases, there are no doubts of this. Among the most harmful species are mentioned *Mnemiopsis leidyi*, *Rapana thomasiana* and *Teredo navalis*.

Economical consequences of accidentally introduced exotic species are insufficiently investigated. Only regarding the ctenophore *Mnemiopsis leidyi* in the Black Sea and the Sea of Azov, the economic consequences of its introduction is rather clear and its damage is sufficently specified.

Geographical origins of introduced species are different in different seas. More than 80% of exotic species introduced in the Aegean Sea are originated from the Indo-Pacific region and directly through the Red Sea.

The Sea of Marmara is populated by species from the North Atlantic (34%), East Atlantic (11.3%), West Pacific (33%), and Indo-Pacific (11.4%) regions. Probably, most of them have been transported by ships, but some species, e.g. *Rhizosolenia calcar avis, Mnemiopsis leidyi, Rapana thomasiana, Scapharca inaequivalvis,* probably, were introduced with the water current from the Black Sea.

Among the Black Sea exotics, more than two thirds (68%) are originated from the North Atlantic, 13 % are from Indo-Pacific region, and 8% from the Western Pacific. It is possible to suppose that the main entry mechanism in this case is the ships' ballast water.

Similar situation can be observed in the Sea of Azov, where 67% of accidentally introduced species are originated from the North and East Atlantic.

Geographical position and isolation of the Caspian Sea is the reason of a peculiar composition of its exotics: 88% are originated from the Black and Azov Seas, or from the Atlantic Ocean but introduced via the Black and Azov Seas.

Proceeding from these data, are named the most unsafe, with respect to the transport of exotic organisms, sea routes (vectors) for each sea of the AMBACS marine system. For the Aegean Sea such is the Indo-Pacific vector, For the Sea of Marmara, and especially for the Black Sea and the Sea of Azov, the North Atlantic vector. For the Caspian Sea, the only danger is the Ponto-Azovian vector through the Volga-Don Canal.

Among information gaps on the topic are pointed the insufficient taxonomic analysis of introduced species, lack of consideration for microscopic organisms, and the impossibility of prompt identification of harmful (pest) species. Indeed, it is practically impossible to determine, immediately after discovering, the ecological status of a recently introduced species: is it harmful one, neutral or helpful for native species and local ecosystem? These characteristics become apparent later and depends on biotic relations and behavioural changes in new habitat. Usually, there are no *a priori* harmful species, they become subsequently as such in new environmental conditions.

Considering means to minimize the risk of transfer of aquatic species in ballast water , main fields of activity are named proposed by IMO: ballast water exchange in the open ocean, and ballast water treatment on board. Other possibilities are the catch of introduced species (e.g. of *Rapana thomasiana* in the Black Sea), and introduction of antagonistic species (e.g. of *Beroe* against *Mnemiopsis* which happened in the Black Sea and the Sea of Azov).

Because it is impossible to stop once and for all the introduction of exotics via ships, it is very important to undertake biological surveys and monitoring in ports. This is also one of recommendations under the current IMO ballast water management guidelines.

Introduction and General Remarks

The geographic chain of intercontinental Eurasian seas, namely the Aegean Sea, the Sea of Marmara, the Black Sea, the Sea of Azov, and the Caspian Sea (the abbreviation AMBACS for this system of seas is proposed), bordering on one side the South-Eastern Europe, on the other side the Asia Minor (Aegean, Marmara and Black seas), and the Middle Asia (Caspian Sea), are scientifically and practically interesting from several points of view. These seas represent different marine water bodies with a common geological history. They have been interconnected, isolated again connected, their flora and fauna reflecting geological processes that have influenced the marine ecosystems, and they are subject to a strong and multiform human impact (ZAITSEV&MAMAEV, 1997).

Marine biologists, ecologists and biogeographers are traditionally interested in the penetration process of marine organisms in low salinity waters and vice versa, spreading of brackish water species in marine waters. In this relation, AMBACS are especially indicative, the Southern Aegean Sea being one of the most saline parts of the world oceans, having as much as 40‰, while the Sea of Azov is 14-8‰, and the Northern Caspian Sea is only 1-2 ‰. Adaptation of marine plants and animals to such broad amplitude of salinity, their morphological change and physiological plasticity as a result of environmental fluctuations presents an important academic and practical interest.

The AMBACS are interconnected by straits and the exchange of water, nutrients, pollution, plants and animals in this marine system occurs. The only exception for a long time was the Caspian Sea, which was isolated from the Sea of Azov, but since 1952 these seas were connected through the Volga-Don shipping canal.

Recently, a special attention has been paid to acquires the problem of exotic species that are intentionally or accidentally transported by human activities into a region where they do not naturally occur. The Eurasian range of seas is an area of impetuous increasing of shipping. Vessels provide habitats for a large variety of organisms in ballast water, sediments in ballast tanks and hull's fouling (GOLLASH&LEPPAKOSKI, 1999), and this factor became crucial in man-made transformation of the inland seas ecosystems.

This book is a first review of exotic species in above mentioned system of Eurasian seas. The responsibility for the statements in this document is entirely ours and could not be interpreted as the official policy declaration of respective states or administrations. The book summarizes the information available to us on man-introduced exotic (non- native) species in five adjacent seas. Unfortunately , we did not have the enough time to consult all hundreds of original references on the topic but we hope that the most important publications were taken into the consideration.

Individual species accounts were compiled by scientists from Azerbaijan, Turkey, Turkmenistan and Ukraine, using many published materials and unpublished personal data. Because of their involvement, this book is much more improved from the original draft. Any remaining errors and deficiences, including Engish imperfection are of our responsibility.

The editors

Chapter 1. The Aegean Sea

Physical Geography, Biology, Ecology

Geographical position

Geographic coordinates of the Aegean Sea are N 35°-45° and E 23°-27°. This sea is a semi-enclosed sea bordering Turkey and Greece and is a sub area of the Mediterranean Sea. Its most important geographical peculiarity is numerous islands and islets.

The boundary of the Aegean Sea (modified from BOUGIS & ARRECGROS, 1991).

Geological evolution

The most important characteristic of the bottom topography of the Aegean Sea is that to a great extent it carries traces of land topography. Deep trenches are found more in a major trench in the shape of an “S” extending from north to south, which divides the Aegean into the eastern and western plateaus. The average depth of the Aegean Sea is about 350 m. However, a significant part of it has depths of 100 to 500 m.

Morphometry and climate

The area of the Aegean Sea is 241,000 km^2, its volume is 74104 km^3, the length from north to south is 660 km, the width is 270 km in the north, 150 km in the middle and 400 km in the south. The shore length of the Turkish boundry is

2633 km. The Aegean Sea is a rather shallow sea, its depth exceeding 1000 m only in very limited areas. In no place it is wider than 200 miles. Main gulfs and bays of the Aegean Sea are Saros Bay, Dikili Bay, Edremit Bay, Izmir Bay, Gökova Bay, Hisarönü Bay in the Turkish coast, and on the Greece coast, Thessaloniki Bay and Thermaikos Gulf. Main incoming rivers are the Meriç, Gediz and Menderes.

Main characteristics of the ecosystem of the Aegean Sea

Abiotic factors and biotic factors

The Aegean Sea, which is a transition area between the Mediterranean Sea itself and the Black Sea, may be divided from the standpoint of oceanography into the northern, middle and southern parts. Among them, the northern part is affected by less saline and colder water originating from the Black Sea and passing through the Sea of Marmara and the Dardanelles; the southern and middle parts are affected by the Mediterranean waters. Thus the northern section is less saline and colder, while the middle and southern sections are warmer and more saline. Surface salinity is usually greater than 39o% but winter convections reduce this salinity to 38.8 o%.There are four masses of water effecting the current system of the Aegean Sea; the Black Sea water, Atlantic water, the middle-depth and the bottom water of the eastern Mediterranean. There are two current systems in the Aegean Sea. The first of these is the main current, coming from the Mediterranean and carrying water masses, warm and rich in salt, moving in clockwise direction. The second is a current system made up by waters originating from the Black Sea, which gain salinity as they move through the Sea of Marmara.

Although the Aegean water is relatively low in the concentration of nutrients, it is greater than in many other areas of the Mediterranean. The concentration of dissolved oxygen is close to that of the Medirerranean, generally around 5 mg/l in surface and bottom layers.Maximum and Minimum dissolved oxygen concentrations at surface in monthly mean are observed in March and August, respectively(YÜCE, 1989).

The surface water temperature in February in the northern Aegean Sea is 10°C, in the southern Aegean Sea about 17° C. But in the water deeper than 200 m depths temperature becomes constant at about 14-15 °C.

The Turkish shores of the Aegean Sea include many areas suitable for fisheries (Saros Gulf, around Gökçeada and Bozcaada, Edremit Bay, Çandarlı Gulf, Sıgacık and Kusadası Bays, Kovela Harbor, the straits between Samos and Tekagac Cape, Güllük Bay, Gökova Bay) and estuaries (Köycegiz, Güllük, Lake Bafa, Sakızburnu, Karna, Homa, Ragıp Pasa, Akköy Çakalburnu and Çalıburnu). Besides, territorial water and open sea area also important for the trawling and purse-seine fisheries for the Turkish fishermen. According to the results of climatic, physical, chemical and biological researches, the Aegean Sea is suitable for aquaculture.

Sponge-fishing has a separate and significant place in the fisheries of the Aegean Sea (KOCATAS & BILECIK ,1992).

About 20 % of the total fish production in Turkey is obtained from the Aegean Sea. The main fish species are Tuna,bonito, mackerel, sardine, grey mullets, and red mullets. Prominent among invertebrates caught are lobsters, shrimps, squids and sponges. The Aegean Sea has unique connection with the Black Sea, thus low saline water mass. This hydrological uniquenless is one of the reasons for the fish diversity. GELDIAY (1969) determined 295 fish species in the Aegean Sea,while QUIGNARD&TOMASINI (2000) mentioned 351 fish species.

The future of the Aegean Sea

The Aegean Sea is ecologically important for several reasons. First of all, the Aegean Sea is a semi-enclosed sea, thus isolated from the other water bodies, though not completely. Secondly, numerous islands are isolated from one another.This insular ecosytem has a unique characteristic such as endemism, thus it is vulnerable to habitat destruction. Thirdly, there is an important interaction with the Marmara and Black Seas.The pelagic fishes, such as tuna, swordfish, bonito and mackerel, migrate from the Black and Marmara Seas to the Aegean Sea through the Turkish Straits Sytem and vice versa (ÖZTÜRK & ÖZTÜRK, 2000). Fourthly, due to its complicated geomorphology, seen as caves, reefs, etc., the Aegean Sea has high habitat diversity, thus high species diversity. Finally, the Aegean Sea is a gene pool for some of the world critically endangered species, such as the Mediterranean monk seal, *Monachus monachus*.

The Aegean Sea is very sensitive and fragile against the invasion of exotic species. There are two threats for the Aegean Sea in particular regarding the introduction of unwanted species.One of these its location close to the Suez Canal. Another one is heavy marine traffic which is the cause for the ballast water problems in this sea. Activities such as fisheries, shipping, aquaculture and tourism, are also sometimes pathways for the unintentional introductions of plants and animals in the Aegean Sea.For the protection of the Aegean Sea, it is necessary to mitigate land-based pollution and transboundary pollution and, to minimize the risk of ship-originated pollution and industrial pollution in this area.

In conclusion, the protection of the Aegean Sea should be a priority for Turkey and Greece rather then other countries. Effective bilatarel cooperation of scientists and decision makers and concerted action plan are essential. In this book mostly Turkish part of the Aegean Sea considered.

Exotic species

<u>Plants</u>

Achanthophora muscoides (Linnaeus, 1753) Bory de Saint-Vincent

Achantophora muscoides

Common names: No

Taxonomy : Class- Rhodophyceae
Order- Ceramiales
Family- Rhodomelaceae

Distribution of *Achanthophora muscoides* in the Eastern Aegean Sea

Common names: No

Distribution. A single finding in Izmir Bay on rocky bottom was registered (AYSEL, 1987).

Origin. The Indo-Pacific, a Lessepsian migrant.

Compiled by V. Aysel

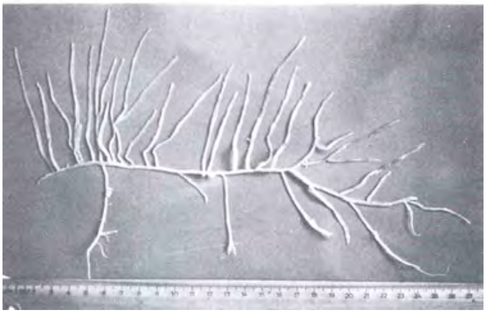
Caulerpa racemosa var. ***lamourouxii*** (Turner)

Synonyms: No

Common name: Sürünücü salkımsı Deniz Üzümü (Tur)

Taxonomy: Class- Chlorophyta
Order- Bryopsidales
Family- Caulerpaceae

Distinctive characteristics. The thallus is represented by creeping stolons 20-80 cm long and 2-3 mm in diameter. At base of the stolons, are situated branchy whitish rhizoids attaching the plant to substratum. At the end of the stolons there are cylindrical attachements 110-220 in cm height pseudodichotomically branchiate.



Caulerpa racemosa var. *lamouroxii*

Probable origin. The Indo-Pacific, Red Sea.

Possible way of introduction. Via ships through the Suez Canal.

Distribution. Firstly discovered in eastern Mediterranean Sea in the 1950s and along Turkish coasts in 1980 (CIRIK & OZTURK, 1991). Spreading in the Aegean Sea bays. In Bodrum Bay it was encountered in May 2000 in large amount in the coastal zone on stony substrata at 20-30 cm depth (Yu. ZAITSEV, pers. comm.)

Distribution of *Caulerpa racemosa* in the Aegean Sea

Habitats. *C. racemosa* colonized all types of substrata ,such as rock, sand, mud and dead *Posidonia oceanica* meadows down to 50 depth and interferes with marine coastal biocenoses.

Impact on native species. Insufficiently known. The expansion of *C. racemosa* could be a particular threat to *P. oceanica* beds. The expansion of this alga may alter marine habitats. More data may show the ecological impacts of *C. racemosa* in the Aegean Sea, but it seems that this species is less harmful than its relative, *Caulerpa taxifolia*. It is an edible species, intensively farmed in the Central Philippines and southern Japan areas (DOUMENGE, 1995).

Compiled by V. Aysel

Codium fragile (Suringar, 1867)

Codium fragile

Common names: Fragile codium (Eng), Narin deniz muflonu (Tur)

Taxonomy : Class- Siphonophyceae
Order- Siphonales
Family- Codiaceae

Distribution. The Marmara Sea, Aegean Sea (Çanakkale, Balıkesir, İzmir). The green alga C. *fragile* found in the Sea of Marmara in the late 1940s.

Distribution of *Codium fragile* in the eastern Aegean Sea

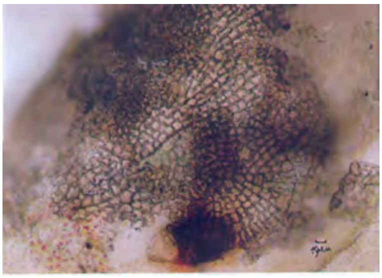
Habitats. Sandy bottom among different macro algae.

Origin. The Pacific Ocean.

Possible way of introduction. Accidentally introduction by ships during the Second World War.

Compiled by V. Aysel

Ganonema farinosum (Lamouroux, 1816)



Hydrolithon farinosum

Common names: Toz gibi örten su perisi (Tur)

Taxonomy : Class- Rhodophyceae
Order- Nemaliales
Family- Galaxauraceae

Distinctive characteristics. This Algae is irregularly dichotomously ramified. The assimilating filaments are composed of nearly- cylindrical cells. The carpoginial branches issue laterally upon branches in the basal part of the asimilator filaments. Antheridial branch is globular or subconic shape, which is the characteristic of this species (AYSEL, 1997).

Distribution. Found only in the Muğla area, the Aegean Sea.

Distribution of *Ganonema farinosum* in the Eastern Aegean Sea

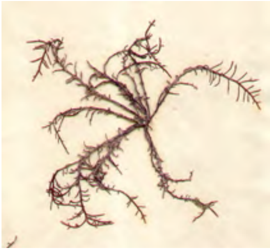
Probable origin. The Indo-Pacific.

Possible way of introduction. Via ships and/or through the Suez Canal .

Habitats. Rocky coasts.

Compiled by V. Aysel

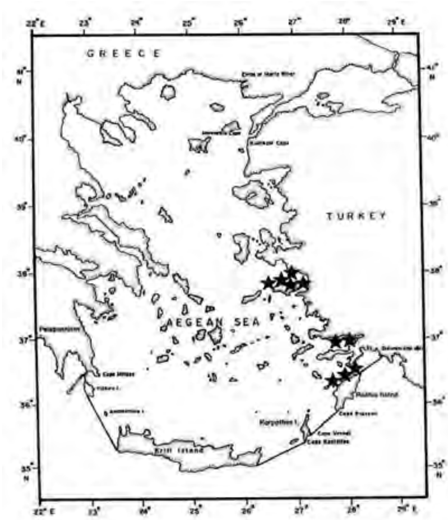
Laurencia intermedia (Yamada 1931)



Laurencia intermedia

Taxonomy : Class- Rhodophyceae
Order- Ceramiales
Family- Rhodomelaceae

Common names: No



Distribution of *Laurencia intermedia in* the Eastern Aegean Sea

Probable origin. The Indo-Pacific.

Possible way of introduction. Via ships and/or with water current through the Suez Canal

Distribution. A single finding in the Çanakkale area.

Habitats. On the rocks.

Compiled by V. Aysel

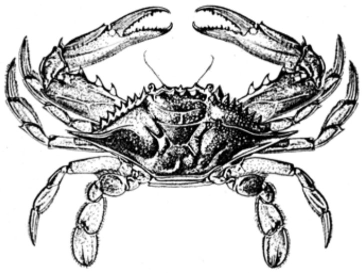
Invertebrates

Callinectes sapidus (Rathbun, 1930)

Common names: Blue crab (Eng), Mavi yengeç(Tur).

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Portunidae

Distinctive characteristics. (See Chapter 3)



Callinectes sapidus

Probable origin. The Atlantic seashore of the North America

Possible way of introduction. Ship's ballast waters and/or hull fouling

Distribution and present state of population. This species found both in the Aegean and Mediterranean coast of Turkey coast. In the Aegean Sea, it was found in Turkish part mainly in Dalyan area. In Greek side, it is also founded and indicated that decline of the stocks in the lagoons, Msei and Fanarion, in the Northern Aegean Sea (RIELD, 1983). In the Aegean Sea, on the coasts of Dalyan area it forms a rather important fishery resource. In the lagoon region between Köyceğiz Lake and Sea it exists an important population of *C. sapidus*. This species often caught by the fisherman working in the lagoon region, however, it was not used economically until 1991 (ENZENROB *et al*., 1997). About 5 tons of export and 10 tons of domestic sales are made by the Dalian Fisheries Cooperatives in Mugla. Besides Dalyan Lagoon, Akbuk, Menderes estuary also distributed area and fishermen catch this species in these areas .This species also reported from the Sea of Marmara (MULLER, 1986),and (FROGLIA *et al*., 1998).

Distribution of *Callinectes sapidus* in the Eastern Aegean Sea

Habitats. It inhabits shallow and brakish waters.

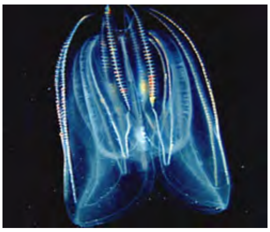
Impact of the local fauna. Insufficiently known.

Compiled by B. Öztürk

Mnemiopsis leidyi (Agassiz,1865)

Common names: American CombJelly (Eng), Kaykay (Tur)

Taxonomy: Class - Tentaculata
Order - Lobata
Family - Mnemiidae



Mnemiopsis leidyi

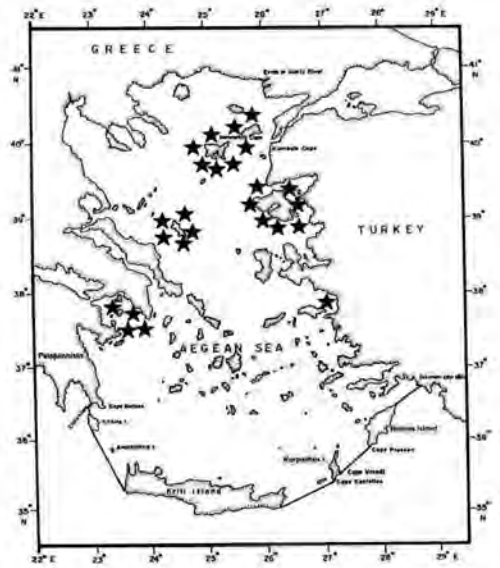
Distinctive characteristics. (See Chapter 3, 3.2.2.)

Probable origin. The astern coasts of the Americas

Possible way of introduction. *M. leidyi* was introduced into the Black Sea in the ships' ballast waters and from there to the Sea of Marmara via the surface water current of the Istanbul Strait and possibly to the Aegean Sea via surface waters of the Çanakkale Strait.

Distribution. *M. leidyi* was recorded in the North Aegean Sea for the first time during summer 1990 and it was found in large numbers in Saranikos Gulf. In the following years, it was also observed during the warm period in several coastal areas of the Aegean Sea islands (Lesbos, Limnos, Alonissos, Skyros). In 1998, this species was recorded in coastal waters of the island Gökçeada throughout the year.

Habitat. *M. leidyi* is usually found close to shore, in bays and estuaries in surface waters above the thermocline.



Distribution of *Mnemiopsis leidyi* in the Aegean Sea

Impact on native species. *M.leidyi* ingests virtually any organisms that it is able to capture with its oral lobes, including holoplanktonic organisms, planktonic larvae of benthic organisms and eggs and larvae of fishes (especially anchovy and sprat).

Compiled by A. Tarkan, A. Kıdeys

Rapana thomasiana (Crosse, 1861)

Synonyms: *Rapana tthomasiana thomasiana* Crosse, *Rapana bezoar* L., *Rapana venosa* (Valenciennes), *Rapana pontica* Nordsieck, 1969.

Common names: Rapana, Rapan (Bul, Geo, Rom, Rus, Ukr), Deniz Salyangozu (Tur).

Taxonomy: Class- Gastropoda
Order- Hamiglossa
Family- Thaididae

Distinctive characteristics. (See Chapter 3, 3.2.2.)

Probable origin. The Sea of Japan.

Possible way of introduction. *R. venosa* entered the Aegean Sea via ships and/or with water current from the Marmara and Black Seas.

Distribution. *R. thomasiana* penetrated and became a new settler in the Aegean Sea. It was observed in the Meriç River estuary and Gökçeada area. There is no accurate information about the present state of its population. In the northern Aegean Sea it was first reported by KOUTSOUBAS & VOULTSIADOU-KOUKOURA (1991) based on two specimens collected near the natural oyster banks in the Bay of Thessaloniki, in 12-14 m depth. In Turkish part of the Aegean Sea this species is reported by YOKEŞ (1996) in Bozcaada in 4 meter depth and ALTUG &ERK (2001) reported from Gökçeada .

Distribution of *Rapana thomasiana* in the North-Eastern Aegean Sea

Habitat. Rocky, sandy and muddy bottoms in coastal areas down to 21 m depth in the Aegean Sea, in the areas of development of oysters, mussels and other bivalves.

Impact on native species. *R. thomasiana* is a notorius predator on oysters, mussels and other bivalves.

Compiled by B. Öztürk

<u>Fishes</u>

Alepes djeddaba (Forsskal, 1775)

Synonyms: *Caranx djeddaba* Forsskal, *Caranx calla* (Steinitz), *Atule djeddaba* Forsskal.

Common names: Shrimp scad (Eng), Çatal Balıgı, Sarıkuyruk istavrit (Tur).

Taxonomy: Class- Osteichthyes
Order-Perciformes
Family-Carangidae

Distinctive characteristics. Body fusiform, comb-like teeth in both jaws small, eye covered posteriorly by fleshy adipose membrane. Dorsal finrays VIII +I + 22-25; anal finrays II + I + 18-20; spinous dorsal fin moderately high, longest spine slightly shorter than length of soft dorsal fin lobe. Curved lateral line with 31-36 scales and 0-3 scutes; straight lateral line with 41-48 scutes. Back bluish-green, silvery to white below; a black blotch on posterio-dorsal margin of the opercle, bordered above by a smaller white spot, caudal fin yellowish, margin of the lower lope dusky. Up to 30 cm, usually 20 cm long (BINI, 1960; WHITEHEAD *et al.*, 1986a; FISCHER *et al.*, 1987; PAPACONSTANTINOU, 1988; BASUSTA, 1997; TORCU & MATER, 2000).

Alepes djeddaba

Origin. The Indo-Pacific.

Possible way of introduction. Migration by way of the Suez Canal (a Lessepsian migrant).

Distribution of *Alepes djeddaba* in the eastern Aegean Sea

Distribution. Aegean Sea and Eastern Mediterrenean: coasts of Israel, Lebanon, Egypt and Turkey (BINI,1960, GÜCÜ *et al.,* 1994; GOLANI, 1996; TORCU & MATER, 2000). An important commercial fish.

Habitats. Usually occurs in coastal waters; a schooling species. Its food consists mostly of larvae of decapods and fishes (WHITEHEAD *et al*.,1986; GOLANI, 1993).

Compiled by N. Basusta

Atherinamorus lacunosus (Froster in Bloch and Schneider, 1801)

Synonyms: *Pranesus pingius* Lacepede, *Atherina pingius* Lacepede.

Common names: Hardyhead silverside (En), Aterinöz, Çipil Balık (Tur).

Taxonomy: Class- Osteichthyes
Order- Atheriniformes
Family- Atherinidae

Distinctive charateristics. Body rather long, slender, moderately flattened. Mouth protrusible, small teeth. Head and body scaly, scales rather large. Lateral line reduced to a row of small, round pits, one on each scale. Dorsal finrays IV-VII, I-II + 9-10; anal finrays I-II + 12-17. Scales in lateral series 40. Back blue-green, belly dusky white. Up to 14 cm, usually 10-12 cm long (WHITEHEAD et al.,1986; FISCHER et al.,1987; TORCU & MATER, 2000).

Atherinamorus lacunosus

Origin. The Indo-Pacific.

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).

Distribution of *Atherinamorus lacunosus* in the eastern Aegean Sea.

Distribution. This species is the first lessepsian migrant fish recorded off Iskenderiye in the eastern Mediterranean. Spread to the Aegean Sea (WHITEHEAD *et al*., 1986; GOLANI, 1996; TORCU & MATER, 2000). Because of small size, it is of little commercial importance.

Habitats. A littoral fish, forming small schools in shallow waters, stenohaline. Its food consists of zooplankton, insects, small bottom-living invertebrates.

Compiled by N. Basusta

Gambusia affinis (Baird & Girard, 1854)

Common names: Mosquitofish (Eng), Sivrisinek Balıgı (Tur).

Taxonomy: Class- Osteichthyes
Order- Cyprinodontiformes
Family- Poeciliidae

Distinctive characteristics. (See Chapter 3)

Gambusia affinis

Origin. North-American wetlands.

Way of introduction. Introduced for the first time by French authorities to control mosquito populations in Amik Lake and its wetlands in the lower Ceyhan River area. Later it was introduced in other wetlands throughout Anatolia by Turkish authorities to combat malaria.

Distribution of *Gambusia affinis* in the Turkish Seas

Distribution. Coastal areas near river mouths (BALIK,1975; GELDIAY & BALIK, 1988).

Habitats. Streams and small lakes , preferring especially stagnant waters. It feeds on mosquito larvae, pupae and crustaceans living in surface microlayer of water (GELDIAY & BALIK, 1988).

Compiled by N. Basusta

Hemiramphus far (Forsskal, 1755)

Synonyms: *Esox far* Forsskal, *H. commersoni* Cuvier.

Common names: Halfbeak (Eng), Çomak, Yarımgaga Balıgı (Tur).

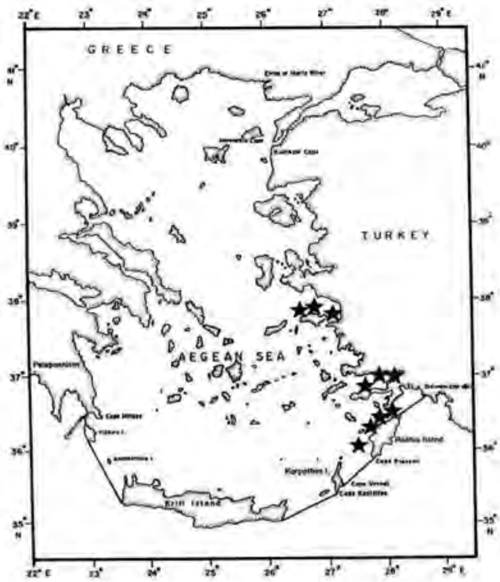
Taxonomy: Class- Osteichthyes
Order- Beloniformes
Family- Hemiramphidae

Distinctive characteristics. Body laterally compressed, alongated oval in cross-section. Lower jaw prolonged; upper jaw short and triangular. Teeth small. Lower lobe of caudal fin much longer than upper. Triangular portion of upper jaw naked. Pectoral branch of lateral line double; anterior part shorter. Preorbital ridge absent. Dorsal finrays 11-14; anal finrays 9-12; pectoral finrays 11-13. Specimen has 3-9 (usually 4-6) prominent vertical bars on sides of body; black pigmented areas in dorsal, pectoral and anal fins. Up to 33 cm long (WHITEHEAD *et al*.,1986; FISCHER *et al.*,1987; BAŞUSTA, 1997; TORCU & MATER,2000).

Hemiramphus far

Origin: The Indo-Pacific.

Possible way of introduction: Migration through the Suez Canal (a Lessepsian migrant).



Distribution of *Hemiramphus far* in the eastern Aegean Sea.

Distribution. The Aegean Sea and eastern Mediterrenean: the coasts of Israel, Lebanon and Turkey (BEN-TUVIA,1966; POR, 1978; PAPACONSTANTINOU, 1987, 1990; TORCU & MATER, 2000). This species has a commercial value.

Habitats. Epipelagic usually living in coastal waters. Schooling species. Its food is composed mainly of sea grasses (*Posidonia* sp.) and epibiontic organisms on sea grasses like green algae and diatoms (WHITEHEAD *et al*., 1986; TORCU & MATER, 2000).

Compiled by N. Basusta

Lagocephalus spadiceus (Richardson, 1844)

Synonyms: *Tetradon spadiceus* Richardson, *Tetradon lunaris* Tillier, *Sphoeroides spadiceus* Richardson, *Lagocephalus lunaris* Clark and Gohor.

Common names: Pufferfish (Eng), Balon Balıgı (Tr).

Taxonomy: Order- Tetraodontiformes
Family- Tetraodontidae

Distinctive characteristics. Two separate lateral lines, caudal peduncle rather narrow. Caudal fin lunate. No bony plates on back. This species has spines on belly and dorsal finrays 12; anal finrays 10-12; dark green above, yellow on sides and white below. Up to 30 cm.

Lagocephalus spadiceus

Probable origin. The Indo-Pacific.

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).

Distribution of *Lagocephalus spadiceus* in the eastern Aegean Sea.

Distribution. The Aegean Sea and eastern Mediterranean:the coasts of Lebanon, Israel, Turkey (WHITEHEAD *et al.*,1986; PAPACONSTANTINOU, 1988, 1990; GÜCÜ *et al.*,1994; BASUSTA & ERDEM, 2000). This species is of little commercial importance.

Habitats. A pelagic fish, living in coastal waters, depths less than 50-60 m on sand and rocky bottom with dense vegetation. The food consists of small invertebrates, shrimps, amphipodas, fish larvae and eggs (WHITEHEAD *et al*., 1986).

Compiled by N. Basusta

Leiognathus klunzingeri (Steindachner, 1898)

Synonyms: *Equcita klunzingeri* Steindachner, *Leiognathus mediterraneus* Erazi.

Common names: Pony fish (Eng), Pul balıgı, Eksi balıgı (Tur).

Taxonomy: Class- Osteichthyes
Order- Perciformes
Family- Leiognathidae

Distinctive characteristics. Small-sized fish with an oblong or elevated compressed body. Small, very protractile mouth with toothless palatines. Dorsal fin long, originating above pelvics, with 7 spines, second the longest, and 15-16 rays; anal finrays III + 15-16; soft dorsal and anal with scaly sheath. Scales cycloid. Back mottled grey with pink patches on the sides, belly silvery, a black line along each side of the dorsal fin. Length to 11 cm, usually 7-8 cm (WHITEHEAD *et al*.1986; FISCHER *et al.*,1987; BASUSTA, 1997; TORCU & MATER, 2000).

Leiognathus klunzingeri

Origin. The Indo-Pacific.

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).

Distribution of *Leiognathus klunzingeri* in the eastern Aegean Sea

Distribution. The Aegean Sea, eastern Mediterrenean (the coasts of Israel, Lebanon, Egypt, Turkey), reaching Tunisia (PAPACONSTANTINOU, 1987, 1990; BASUSTA & ERDEM, 2000). This species has no commercial value.

Habitats. A pelagic fish in coastal waters, entering brackish water and saline lagoons. Schooling fish in depths not exceeding 100 m. The main food consists of bottom macro- and meiobenthic invertebrates, mostly copepods, amphipods and ostracods (TORCU & MATER, 2000).

Compiled by N. Basusta

Liza carinata (Valenciennes, 1836)

Synonyms: *Mugil carinatus* Valenciennes, *Mugil seheli* Tillier.

Common names: Roving grey mullet (Eng), Topan, Bıldırcın Kefali (Tur).

Taxonomy: Class- Osteichthyes
Order- Perciformes
Family- Mugilidae

Distinctive characteristics. Body cylindrical or slightly oval, head broad, adipose eyelid well developed; upper lip thin, pectoral fin tip to vertical through first dorsal fin origin. Scales in lateral series 31-39; scales on head extend forward to level of anterior nostrils. Pyloric caeca 5. Back grey-blue, flanks and belly pale or silvery. Up to 30 cm long (WHITEHEAD *et al*;1986; FISCHER *et al.*,1987; BALIK *et al.*,1992; BASUSTA, 1997; TORCU & MATER, 2000).

Liza carinata

Origin. The Indo-Pacific.

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).

Distribution of *Liza carinata* in the eastern Aegean Sea.

Distribution. The Aegean Sea and eastern Mediterrenean: the coasts of Israel, Lebanon, Egypt, Turkey (BALIK *et al.*,1992; GOLANI, 1996; BASUSTA & ERDEM, 2000; TORCU & MATER, 2000). An important commercial fish.

Habitats: Pelagic, coastal waters, entering lagoons and estuaries for feeding, but spawning in the open sea. Feeding on bottom unicellular algae meiobenthic invertebrates and detritus by filtration (WHITEHEAD *et al.*, 1986; BALIK *et al.*, 1992).

Compiled by N. Basusta

Mugil soiuy (Basilewsky, 1855)

Common names: Haarder, Russian grey mullet (Eng), Rus Kefali, Pelingas (Tur).

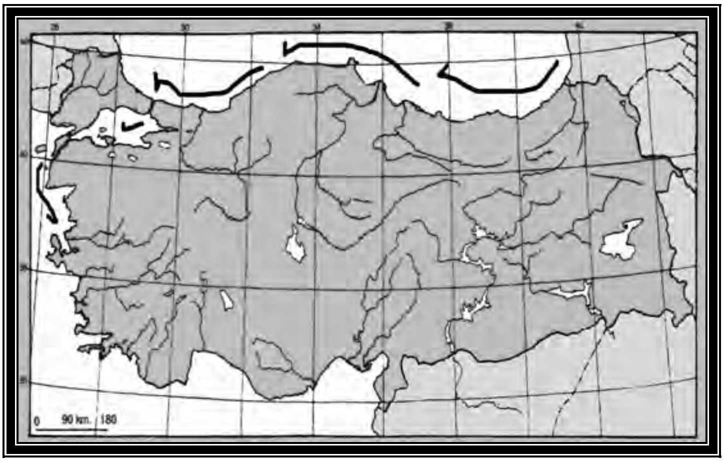
Taxonomy: Class- Osteichthyes
Order- Perciformes
Family- Mugilidae

Distinctive characteristics. The head is small and flattened dorsally, maxillae protractile. The jaws, vomer and palatine are without dentition; small teeth are present only on the arch of the tongue. The body scales are present especially pre and postorbital on the head. Suborbital without scales. First dorsal finrays IV; second dorsal finrays I 8; anal finrays I 8-9. A total of 6 phyloric caeca in a single group, all of approximately equal length. The colour of the dorsal is green-gray or greenish, brown, the flanks lighter colored and the ventral pink-white. Both of the dorsal fins are blackish, the anal fin and ventrals with yellow pigments.Up to 68.9 cm long and 3260 g in weight in the eastern Turkish Black Sea coasts (ÜNSAL, 1992; OKUMUS & BASCINAR, 1997; KAYA *et al.*, 1998).

Mugil soiuy

Origin. The Lower Amur River, northern Sea of Japan .

Way of introduction. Deliberately released as a commercial fish species in the Black Sea and Sea of Azov by Ukrainian and Russian ichthyologists in the 1970s. Migration through the Turkish Straits in the Mediterranean.



Distribution of *Mugil soiuy* in the Black, Marmara and Aegean seas.

Distribution. In 1989 two adults were caught for the first time along the Turkish Black Sea coast. The species migrated to the west, reaching the Sea of Marmara via the Bosphorus and from there to coasts of Aegean Sea via the Çanakkale Strait. One specimen was caught in Homa Lagoon and one in Foça (Izmir) by local fishermen in 1997. An important commercial fish (KAYA *et al.*,1998).

Habitats. Pelagic, usually inshore, entering lagoons, estuaries and rivers. Young fish are planktophagous, adult specimens feed on meiobenthos and detritus (OKUMUŞ & BASÇINAR, 1997).

Compiled by N. Basusta

Parexocoetus mento (Valenciennes, 1846)

Synonyms: *Exoccoetus mento* Valenciennes.

Common names: Flying fish (Eng), Uçan Kefalbaligi (Tur).

Taxonomy: Class- Osteichthyes
Order- Beloniformes
Family- Exocoetidae

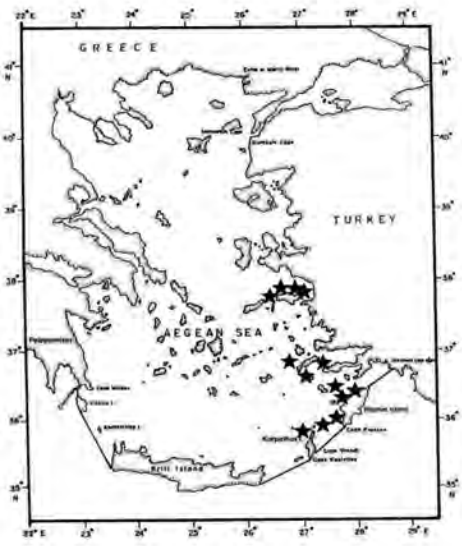
Distinctive characteristics. Body elongated, compressed, rounded ventrally. Upper jaw protrusible. Dorsal fin high, middle rays the longest, pectoral fin long, pelvic fins medium-sized. Dorsal finrays 9-12; anal finrays 10-12; pectoral finrays 13-15.

Iridescent greenish-blue above, silvery below; dorsal fin with any black pigments, pectoral fins greyish.Up to 10 cm long (WHITEHEAD *et al*., 1986; FISCHER *et al.*, 1987).

Parexocoetus mento

Origin. The Indo-Pacific .

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).



Distribution of *Parexocoetus mento* in the eastern Aegean Sea

Distribution. The Aegean Sea and eastern Mediterranean:the coastal waters of Israel, Lebanon, Turkey (BEN-TUVIA, 1966; PAPACONSTANTINOU, 1987, 1990). This species is of little commercial importance.

Habitats. A pelagic fish, living in the near shore waters. A schooling species, its main food are some pelagic invertebrates and larvae of fishes.

Compiled by N. Basusta

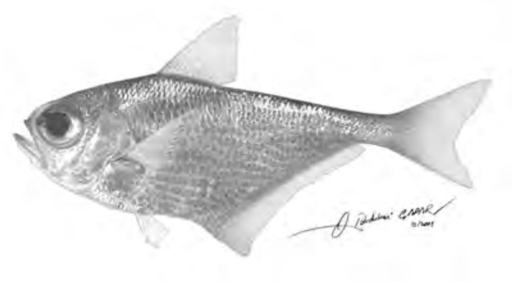
Pempheris vanicolensis (Cuvier, 1831)

Synonyms: *P. moluca* Bleeker, *P. magula* Kner.

Common names: Sweeper (Eng), Ateş Balığı, Üçgen Balıgı (Tur).

Taxonomy: Class- Osteichthyes
Order- Perciformes
Family- Pempheridae

Distinctive characteristics. Body laterally compressed and the belly triangular, eyes large and near dorsal edge, mouth large. Dorsal finrays: IV-VI, 7-12; anal finrays: II-III, 23-45; pectoral finrays: I, 15-16; ventral finrays: I, 5. Back brownish-pink with small spots on the dorsal and anal fins. Distinguished by a dark area on the tip of the dorsal fin and the presence of a similiar projection distal edges of the first few anal rays (PAPACONSTANTINOU, 1990; GÜCÜ *et al*., 1994; TORCU & MATER, 2000).



Pempheris vanicolensis

Origin. The Indo-Pacific.

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).

Distribution of *Pempheris vanicolensis* in the eastern Aegean Sea.

Distribution. This small nocturnal species was firstly recorded in Lebanon. Then, it was reported from the Israel and Turkish coasts of the Mediterranean Sea (BEN-TUVIA, 1978; GÜCÜ *et al.*, 1994; GÜCÜ & BINGEL, 1994). It has recently spread westward toward the Aegean Sea (PAPACONSTANTINOU, 1987, 1990; TORCU & MATER, 2000). This species has no commercial value.

Habitats. During the day this species forms large hovering aggregrations in caves and among rocks. At dusk, it leaves the caves. It feeds on nocturnal zooplankton (GOLANI & DIAMANT, 1991; TORCU & MATER, 2000).

Compiled by N. Basusta

Sargocentron rubrum (Forsskal, 1775)

Synonyms: *Holocentrus ruber* Forsskal, *H. hastatus* Cuvier, *Adioryx hastatus* (Cuvier), *Holocentrus rubrum* Forsskal.

Common names: Red soldier fish (Eng), Hindistan, Naylon balıgı (Tr).

Taxonomy: Class- Osteichthyes
Order- Beryciformes
Family- Holocentridae

Distinctive characteristics. Body compressed, eyes and large mouth small teeth in jaws . A strong preopercular and two smaller opercular spines. Dorsal finrays XI + 12-14 (usually 13); anal finrays IV + 8-9 (usually 9). Scales large and spiny, 34-39 in lateral line. Body and fins reddish colour and 7-9 longitudinal dark stripes, edge of spiny dorsal and caudal fins blackish.Up to 25 cm, usually 10-20 cm long (WHITEHEAD *et al.*, 1986; FISCHER *et al.*,1987; BASUSTA, 1997; TORCU & MATER, 2000).

Sargocentron rubrum

Origin. The Indo-Pacific.

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).

Distribution of *Sargocentron rubrum* in the eastern Aegean Sea.

Distribution. The Aegean Sea and eastern Mediterranean. It is a nocturnally active fish that was firstly recorded from the coasts of Israel and later of Turkey, Greece, Lebanon (BEN-TUVIA, 1966; POR, 1978; PAPACONSTANTINOU, 1987, 1990; GOLANI, 1996; TORCU & MATER, 2000). This species is of little commercial Cimportance.

Habitats. Inshore waters, common in rocky grounds at 0-25 m depth in the Aegean Sea and Eastern Mediterranean (TASKAVAK et al.,1998). It feeds mainly on molluscs, crustaceans and small fishes (GOLANI & BEN-TUVIA, 1985; WHITEHEAD *et al;* 1986; GOLANI, 1993).

Compiled by N. Basusta

Saurida undosquamis (Richardson, 1948)

Synonyms: *Saurida argyophanes* Jordan et Evermann, *Saurida tumbil* Regan, *Saurida macrolepis* Tanaka.

Common names: Brushtooth lizardfish (Eng), Iskarmoz (Tur).

Taxonomy: Class- Osteichthyes
Order- Aulopiformes
Family- Synodontidae

Distinctive characteristics. Body slender, elongated, cylindrical, covered with deciduous cycloid scales. Head somewhat depressed but generally narrow; naked above bones never rugose. Snout rounded in dorsal aspect. Pectotal fin rather short. Longest ray of dorsal fin slightly shorter that head length. Caudal peduncle depressed. Dorsal finrays 11-12; anal finrays 10-12; pelvic finrays 9; pectoral finrays 14-15. Lateral line scales 41-52. Brown with a row of disky spots along sides; upper lobe of caudal fin 4-5 dark dots along dorsal edge (WHITEHEAD *et al;* 1984; FISCHER *et al.*, 1987; MATER & TORCU, 1996; BASUSTA, 1997).

Saurida undosquamis

Origin. The Indo-Pacific .

Possible way of introduction. Migration by way of the Suez Canal (a Lessepsian migrant).

Distribution of *Saurida undosquamis* in the eastern Aegean Sea

Distribution. The Aegean Sea and eastern Mediterranean: the coasts of Israel, Lebanon and Turkey (BEN-TUVIA, 1971; PAPACONSTANTINOU, 1987, 1990; MATER *et al.*,1995; TORCU & MATER, 2000). An important commercial fish.

Habitats. Generally coastal waters, depths less than 100 m on sandy and muddy bottoms. Feeds on small fishes like anchovy, pony fish and red mullet (WHITEHEAD *et al*.,1984; GOLANI, 1993).

Compiled by N. Basusta

Scomberomorus commerson (Lacepede, 1802)

Synonyms: *Scomber conam* Russel, *Cybium commersone* Cuvier .

Common names: Narrow-barred Spanish mackerel (Eng), Ceylan Baligi, (Tur).

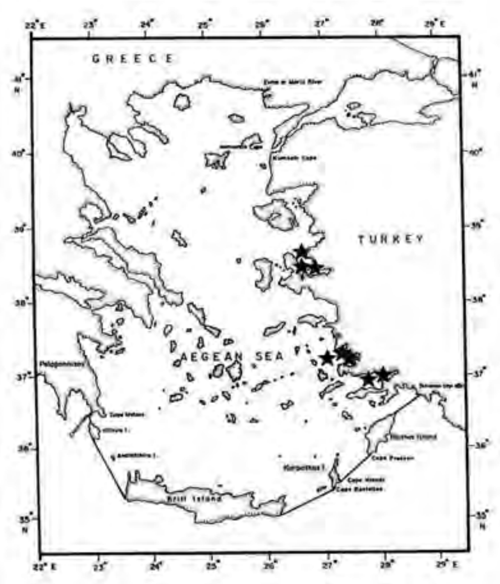
Taxonomy: Class- Osteichthyes
Order- Perciformes
Family- Scombridae

Distinctive characteristics. A very large species, body laterally compressed. Lateral line curves down to the end of the second dorsal fin; a well developed carina in the middle of the caudal peduncle. Dorsal spines 15-18, usually 16-17; dorsal and anal finlets 8-11, usually 9 or 10, and pectoral finrays 21-24, usually 22. Back iridescent blue-grey, sides silver, marked with slightly wavy vertical bands. Up to 225 cm, usually 60-90 cm (COLLETTO & RUSSO, 1984; WHITEHEAD *et al.*, 1986; FISCHER *et al.*, 1987; BASUSTA, 1997; TORCU & MATER, 2000).

Scomberomorus commerson

Origin. The Indo-Pacific .

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).



Distribution of *Scomberomorus commerson* in the eastern Aegean Sea

Distribution. The Aegean Sea and eastern Mediterranean (the coasts of Israel, Lebanon and Turkey). An important commercial fish (MATER *et al.*,1995; BUHAN *et al.*,1997; BASUSTA & ERDEM, 2000; TORCU & MATER, 2000).

Habitats. Epi- and mesopelagic fish in coastal waters between 15 and 200 m depth. It migrates in small schools and feeds on pelagic fish (WHITEHEAD *et al*., 1986).

Compiled by N. Basusta

Siganus luridus (Ruppell, 1878)

Synonym: *Ampacanthus luridus* Ruppell.

Common names: Dusky spine-foot (Eng), Siyah sokar, çarpan baligi (Tur).

Taxonomy: Class- Osteichthyes
Order- Perciformes
Family- Siganidae

Distinctive characteristics. Body compressed, its depth 2.1-2.8 in standard length. Dorsal fin rays XIV+10, the longest dorsal spine longer than the distance from front of eye to posterior edge of opercle, the longest dorsal ray longer than the length of snout; anal finrays VII 9; pectoral finrays 16; ventral finrays I+3+I; caudal fin truncate. Usually mottled olive green to dark brown; pectoral fins hyaline-yellow; dark crossbars on caudal fin. Up to 30 cm, usually 10-20 cm (WHITEHEAD *et al*.,1986; FISCHER *et al.*,1987; BASUSTA, 1997; TORCU & MATER, 2000).

Siganus luridus

Probable origin. The Indo-Pacific.

Possible way of introduction. Migrated through the Suez Canal (a Lessepsian migrant).

Distribution of *Siganus luridus* in the eastern Aegean Sea

Distribution. The Aegean Sea and eastern Mediterranean: the coasts of Turkey, Cyprus, Lebanon, Israel and Tunisia (PAPACONSTANTINOU, 1987, 1990; MATER *et al.*,1995; BASUSTA & ERDEM, 2000). An important commercial fish.

Habitats. Inhabits inshore waters, close to the bottom not exceeding 40 m in depth. It is a herbivorous species, feeding on seaweeds, mostly on brown algae (WHITEHEAD *et al*.1986; GOLANI, 1993). The feeding habits of this species in the eastern Mediterranean was investigated by K. STERGIOU (1988). The stomach contents of 209 specimens of *S. luridus* 131-250 mm long were examined. The main food was represented by benthic algae, pertaining to 24 genera. The green algae made up 3% by weight, brown algae 70.3%, and red algae 11%. *Dictiota* sp., *Cystoseira* sp., *Sphacelaria* sp., *Gelidium* sp., *Dictyopteris membranacea*, *Kuckuckia spinosa* and *Padina pavonia* predominated in the diet. *Posidonia oceanica*, benthic diatoms, hydrozoans and sand graons were also found in the stomachs examined.

Compiled by N. Basusta

Siganus rivulatus (Forsskal, 1775)

Synonyms: *Ampacantus rivulata* Forsskal, *Teuthis sigan* Steinitz, *Siganus nebulosus* Norman, *Siganus siganus* Chabanaud.

Common names: Marbled spinefoot (Eng), Çilli çarpan baligi (Tur).

Taxonomy: Class- Osteichthyes
Order- Perciformes
Family-Siganidae

Distinctive characteristics. Body deep and compressed, its depth 2.7-3.4 in standard length, head small; snout rounded; mouth small, upper lip high, skin smooth, scales tiny, cycloid. Anal finrays VII 9, pectoral finrays 16; ventral finrays I+3+I; caudal fin only moderately forked. Body light brown-olive, longitudinal yellow stripes on each side. Reached up to 40 cm long, usually 10-20 cm (WHITEHEAD *et al.*,1986; FISCHER *et al.*,1987; BASUSTA, 1997; TORCU & MATER, 2000).

Siganus rivulatus

Origin. The Indo-Pacific.

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).

Distribution of *Siganus rivulatus* in the eastern Aegean Sea.

Distribution. From the Aegean Sea along the southern coasts of Turkey, Cyprus, Lebanon, Israel, Egypt up to Libya. This species is able to spread in low salinity waters towards the northern part of the Aegean Sea (PAPACONSTANTINOU, 1987, 1990; MATER *et al.,* 1995; BASUSTA & ERDEM, 2000). An important commercial fish.

Habitats. It is common in shallow coastal waters, close to the bottom, in depth not exceeding 60 m. It feeds chiefly on seaweeds, mainly on green and red algae. Young siganids are eaten by such predators as *Euthynnus alletteratus, Scomber japonicus, Sphyraena chrysotaenia* (WHITEHEAD *et al*.,1986; GOLANI, 1993).

Compiled by N. Basusta

Sphyraena chrysotaenia (Klunzinger, 1884)

Synonym: *S. obtusata* Cuvier.

Common names: Obtuse barracuda (Eng), Zurna Baligi (Tur).

Taxonomy: Class- Osteichthyes
Order- Perciformes
Family- Sphyraenidae

Distinctive characteristics. Body oblong, jaws elongated, strong canin teeth. Preoperculum fully scaled, pectoral fins inserted in front of first dorsal fin; pectoral fins above pelvic fins. Lateral line with 82-86 scales. Brown-grey above, silvery below; tips of first dorsal and caudal fin blackish, second dorsal, pectoral and caudal fins yellowish. Up to 40 cm long (WHITEHEAD *et al*., 1986; FISCHER *et al.*, 1987; BASUSTA, 1997; TORCU & MATER, 2000).

Sphyraena chrysotaenia

Origin. The Indo-Pacific.

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).

Distribution of *Sphyraena chrysotaenia* in the eastern Aegean Sea

Distribution. The Aegean Sea and eastern Mediterranean: the coasts of Israel, Lebanon, Egypt, Turkey (BEN-TUVIA, 1966; 1978; WHITEHEAD *et al*.,1986; TORCU & MATER, 2000). An important commercial fish.

Habitats. Inhabits both pelagic and benthic zones in shore waters. They swim in small schools. It feeds on pelagic planktophagous fish like sardine, anchovy and sometimes also young barracudas (GOLANI, 1993; TORCU & MATER, 2000).

Compiled by N. Basusta

Stephanolepis diaspros (Fraser-Brunner, 1940)

Synonyms: *S. ocheticus* Fraser-Brunner, *S. hispidus* Sanzo, *Monacanthus setifer* Tillier.

Common names: Filefish (Eng), Dikenli Çütre Baligi (Tur).

Taxonomy: Class- Osteichthyes
Order- Tetraodontiformes
Family- Monacanthidae

Distinctive characteristics. Body compressed and deep, eyes near dorsal edge, mouth small. Dorsal finrays: I + 30-33: anal finrays, 30-33: pelvics absent. Scales small and ctenoid giving a velvety appearance. Grey brown or greenish with spots and lines; adult have pale lines on the sides, enclosing dark lozenge shaped areas; caudal fin with 2 dark bands. Up to 25 cm long (WHITEHEAD *et al*.,1986; FISCHER *et al.,* 1987; BASUSTA, 1997; TORCU & MATER,2000).

Stephanolepis diaspros

Origin. The Indo-Pacific.

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).

Distribution of *Stephanolepis diaspros* in the eastern Aegean Sea.

Distribution. The Aegean Sea, Ionian Sea, eastern Mediterrenean:the coasts of Israel, Lebanon, Egypt, Turkey. It reached the coastal waters of Tunisia and southern Italy (POR, 1978; PAPACONSTANTINOU, 1987, 1990; GOLANI, 1996; TORCU & MATER, 2000). This species is of little commercial importance.

Habitats. Littoral near bottom or reefs in tropical to warm temperate seas. It seems to prefer migration westward with sea grasses such as *Posidonia* sp. (TORCU & MATER, 2000).

Compiled by N. Basusta

Upeneus moluccensis (Bleeker, 1855)

Synonym: *Upenoides moluccensis* Bleeker, *Upenoides dubrus* Krer, *Mulloides aurijlamma* Hoces et Steinite, *Mulloidichthys aurijlamma* Ben-Tuvia.

Common names: Golden-banded goat fish (Eng), Pasa barbunya balıgı (Tur).

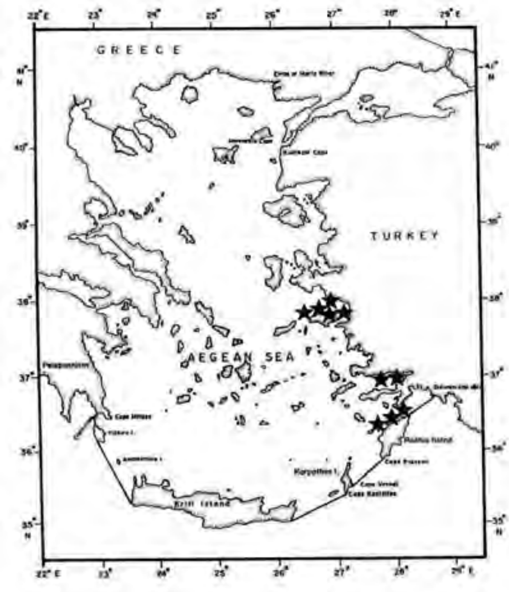
Taxonomy: Class- Osteichthyes
Order- Perciformes
Family- Mullidae

Distinctive characteristics. Body elongated. Snout rounded, chin with two short thin barbels. Villiform teeth on both jaws, vomer and palatines. Preorbital scales absent. First dirsal fin with 8 spines and second dorsal fin with 1 spine and 8 soft rays. Caudal fin deeply forked. Lateral line 33-36 scales. Head and back brown-red or bright red, sides and belly white. A distinct yellow band from anterior profile of head through eye above lateral line to caudal fin. Both dorsal fins yellow with 3 red horizontal bars, pectorals colourless, pelvics yellowish, upper lobe of caudal fin whitish, with 5-6 black oblique bars.Up to 25 cm, usually 10-15 cm (WHITEHEAD *et al*.,1986; FISCHER *et al.*,1987; BASUSTA, 1997; TORCU & MATER, 1997).

Upeneus moluccensis

Origin. The Indo-Pacific .

Possible way of introduction. Migration through the Suez Canal (a Lessepsian migrant).



Distribution of *Upeneus moluccensis* in the eastern Aegean Sea

Distribution. The Aegean Sea and eastern Mediterranean (the coasts of Israel, Lebanon and Turkey). An important commercial fish (PAPACONSTANTINOU, 1987, 1990; MATER *et al.*,1995; TORCU, 1995; BASUSTA *et al.*,1997).

Habitats. A bottom living fish in tropical and subtropical inshore waters down to 80 m depth. Usually found in large schools. Its food consists on macrurid crustaceans and small fishes such as *L. klunzingeri* (WHITEHEAD *et al*.,1986; GOLANI, 1993; TORCU & MATER, 2000).

Compiled by N. Basusta

Additional Information to the Chapter 1

Some non-native species introduced in the Aegean Sea by human activities are not included in the above lists of exotics because of lack of information. Those are the following species.

Phytoplankton species *Alexandrium monilatum* (Howell) F.J.R. Taylor 1979 (Pyrrophyta, Gonyaulacales, Gonyiodomataceae), originated from the American Atlantic coastal waters and distributed in the Gulf of Mexico, Caribbean Sea, Atlantic coast of Florida, Chesapeake Bay and Ecuador. *A. monilatum* is probably inhabiting the Aegean Sea, because after the first registration of this species in the Mediterranean Sea in 1985 (GOTSIS-SCRETAS & FRILIGOS, 1990), it was found in 1991 in blooming densities in the Black Sea (MONCHEVA *et al.*, 1995; MONCHEVA & KRASTEV, 1997; MONCHEVA et al., 1999).

Phytoplankton species, *Phaeocystis pouchetii* (Hariot) Lagerheim, 1893 (Prymnesiaphyceae, Prymnesiales, Phaeocystaceae), originated from the coastal waters of Arctic, Antarctic, Atlantic and Pacific. It was registered in blooming densities for the first time in the Aegean Sea in February-March, 1989 (GOTSIS-SKRETAS & FRILIGOS, 1990). *Rhizosolenia calcar-avis* Schultze was also recorded in Bay of Bodrum in the Aegean Sea (KORAY&KESİCİ, 1994).

The scyphozoan jellyfish *Rhopilema nomadica* Galil 1990 (Coelenterata, Discomedusae, Rhizostomidae) was first collected in the eastern Mediterranean in 1977, and a single specimen was found near Izmir in 1998 (GALIL, 2000).

The bristle worm *Hydroides dianthus* (Verrill, 1873) (Polychaeta, Serpulimorpha, Serpulidae) was documented in Izmir. (KOCAK *et al.*, 1999).

Zooplankton species *Acartia tonsa* Dana, 1849 (Crustacea, Copepoda, Acartiidae), originated from coastal waters (close to estuaries) of the West Atlantic and Indo-Pacific Oceans (BRYLINSKI, 1981),is newly introduced species in the Mediterranean Sea (GAUDI & VINAS, 1985). Successive records of *A. tonsa* in the Mediterranean Sea suggest its spread eastward in this basin. It has been registered inthe Tyrhenian Sea (ZAGAMI & GUGLIELMO, 1990), in a Northern Adriatic lagoon (FARABEGOLI *et al.,* 1989) and in the Black Sea (BELMONTE et al., 1994). Apparently *A. tonsa is* recorded from the Sea of Marmara (ÜNAL *et al.*, 2000) and from the Aegean Sea (TARKAN *et al.*, 2001). As a total, 19 *Acartia* species were reported from the Mediterranean Sea (KOVALEV & SHMELEVA, 1982).

The shrimp *Penaeus semisulcatus* de Haan, 1844 (Crustacea, Decapoda, Penaeidae). Synonym: *Penaeus monodon* Fabricius, 1798. Indo-West Pacific origin. Recorded in the Aegean Sea (coastal waters of Turkey) (KOCATAŞ *et al.*, 1991) This species has commercial importance at present.

The pebble crab *Ixa monodi* Holthuis & Gottlieb, 1956 (Crustacea, Decapoda, Brachyura). Synonym: *Ixa cylindrus* Monod (1938).The Red Sea origin. First registered in single specimens in the Aegean Sea (coastal waters of Turkey) (HOLTIUS& GOTTLIEB, 1956). It has possibly been introduced via the Suez Canal.

The swimming crab *Charybdis (Goniohellenus) longicollis* Leene, 1938 (Crustacea, Decapoda, Brachyura). Synonym: *Charybdis (Goniohellenus) hoplites* var. *longicollis* Leene, 1938.The Red Sea, East Africa, and Persian Gulf origin. First registered as single specimen in the Turkish coastal area (HOLTHUIS, 1961).

Decapoda *Thalamita poissonii* (Audouin, 1826) (Crustacea, Decapoda, Brachyura). Synonym: *Thalamita admete* (Herbst, 1803).Its common name is the swimming crab. The Indo- West Pacific origin. First registered in the Turkish coastal area of the Aegean Sea (KOCATAŞ, 1981) . It has been possibly introduced through via the Suez Canal. Source of information: (http://www.ciesm.org/atlas).

Decapoda *Pilumnopeus vauquelini* (Audouin, 1826) (Crustacea, Decapoda, Xanthidae). Synonym: *Heteropanope vauquelini* (Audouin, 1826). The Red Sea and Persian Gulf origin. First registered of the Aegean Sea in the Turkish coastal area . It has possibly been introduced through the Suez Canal. Source of information: (http://www.ciesm.org/atlas).

Decapoda *Erugosquilla massavensis* (Kossmann, 1880) (Crustacea, Stomatopoda). Synonyms: *Squilla africana* Calman, 1917; *Squilla masawensis* Por, 1971; *Oratosquilla massavensis* (Kossmann, 1880).Red Sea, Persian Gulf origin. First registered in the Turkish coastal waters of the Aegean Sea (HOLTHUIS, 1961), (ENZENBROSS *et al*., 1990) Now an abundant species.It has possibly been introduced through via the Suez Canal. Source of information: (http:// www. ciesm. org/atlas).

The snail *Cellana rota* (Gmelin, 1791) (Mollusca, Gastropoda, Patellidae). Synonyms: *Patella rota* Gmelin, 1791; *Patella variegata* Reeve, 1842; *Patella karachiensis* Winckworth, 1930; *Patella radiata* "Chemnitz" (name available from Born, 1778). Originally distributed in the Red Sea and Indian Ocean: Southern Arabia, Arabian Gulf, India. Limits of distribution difficult is to assess due to confusion with other species or subspecies of the *C. radiata* complex. First registered in the Aegean Sea in Greece, Saronikos Gulf. A possible way of introduction is progressive penetration through the Suez Canal. Source of information: (http://www.ciesm.org/atlas).

The snail *Smaragdia souverbiana* (Montrouzier, 1863) (Mollusca, Gastropoda). Originally distributed the Indo-Pacific, from Japan, to Fiji, Tonga and the Samoa in the Western Pacific, the Indian Ocean, and the Red Sea where the species is common. It has been found in the southeastern Turkish waters in the Aegean Sea (BUZZURRO & GREPPI, 1996; ENG, 1995)

The snail *Strombus persicus* Swainson, 1821 (Mollusca, Gastropoda, Strombidae). Synonym: *Strombus decorus raybaudii* Nicolay & Romagna-Manoja, 1983. *S. persicus* is originally restricted to the southern coast of Arabia and part of Persian Gulf (MOOLENBECK & DEKKER, 1993), whereas related species *S. decorus* (Röding, 1798) has broader distribution in the other parts of the Indian Ocean. It is registered in shallow bays on mixed (rock/sand/mud) bottoms of Aegean Sea along the southern coast of Turkey (CRUCITTI & ROTELLA, 1991; ENG, 1995) and Greece around Rhodes (NICOLAY, 1986). It was supposed that the introduction of this species was made by ships coming from Persian Gulf, a tenable scenario since (1) the species does not occur in the the Red Sea and (2) the current Mediterranean area is close to Iskenderun, a port of call for tankers which may proceed from the Persian Gulf. Further localities have been found shortly later but it is not known whether this is due to rapid spreading or to an increase in the exploration effort during the 1980's;

The snail *Cylichna girardi* (Audouin, 1826) (Mollusca, Gastropoda, Retusidae). Synonyms: *Bulla girardi* Audouin, 1826; *Ventomnestia girardi* Audouin: Mienis, 1976; *Cylichnina girardi* Audouin. Indo-Pacific origin, found also in the Suez Canal. Registered in the Aegean coastal waters of Turkey near Bodrum (BUZZURO & GREPPİ, 1996) and Greece: Crete, Ierapetra (COSENZA & FASULO, 1997). Possible way of introduction is progressive penetration through the Suez Canal.

The snail *Pyrunculus fourierii* (Audouin, 1826) (Mollusca, Gastropoda, Bullidae). Synonyms: *Bulla fourierii* Audouin, 1826; *Bulla mica* Ehrenberg, 1831; *Retusa fourierii* (Audouin, 1826). The Indo-Pacific origin. It was first registered in the Turkish coastal water of the Aegean Sea in Datça area (TRINGALI & VILLA, 1990). A possible way of introduction is progressive penetration through the Suez Canal.

The bivalve *Anadara demiri* (Piani, 1981) (Mollusca, Bivalvia, Arcidae). Synonyms: *Arca amygdalum* Philippi, 1847; *Scapharca demiri* Piani, 1981. Original distribution uncertain, with records in the Indian Ocean. In the Mediterranean, from Turkey Izmir Harbour (DEMIR, 1977; ENG, 1995); N. Aegean: Thermaikos Gulf (ZENETOS, 1994). Probably introduced through shipping. Source of information: (http://www.ciesm.org/atlas).

Brachidontes semistriaus (Krauss), *Pinctada radiata* (Leach) *Strombus decorus percicus* Swainson recorded NIEDERHÖFER &ENZENROBE (1991). from the Aegean Sea around Bodrum, Marmaris and Fethiye .

Chrysallida obtusa (Brown, 1827)**,** *C. julia*, *Euparthenia humboldt* (Risso, 1826), *Tragula fenestrata* (Jeffrys,1848), *Odostomia conoidea* (Brocchi,1814), *Eulimella acicula* (Philippi, 1867) *Ondina vitrea* (Brusina, 1866),*Turbonilla striatula* (Linne, 1758), *T. rufa* (Philippi), *T. pusilla* (Philippi, 1844) were recorded by around the Marmaris area in the Aegean Sea. *Strombus persicus*, *Scapharca demiri. S. inaequivalvis*, *Pinctada radiata* recorded (ENG ,1995) from Bodrum and İzmir.

Halophila stipulacea a marine phanerogam recorded from Cape Sancak in the Aegean Sea by ZIBROWIUS (1993).

KIRKIM *et al.,* (2001) reported a lessepsian (Isopoda, Crustacea) *Sphaeroma walkeri* (Stebbing, 1905) from the Aegean Sea.

Synaptula reciprocans (Forskal, 1775) also found in the Aegean Sea in Gökova Bay, Datça and Turunç Bay in Marmaris in 2000.

Chapter 2. The Sea of Marmara

Physical Geography, Biology, Ecology

Geographical position

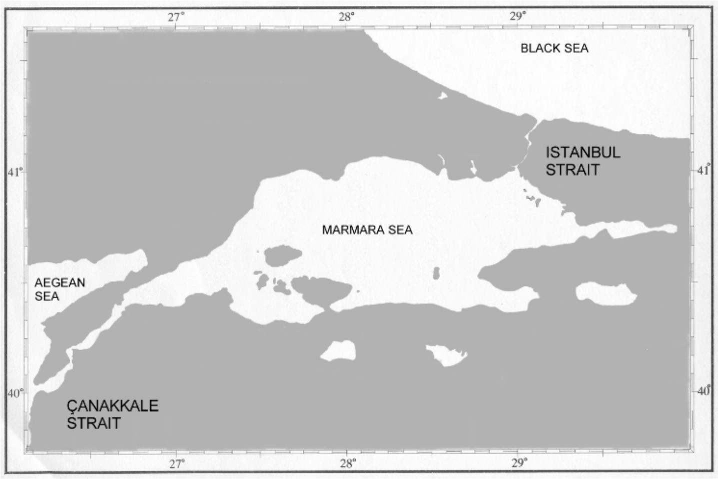
The Sea of Marmara or Marmara Sea, including the Istanbul Strait (Bosphorus), the Marmara Sea proper and the Çanakkale Strait (Dardanelles), lies between latitudes N 40^{o} 00'and N 41^{o}10' and longitudes E 26^{o}15' and E 29^{o} 55' E. The sea is surrounded by Anatolia and Trace regions in Turkey.

Geological evolution

Stratigraphic analyses of the Late Quaternary sediments of the Sea of Marmara basin indicates that it was a freshwater lake during the late glacial to ca 12,000 years ago depositing sediments with Neoeuxinian fauna characteristic of the Balck Sea Basin. At that time, the area it was inundated by the Mediterranean waters and gradually converted into a marine realm as indicated by the presence above the Neouexinian sediments of a mixed layer, containing both marine and freshwater fauna (ÇAGATAY *et al.,* 2000).

Morphometry and climate

Due to its geological, hydrological and biological characteristics, the Sea of Marmara represents a peculiar marine ecosystem between the Mediterranean and Black Sea. The Bosphorus, Marmara Sea and Dardanelles together constitute The Turkish Straits System. The surface area of the Marmara Sea is 11,500 km^2 and the volume is 3,378 km^3. The length of the coastline of the sea is 927 km. A continental shelf with three adjoining depressions dominates the bottom of the Marmara Sea. The contiental shelf on the southern side is wide, and extentds nearly to the center of the sea. Boundary of the shelf is 100 m depth, however the depth of about 75 m dominate the shelf. The deepest area is in the middle depression reaching 1335 m depth (KOCATAS *et al*., 1993).



The Sea of Marmara

The Black Sea waters enter the Marmara Sea through the Istanbul Strait upper layer flow and exits through the Çanakkale Strait. Likewise, the Aegean Sea water enters the Marmara Sea through the Çanakkale Strait with lower layer flow, and exits to the Black Sea with the Istanbul Strait underflow. The oceanography of the Marmara Sea is dominated by the conditions in the adjacent basins. The Marmara Sea is made up of two layers of water either Black Sea or Mediterranean Sea origin, separated by a sharp interface. The upper layer has a volume of 230 km^3 and an average renewal time of 4-5 months. The lower layer has a volume of 3,378 km^3 and average renewal time of 6-7 years (BESİKTEPE *et al.*, 2000). The Sea of Marmara is composed by the less saline Black Sea waters in the upper 15-20 m and by the Mediterranean salty water at the depth. Life in the upper layer is nourished primarily by the brackish water of the Black Sea. On average, the Marmara Sea upper waters are renewed about twice a year by the inflow from the eutrophicated southern Black Sea area (TUGRUL *et al* ., 2000).

The temperature of the surface water of the Istanbul Strait, which is under the influence of the Black Sea, ranges from 4º C to 24º C . The salinity varies between 18‰ and 10‰. The salinity at 20 m rises to 30‰ and at 40-50 m to 37‰. The temperature of the surface waters of the Çanakkale Strait varies from 6º to 26º C and the salinity from 24‰ to 36‰ (KOCATAS *et al.*, 1993).

The Turkish Straits Sytem plays a significant roles in the biology of the Mediterranean and Black Sea basins.

The main gulfs of the Sea of Marmara are Izmit Bay, Gemlik Bay, Erdek and Bandirma Bays. All these bays are on the Anatolian side of the sea. Some rivers like the Susurluk and Nilüfer, Gönen creek and Karsak in the Asian side drain in to the Marmara Sea.

Main characteristics of ecosystem of the Sea of Marmara

Abiotic factors

Due to intensive development of phytoplanktons, the dissolved oxygen can exceed 100% of saturation in the surface layers . The intensive consumption of oxygen in benthic and pelagic zones causes rapid decrease in the concentration of this gas in the near bottom layer of water, thus creates hypoxic and anoxic zones mainly in shallow bays like Izmit and in some intensively eutrophicated areas of the sea, such as Prince Islands, The Istanbul Strait and Gemlik Bay (OZTURK *et al.*, 2001).

Biotic factors

According to its origin, the fauna of the Sea of Marmara can be divided in four groups. These are Pontian relics like the sturgeon, which is one of endangered species in the Sea of Marmara. The second group are the cold -water relics, like the copepod *Calanus helgolandicus*, the spiny dog fish, the whiting. The third group are Mediterranean origin species, which are the most numerous, like various Sponges, black coral and gorgons, cephalopods, echinoderms and fishes such as mackerel, bonito, bluefish, grey mullets, and red mullets. The fourth group is composed of exotic speices which are new settlers in the Sea of Marmara.

It is obvious that the fauna and flora of the Marmara Sea are mixture of the Black Sea and Mediterranean Sea inhabitants, due to hydrological and geological peculiarities of the Marmara Sea. Therefore, the deep depressions of the Marmara Sea need to be more investigated in terms of its faund.

Until the early 1970s, the Turkish straits were biologically the richest and the most productive areas. Among the commercial species, the most numerous fishes were *Pomatomus saltator, Trachurus trachurus, Mullus barbatus, M. surmuletus, Lichia amia, Gaidropsarus mediterraneus, Mugil cephalus, Psetta maxima, Scomber japonicus, Xiphias gladius, Atherina boyeri, Thunnus thynnus* and *Acipenser sturio*. Now among these species, *Acipenser sturio, Scomber scombrus, Xiphias gladius, Psetta maxima, Pomatomus saltator, Lichia amia, Atherina boyeri and Gaidropsarus mediterraneus have* disappeared in the Sea of Marmara fisheries (OZTURK &OZTURK 1996). However, the cause of the decline of these fish populations is not only related to overfishing, illegal fishing methods and ship originated pollution, but also to organic pollution, changing hydrological regime and other ecological factors. Heavy marine traffic covers the fishing ground in nearly all bays or inlets of the straits, making it difficult to fish. Pollution load of the Marmara Sea is very closely related to the adjacent seas. Industrial and domestic pollution comes from local sources and from the Black Sea, which receives pollutants from eastern and central Europe through major rivers such as the Danube, Dnieper and Dniester.

ERAZI (1942) recorded 181 species of fish living in the Marmara. According to SLASTENENKO (1955-1956), this number is 135 and according to GELDIAY (1969), 175.

Future of the Sea of Marmara

Future of the Sea of Marmara depends on four major factors. These are: a) mitigation of the pollution load from the Black Sea, which is originated mainly from land- based sources, b) controlling local land based sources of agricultural and industrial pollution from the drainage basin of the Sea of Marmara. (This sea is already a mesotrophic and intensively eutrophicated basin).c) taking of appropriate measures against ship originated pollution in the harbours and open sea.(due intensive shiping activity, the Sea of Marmara is open for different exotic aquatic organisms).d) protection of the biodiversity. This sea already suffers from the overfishing and pollution. Now 53 marine species are under the threat in the Sea of Marmara. Among them there are 2 algal species, 3 sea grass species, 15 invertebrates, 20 fish species, 9 sea birds species and 4 marine mammals (ÖZTÜRK & ÖZTÜRK, 2000b).

Exotic species

Plants

Rhizosolenia calcar-avis (M. Shultze, 1858)

Common names: No

Taxonomy: Class- Centrophyceae
Order- Bacillariophyta
Family- Soleniaceae

Synonyms: No

Distinctive characteristics. (See Chapter 3)

Probable origin. The Black Sea.

Possible way of introduction. Via ships and/or introduced with the surface current through the Bosphorus from the Black Sea.

Distribution. All the Sea of Marmara (KOCATAS *et al.,* 1993)

Habitats. A mass species of the surface phytoplankton.

Impact on native species. Insufficiently known.

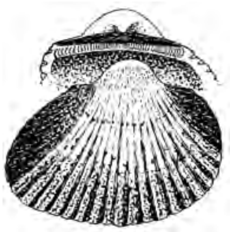
Compiled by B. Öztürk and Yu. Zaitsev

Invertebrates

Anadara inaequivalvis (Bruguière, 1789)

Synonyms: *Arca inaequivalvis* (Bruguière, 1789); *Scapharca inaequivalvis* (Bruguière): Ghisotti & Rinaldi, 1976; *Cunearca cornea* (Reeve,1844)

Common names: Kum kabugu (Tur)



Anadara inaequivalvis

Taxonomy: Class- Bivalvia
Order- Mytilida
Family- Anadaridae

Distinctive characteristics. (See Chapter 3)

Probable origin. The Indo-Pacific Ocean.

Possible way of introduction. in ballast waters. This species was first observed in the Adriatic Sea in 1969 and later in the Aegean, Marmara and Black Seas.

Distribution. TheIstanbul Strait, Prince Islands.

Distribution of *Anadara inaequivalvis* in the Sea of Marmara

Habitats. Sandy-muddy bottoms between 3 to 15 m depth.

Impact on native species. Insufficiently known.

Compiled by B. Öztürk

Mya arenaria (Linne, 1758)

Common names : Soft-shelled clam (Eng), Peschyanaya rakushka (Rus), Mya pisochna (Ukr).

Taxonomy : (See Chapter 3).

Distinctive characteristic. (See Chapter 3).

Probable origin : Origin of the species is the North Sea or the Atlantic coast of North America.

Possible way of introduction. In ballast waters.

Distribution. In the Istanbul Strait and its entrance to the Black Sea. In many parts of the of the Istanbul Strait, it is a dominasnt bivalve ant its population reached 1300 ind./m^2 . Around the Prince Islands, the average biomass is 1 kg/ m^2 in 1999.

Habitats. This species is found mainly in the sandy and muddy shallow botttms between 2-15 m. This bivalve is eaten by turbot, gobby and mullet in the Marmara Sea. Adults are eaten by *R. thomasiana*. It has no commerciale importance.

Impact on native species. Insufficiently known.

Compiled by B.Öztürk

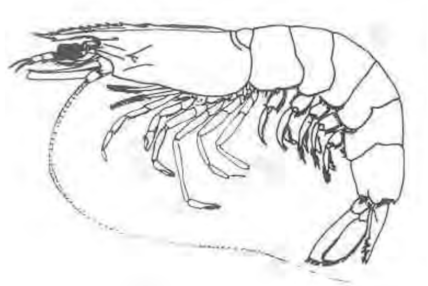
Marsupenaeus japonicus (Bate, 1888)

Synonym: *Penaeus japonicus* Bate, 1888

Common name : Jumbo Karides (Tur).

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Penaeidae

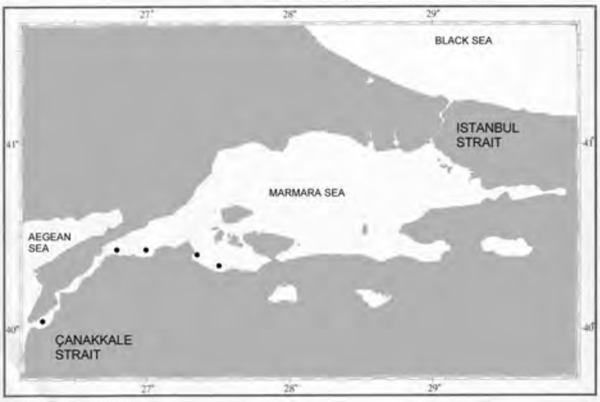
Distinctive characteristics. The species is characterised by the smooth carapace with no hair .But more than 10 cross-bars of dark brown. Rostrum bears 8-10 spines dorsally and 1-2 ventrally adrostral groove is a little narrower than post-rostral carina; the anterior piece of thelycum is rounded at the apex ,median groove and adrostral reach the posterior edge of carapace. They are attractive in colors with alternate cross-bars of brown, blue and yellow. Total length up to 19 cm for male, and 23 cm for females.



Probable origin of species. The Indo-Pacific, probably entered the Mediterranean Sea from the Red Sea (a Lessepsian migrant).

Possible way of introduction. Intentionally introduced into the Marmara Sea in the late 1960s from Iskenderun Bay (Pers. comm. DEMIR. M., 1998). Some speciment founded in the Bozcaada in the Aegean Sea. This species is commercially important in many countries.

Distribution. Mediterrean Sea, Aegean Sea and Marmara Sea.



Distribution of *Marsupenaeus japonicus* in the Sea of Marmara.

Habitat. Mainly shallow waters and sandy –muddy bottoms.

Impact on native species. Insufficiently known.

Compiled by B. Öztürk

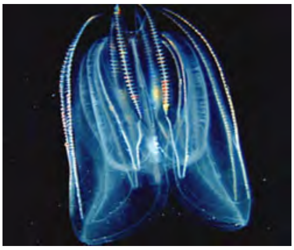
Mnemiopsis leidyi (Agassiz, 1865)

Synonyms: *Bolinopsis* sp. (Pereladov, 1988), *Bolinopsis infundibulum* (Zaitsev et al., 1988), *Leucothea multicornis* (Konsulov, 1990), *Mnemiopsis mccradyi* (Zaika, Sergeeva, 1990).

Common names: Leidy's comb jelly (Eng), Kaykay (Tur).

Taxonomy: Class- Tentaculata
Order- Lobata
Family- Mnemiidae

Distinctive characteristics. (See Chapter 3, 3.2.2.)

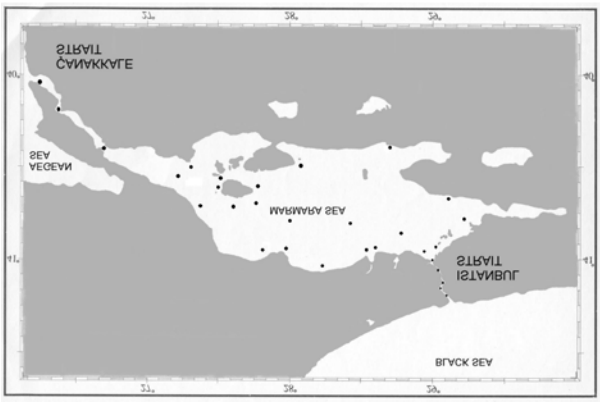


Probable origin. North American Atlantic coasts.

Possible way of introduction. Via ship ballast water and/or with the surface water current from the Black Sea.

Distribution. This species was noted by ARTÜZ (1991)and ÖZTÜRK (1992). In 1992 an extremely vigorous outbreak of *M.leidyi* was recorded in the Sea of Marmara. Its biomass was between 4,3-9,7 kg.m^{-2} in its Northwestern part.The decline of the fish stoks and economical loss of fisheries was estimated at 400.000US$ for Turkey. The fresh water reservoire of the Istanbul City was invided by *M.leidyi* and it caused a serious economic loss due to the damage of the pipeline. (ÖZTÜRK *et al*; 2001). By late summer in 1993 the *M. leidyi* was still in this sea but its density was much less (KIDEYS & NIERMAN, 1994).

Habitat. *M. leidyi* is usually found close to shore, in bays and estuaries.



Distribution of *Mnemiopsis leidyi* in the Sea of Marmara

Impact on native species. *M. leidyi* ingests virtually any pelagic organisms that it is able to capture, including holoplanktonic species, the planktonic larvae of benthic organisms and the eggs and larvae of fishes (especially anchovy).

Compiled by A.N. Tarkan

Rapana thomasiana (Crosse, 1861)

Common names : Thomas rapa whelk (Eng), Deniz Salyangozu (Tur)

Taxonomy: Class- Gastropoda
Order- Hamiglossa
Family- Thaididae

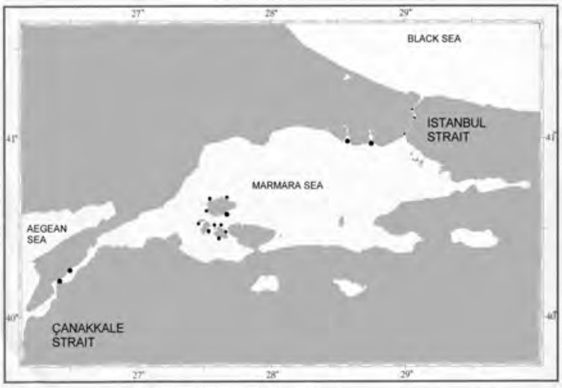
Rapana thomasiana

Probable origin. The Sea of Japan, the Black Sea.

Possible way of introduction. Via ships and with the surface current through the Istanbul Strait from the Black Sea.

Distribution. Firstly discovered in the Black Sea in the 1940s. Now is common in the Black, Marmara and Aegean Seas. Since the 1980s is harvested intensively in the Istanbul Strait, Büyük and Küçük Çekmece, Silivri, Selimpasa, Marmara Islands and Çanakkale Strait (Gelibolu, Kemer, Lapseki).

Habitats. ÖZTURK & OZTURK (1996) reported *Rapana* was founde*d* in the Turkish Strait Sytem and devastating mussel beds. *Rapana* is one of the commercially exploited species and exported mainly to Japan and Korea, as frozen food from Turkey. (Estimated export value about US$ 2 million). Yearly production was over 4.000 ton in the 1997 as meat. In the coast of Turkish Black Sea, 9 temporary and 2 permanent factories process *Rapana* for export.



Distribution of *Rapana thomasiana* in the Sea of Marmara.

Habitats. Sandy and muddy bottoms in coastal areas up to 45 m depth in the Black Sea and Marmara Sea, 21 m depth in the Aegean Sea.

Impact on native species. *Rapana* is a predator of mussels, oyster and other bivalves. Due to high population density in the area, mussels and oysters beds are exterminated mainly in the Black Sea. Sea stars feed on *Rapana* and control its population, but these echinoderms are very rare in the Black and Marmara Seas.

Compiled by B. Öztürk

Sirpus zariquieyi Gordon (See Chapter 3)

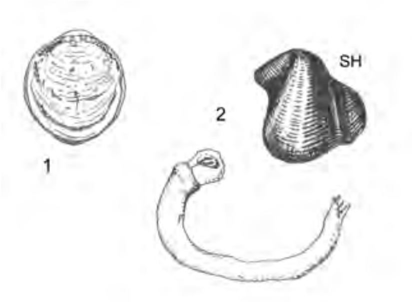
Teredo navalis (Linne, 1758)

Synonyms: No

Common names: Shipworm (Eng), Gemi Kurdu (Turkish).

Taxonomy: Class- Bivalvia
Order- Venerida
Family- Teredinidae

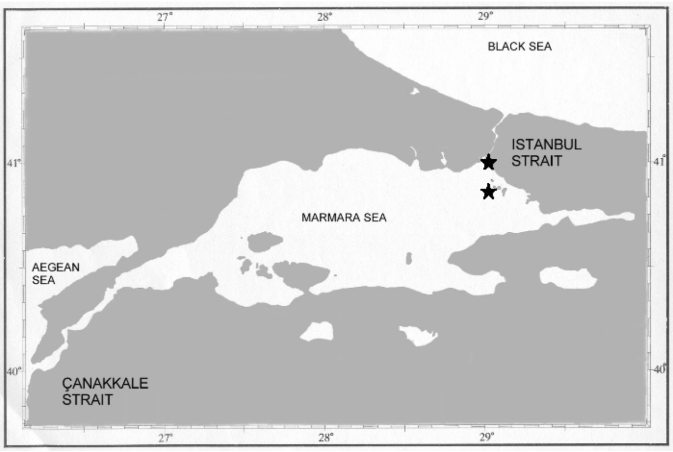
Distinctive characteristics. (See Chapter 3)



Teredo navalis: 1 – larva, 2 – adult (SH – shell)

Probable origin. The Atlantic and Pacific Oceans of the Northern Hemisphere.

Possible way of introduction. There are two possible ways of introduction: marine currents at the stage of pelagic larvae and with floating wood (stem of tree, wooden hull, etc.) or contaminated ship's hulls, as adult organisms.



Distribution of *Teredo navalis* in the Sea of Marmara

Distribution. The Istanbul Strait and Sea of Marmara (DEMIR, 1954)

Impact on native species. Insufficiently known.

Compiled by B. Öztürk

Fishes

Gambusia affinis (Baird & Girard, 1854)

Common names: Mosquito Fish (Eng), Sivrisinek Balık (Tur).

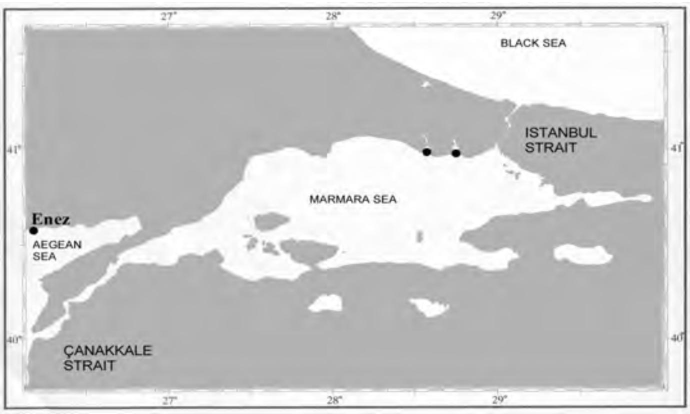
Taxonomy: Class- Osteichthyes
Order- Cyprinodontiformes
Family- Poeciliidae

Distinctive characteristics. (See Chapter 3).

Gambusia affinis

Origin. North American fresh waters.

Way of introduction. Introduced for the first time by French to control mosquito populations in the Amik Lake and its wetlands. It was later introduced to another wetlands throughout Anatolia by Turkish authorities to combat malaria. Enez and Meriç River areas in the Aegean Sea are also inoculated areas.



Distribution of *Gambusia affinis* in the Sea of Marmara

Distribution. Coastal areas of the Black Sea, Marmara Sea (Büyük, Küçük Çekmece), Aegean Sea (Enez).

Habitats. Streams and small lakes, preferable stagnant and temperate waters. This fish consumes mosquito larvae, pupae and microcrustaceans living in surface water layer (neustonic organisms).

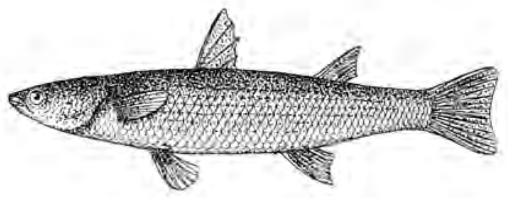
Compiled by N. Basusta

Mugil soiuy (Basilewsky, 1855)

Common names: Russian grey mullet, Haarder (Eng), Rus Kefali, Pelingas (Tur).

Taxonomy: Class- Osteichthyes
Order- Mugiliformes
Family- Mugilidae

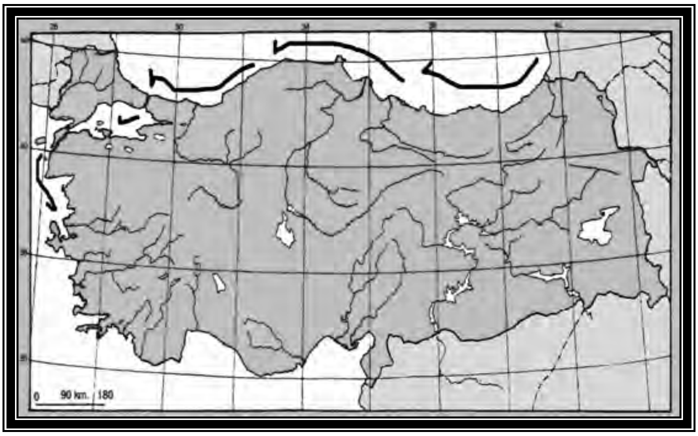
Distinctive characteristics. (See Chapter 3).



Mugil soiuy

Origin. The Amur River estuary, the Sea of Japan

Way of introduction. Introduced in the Black Sea and the Sea of Azov in the 1970s, as a commercial fish.



Distribution of *Mugil soiuy*

Distribution. In 1989 two adult fish were caught for the first time along the Turkish Black Sea coast. The species migrated to the west, reaching the Sea of Marmara via the Istanbul Strait and to the coasts of the Aegean Sea via the Çanakkale Strait. One specimen was caught in Homa Lagoon and one in Foça (Izmir) by local fishermen in 1997. An important commercial fish. It reaches 68.9 cm in length and 3260 g in weight in the eastern Turkish Black Sea.

Habitats. Pelagic, usually inshore, entering lagoons, estuaries and rivers.Main food of adult fishes are meiobenthic organisms.

Compiled by N. Basusta

Additional information to Chapter 2

Some non-native species introduced in The Sea of Marmara by human activities were not included in the above-mentioned lists of exotics because of lack of information. There are following species;

The green macroalga *Codium fragile* Suringar, 1867 (Siphonophyceae, Siphonales, Codiaceae) was found in the Sea of Marmara in 1940's (AYSEL, this book).

Phytoplankton microalga *Alexandrium monilatum* (Howell) F.J.R. Taylor 1979 (Pyrrophyta, Gonyaulacales, Gonyodomataceae), has origin from American Atlantic coastal waters and distribute in Gulf of Mexico, Caribbean Sea, Atlantic Ocean off Florida and Chesapeake Bay. Probably *A. monilatum* is inhabiting the Sea of Marmara, because after the first registration of this species in the Mediterranean Sea since 1985 (GOTSIS-SCRETAS & FRILIGOS, 1990) it has been found in blooming densities along the Bulgarian coastline in the Black Sea (MONCHEVA *et al.,* 1995; MONCHEVA & KRASTEV, 1997; MONCHEVA *et al.,* 1999).

Phytoplankton species *Phaeocystis pouchetii* (Hariot) Lagerheim,1893 (Prymnesiophyceae, Prymnesiales, Phaeocystaceae), is widely distributed in coastal waters of Arctic, Antarctic, Atlantic and Pacific. This species should be in the Sea of Marmara, because it has been registered in blooming densities in Aegean Sea (GOTSIS-SKRETAS & FRILIGOS, 1990) and in the Black Sea (PETROVA-KARADJOVA, 1990; MONCHEVA, 1991) practically at the same period.
Beroe cucumis is also distributed in the Sea of Marmara according to ÖZTÜRK.B, (unpublished data).

Blue Crab, *Callinectes sapidus* is also reported from the Sea of Marmara by several authors (MULLER 1986); (FROGLIA *et al*;1998); (EEA, 1999); (ÖZTÜRK.B unpublished data).

Chapter 3. The Black Sea

Physical Geography, Biology, Ecology

Geographical position

The Black Sea is an inland Eurasian sea, bordering Ukraine and Russian Federation to the north, Bulgaria and Romania to the west, Georgia to the east, and Turkey to the south. Its geographic co-ordinates are between N 46° 32,5' and N 40° 55,5', and E 27° 27' and E 41° 42' E (LEONOV, 1960). On the north-eastern corner of the Black Sea is connecting to the Sea of Azov through the Kerch Strait and on the south-west with the Sea of Marmara through the Istanbul Strait.

Geological evolution

Before the beginning of the Tertiary Period, some 50-60 million years ago, a huge oceanic basin extended from west to east across Southern Europe and Central Asia, linking the Atlantic and Pacific Oceans. It was the salty Tethys Sea (ZENKEVICH, 1963, ZAITSEV&MAMAEV, 1997). By the middle of the Tertiary Period, as a result of crust upheavals, the Tethys Sea had become separated first from the Pacific Ocean and later from the Atlantic. Much later, from 5 to 7 million years ago, because of the formation of the Alps, the Carpathians, Balkan Mountains and the Caucasus Mountains, the Tethys Sea shrunk in size and became divided into a number of brackish basins. One of them, the Sarmatic Sea, stretched from the present location of Vienna to the foothills of the Tien Shan Mountains and included the modern Black Sea, the Sea of Azov, the Caspian Sea and the Aral Sea.

Some 3-5 million years ago, the Sarmatic Sea had shrunk to the size of the Maeotic Sea connected with the Atlatic Ocean, but in the Pliocene, 1.5-3 million years ago, the connection to the ocean was again severed, and the salty Maeotic Sea was replaced by the almost freshwater Pontian Sea-Lake. Within it the future Black and Caspian Seas were connected through the present-day northern Caucasus. Marine fauna disappeared from the Pontian Sea-Lake and was replaced by brackish-water fauna. Now its representatives are rather common in the northern Caspian Sea, the Sea of Azov and the north-western part of the Black Sea.

During the Riss-Würm Interglacial Period, following the opening of the Dardanelles, the future Black Sea became connected to the Mediterranean and the ocean. The so-called Karangat Sea was formed with a salinity higher than of the modern Black Sea. Representatives of marine flora and fauna were introduced into it. They occupied a larger part of the basin, forcing the Pontian species into bays, limans and river deltas with reduced salinity. However, that basin too was to undergo changes.

About 18,000-20,000 years ago the Karangat Sea was replaced by the Neoeuxinian Lake-Sea. This coincided with the end of the last Würm Glaciation. The sea was filled with melting waters. Once again it lost its connection to the Mediterranean and its salinity was greatly reduced. The halophilic flora and fauna also disappeared, while the Pontian species, that had survived the unfavourable Karangat period in limans and river deltas, came out of hiding and yet again occupied the entire sea.

About 6,000 years ago, a connection to the Mediterranean and the Atlantic Ocean was established through the Istanbul Strait, the Sea of Marmara and the Dardanelles. A gradual salinisation of the Black Sea followed and probably within 1,000-2000 years the salinity of the sea became sufficient to support a large number of Mediterranean species. They are forming a considerable part of the recent Black Sea biota and are named Mediterranean immigrants. The Pontian relics have again moved to the brackish-water limans and river deltas, as happened during the time of the Karangat Sea.

Morphometry and climate

The surface of the Black Sea is 422,000 km^2, the volume of water- 547,000 km^3, the average depth- 1,271 m, coastal length- 4090 km. According to other authors, the surface is 423,000 km^2, the volume is 537,000 km^3, the average depth- 1,315 m, and the coastal length- 4,740 km (ZENKEVICH, 1963).

The main gulfs and bays of the Black Sea are Karkinitsky, Tendrovsky, Yegorlyksky, Feodosiysky, Varna, Odessa gulfs, Sevastopol and Novorosiysk bays. The main peninsulas are the Crimean Peninsula and Taman Peninsula, the main capes are Kaliacra, Tarkhankut, Khersones, Pitsunda, Ingeburun and Bafra.

The only island remote from the coast is the Zmeiny Island (Fidonysi, Insula Serpilor, Snake Island) situated at 40 km to the east of the Danube delta. The area of this rocky island is 1.5 km^2 , its height above sea level- 41m.

The major rivers of the Black Sea are the Danube (length 2,860 km, average yearly runoff- 208 km^3), Dnieper (2,285 and 51.2, respectively), Dniester (1,328 and 10.2), Rioni (228 and 12.8), Coruh (500 and 8.7), Kizilirmak (1,151 and 5.02), and Yesilirmak (416 and 4.93) (ZAITSEV&MAMAEV, 1997).

The main river entering the Black Sea, the Danube, forms a delta covering about 5,650 km^2. This is the largest relatively intact wetland complex in Europe, except the Volga River delta, which is in fact an Eurasian delta. The Yesilirmak Delta is 600 km^2 in area and Kizilirmak Delta- 500 km^2.

The average total river discharge for the period from 1921 to 1988 was 353 km^3 (RESHETNIKOV, 1992).

The largest Black Sea wetlands are found in the coastal lowlands of Romania, Ukraine, and Russia, where the massive catchments of Danube, Dniester, Dnieper, Don and Kuban support the river deltas and adjacent coastal wetlands. In contrast, the Black Sea wetlands of Bulgaria and Turkey, tend to be much smaller and with much smaller catchments, reflecting the mountainous hinterlads of these countries.

The volume of water flowing into the Black Sea through Bosphorus has been estimated as between 123 km^3 per year (ŞERPOIANU, 1973) and 312 km^3 (UNLUATA et al., 1990). Estimates for the Bosphorus outflow range from 227 km^3 (RESHETNIKOV, 1992) to 612 km^3 per year (UNLUATA et al., 1990). But all authors agree that the outflow through the Bosphorus is twice as large as the inflow.

The inflow through the Kerch Strait ranges between 22 km^3 and 95 km^3 per year, while the outflow- between 29 km^3 and 70 km^3 per year (LEONOV, 1960; RHESETNIKOV, 1992).

For many years the average early fresh water balance has been positive at 180 km^3. The considerable annual and seasonal fluctuations in the Black Sea fresh water balance are caused by variations in river discharges. Evaporation is a major influence factor only in the summer.

The Black Sea has a temperate climate. It lies in temperate latitudes where short, mild winters and long summers prevail. The mean annual surface water temperature of the Black Sea is about 14º. But southern Crimean and Caucasian coasts are subtropical areas with corresponding terrestrial and marine flora and fauna and thermophylous organisms in coastal waters. The mean annual surface temperature in these areas is about 15º (LEONOV, 1960).

Main characteristic of the Black Sea ecosystem

Abiotic parameters

The Black Sea is a practically tideless sea as , tide amplitudes do not exceed 8 cm, and only at the South Crimean coast it can reach 10-15 cm. Wind-induced level changes can reach 40-60 cm, and even 150 cm near the coast.

There are four quasi-stationary currents at the periphery of the deep part of the sea, namely Anatolian, Caucasian, Crimean, and Rumelian currents (LEONOV, 1960). Within these currents there are four cyclonic gyres: western, central, eastern and south-eastern. The last is not a permanent one.

Transparency of water in the open sea is 16-24 m.

The surface water temperature in summer in the shelf zone is 23-26º C. In the shallow water gulfs and bays, it reaches up to 27-29° C. In the open sea , it is 22-23ºC .The Average surface water temperature in winter season is 7-9º C, except the north-western part, where it falls to 0º C and even –1º C, when the sea is covered by ice. The ice in the north-western part lasts several days on average but in severe winters it can last for 30 and even 45 days, like in 1985.

Deeper than 150 m, the water temperature is quasi-stationary ranging from 8.6 to 9.0º C.

The salinity of the Black Sea surface waters is 10-18.3‰ and of the deep waters- 22.3-22.6‰, the average salinity is 21.8‰ .

The average salinity of the upper current in the Bosphorus Strait, directed from the Black Sea to the Sea of Marmara is 18.2%0 and of the deep current directed to the Black Sea is 34.90%0 (BOGUSLAVSKY et al., 1989).

High temperature and salinity gradient is the reason for the low vertical mixing of water masses and this, is the main reason of the hydrogen sulphide formation in the deep waters of the sea. About 87% of the volume of the Black Sea (from 120-150 m to the bottom) is the anoxic zone contaminated by the H_2S. Firstly discovered in 1890, this zone has been investigated by specialists in marine physics, chemistry, biology and ecology. The sources of the hydrogen sulphide are the bacterial decomposition of dead organisms from upper (oxygenated) layers of the sea by microorganisms pertaining to genera *Bacterium* and *Bacillus*, and especially the bacterial reduction of sulphates by microorganisms of genus *Microspira* (LEONOV, 1960; ZENKEVICH, 1963).

The salinity of more than 50 Black Sea wetlands varies from 1‰ in practically freshwater Dnestrosky and Dneprobugsky limans to 150-250‰ in hyperhaline water bodies like Kuyalnik and Uzunlarsky limans.

A special factor in the eutrophicated coastal water Black Sea is the dissolved oxygen. As a result of phytoplankton blooms it can exceed 100% of the saturation on the surface, but after the sedimentation of dead cells on the bottom and their decomposition, a sharp decrease in dissolved oxygen and hypoxic zones on the shelf occur.The first hypoxic zone in the Black Sea was discovered on the north-western shelf in August 1973, When, over a surface area of 3,500 km^2, a mass mortality of benthic invertebrate and fish occured. Later, mass mortalities of benthic organisms because of hypoxia became ordinary phenomena. The total biological losses over 18 years (1973-1990) are estimated as 60 million t, including 5 million t of fish, both young and adult, both commercial and non commercial species (ZAITSEV, 1993).

Biotic parameters

The Black Sea biota is composed by different elements reflecting the geological history of the sea and recent state of its ecosystem (ZAITSEV & MAMAEV, 1997).

The species which had once lived in the predecessors of the modern Black Sea, namely the brackish water Pontian Sea-Lake (1.5-3 million years ago) and Neoeuxinian Lake (20,000-8,000 years ago) are the most ancient inhabitants. Today they can be only found in low salinity areas of the Black Sea, in the Sea of Azov and the northern Caspian Sea. These organisms are referred to as the Pontian or Caspian relics. Among them there are bivalves such as *Dreissensia (Dreissena) polymorpha*, *Hypanis pontica* and *H. colorata*, polychaetes *Hypania invalida* and *Hypaniola kowalewskii*, crustaceans *Heterocope caspia*, *Pontogammarus maeoticus* and *Paramysis intermedia*. Among fishes Pontian relics are the kilka, *Clupeonella cultriventris*, the herring, *Caspialosa kessleri pontica*, gobies, *Neogobius melanostomus* and *N. fluviatilis*, sturgeons *Huso huso ponticus* and *Acipenser nudiventris*.

Another group of the Black Sea inhabitants consists of salt-water thermophobic species originating from North-European seas. They are referred to be a number of names: cold-water complex, Boreo-Atlantic relics or Celtic relics. In this book they are called cold-water relics. They may have entered through the river systems during the time of Neoeuxinian Lake, or at a later date during the early stages of the formation of the Bosphorus, when the Mediterranean Sea was colder than it is today. Whenever they entered the Black Sea, they definitely constitue the second oldest element in the Black Sea biota. They include the ctenophore sea gooseberry *Pleurobrachia rhodopis*, copepods *Calanus helgolandicus* and *Pseudocalanus elongatus*. Among cold-water fishes there are the spiny dogfish *Squalus acanthias*, the sprat *Sprattus sprattus phalericus*, the flounder *Platichthys* *flesus luscus*, the whiting *Merlangius merlangus euxinus,* and the Black Sea trout *Salmo trutta labrax*.

In summer season the cold-water relics are living below the thermocline where the water temperature does not exceed 8-10ºC. They spawn either during winter and spring near the surface (flounder) or during the warm season in deeper layer (sprat, whiting).

The Istanbul Strait (Bosphorus) established a connection with the Mediterranean and the Atlantic Ocean. Gradually, the salinity of the Black Sea began to rise, and soon reached a sufficiently high level to support many Mediterranean species. These Mediterranean immigrants, or Mediterranean settlers constitue the third, and most populous elements in the Black Sea biota, comprising in some taxa up to 80% of the total number of species. Most of them prefer warm, saline waters and are predominantly found in the upper layers of the sea, which are not directly affected by the rivers.

The intrusion of saline waters and of Mediterranean immigrants into the Black Sea put pressure on the Pontian relics and many of them retreated to the brackish-water areas, some limans and deltas.

In summer season Mediterranean immigrants can be found throughout the sea. Among them there are many species of copepods (*Pontella mediterranea, Acartia clausi, Paracalanus parvus*), cladocerans (*Evadne spinifera, Penilia avirostris*), decapods (*Palaemon adspersus, P. elegans, Callianassa pontica, Macropipus arcuatus, Eriphia verrucosa*) and fishes (*Engraulis encrasicholus, Trachurus mediterraneus ponticus, Scomber scombrus, Mugil cephalus*). Invertebrates spent the winter in a state of anabiosis, or in form of dormant eggs and spores. As to pelagic fish and dolphins, they are wintering mostly in the warmest areas of the sea along South Crimean, Caucasian and Anatolian coasts. The most termophilic species (mackerel, bonito, bluefish, tuna) migrate to the Sea of Marmara for the winter. In spring, the overwintering species migrate back to their breeding and feeding grounds in the Black Sea. Last time, because of pollution and, very likely, because of the sound barrier, the Bosphorus loses its past significance of a biological corridor (ÖZTÜRK&ÖZTÜRK, 1996).

The fourth elements in the Black Sea biota freshwater origin species. They are permanently introduced into the sea in river discharges and are usually found in greatly diluted sea waters. Fresh-water origin species include different blue-green algae (*Microcystis aeruginosa, Aphanisomenon flos-aquae*), cladocerans (*Daphnia longispina, Bosmina longirostris, Leptodora kindtii*), copepods (*Calanipeda aquae dulcis*), rotifers and other invertebrates and many fish species, such as carp, perch, sabrefish.

The last and the youngest element of the Black Sea biota, is represented by introduced exotic species, described in this book.

The phytoplankton of the Black Sea is composed by 745 species (ZAITSEV&MAMAEV, 1997), but their number is increasing due to the progress in the microscope technique and the introduction of new species in ballast waters. The average summer biomass of phytoplankton in surface waters varies between

2,500 mg/m^3 in the north-western part of the sea and 150 mg/m^3 in central Black Sea areas.

Bottom macroalgae in the Black Sea are represented by 304 species (KALUGINA-GUTNIK, 1975). Some of them are key species of important benthic biocoenoses. The perennial brown alga, *Cystoseira barbata*, growing on the edge of rocky coasts, is the key species of the *Cystoseira* biocoenoses, composed by more than 60 species of invertebrates and fish. The red alga *Phyllophora nervosa*, is the key species of the *Phyllophora* biocoenosis occupying the central part of the north-western shelf at 20-50 m depth. This community is composed of more than 100 species of invertebrates and 40 species of fish.

Besides, macroalgae and microalgae, the Black Sea coastal zone is inhabitated by seven species of higher plants. The most common are the sea grasses *Zostera marina, Z. noltii*, *Ruppia spiralis* and *Potamogeton pectinatus*.

The macrozoobenthos of the Black Sea is composed of more than 760 species of invertebrates (ZAITSEV & ALEXANDROV, 1998). The most numerous taxa are Polychaeta, Bivalvia, Gastropoda, and Amphipoda. The most important bottom biocoenoses, except above mentioned *Cystoseira* and *Phyllophora* communities, are the biocoenoses of bivalves *Mytilus galloprovincialis* with 40 species of macrozoobenthic invertebrates and *Modiolus phaseolinus* in the deeper part of the shelf at 60-125 m, with 85 species of invertebrates .

The zoolpankton fauna of the Black Sea is composed by about 100 euplanktonic species, except those originated from fresh waters, which are distributed only in the river mouth areas. The most common are the copepods *Calanus helgolandicus (C. ponticus), Paracalanus parvus, Pseudocalanus elongatus, Acartia clausi)*, and cladocerans (*Penilia avirostris, Pleopis polyphemoides, Evadne spinifera)*. Among other taxons , rather common are *Sagitta setosa* (Chaetognatha), *Oikopleura dioica* (Appendicularia), *Pleurobrachia rhodopis* (Ctenophora), *Aurelia aurita* and *Rhizostoma pulmo* (Scyphozoa). The average zooplankton biomass in the upper layer of water is 0.3-1.0 g.m^{-3} (GREZE, 1979), but in some cases it reached up to 2-3 g.m^{-3}.

Until the late 1960s, the Black Sea was considered as a productive marine area. The number of species supporting commercial fisheries in the Black Sea was 26. In the 1980s, this number declined to five (ZAITSEV, 1992). Successful naturalization of the grey mullet *Mugil soiuy* from the Sea of Japan eraised this number to six in the 1990s. The catches of Black Sea countries increased until 1985 up to about 700,000 t, followed by a sharp decline to 80,000 t (ZAITSEV, 1993). The widespread explanation of this unprecedented event is the outbreak of the exotic ctenophore *Mnemiopsis leidyi*, consumer of zooplankton, fish eggs and larvae. In the late 1990s, antagonistic ctenophores *Beroe cucumis,* and *B. ovata,* were accidentally introduced into the Black Sea (ZAITSEV, 1998). After this, a decrease in *Mnemiopsis* population and an increase in fish catches were observed.

The future of the Black Sea

The future of the Black Sea as a receiving area of exotic species depends on the improvement of the marine ecosystem, first of all on deeutrophication, and on preventive actions, including those envisaged by the Global Ballast Water Management Programme of the International Maritime Organization.

Exotic species

<u>Plants</u>

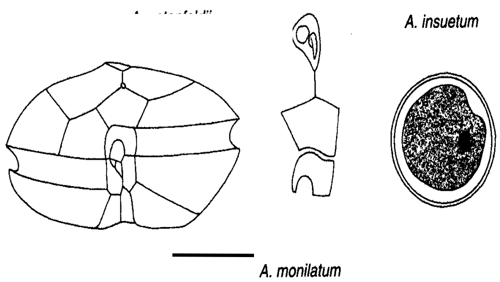
Alexandrium monilatum (Howell) (F.J.R. Taylor 1979)

Synonyms: *Gonyaulax monilata* Howell, *Gessnerium mochimaensis* Halim 1967, *Gessnerium monilata* (Howell) Loeblich III 1970; *Pyrodinium monilatum* (Howell) F.J.R. Taylor 1976 .

Common names: No

Taxonomy: Class- Pyrrophyta
Order- Gonyaulacales
Family- Goniodomataceae

Distinctive characteristics. Cells typically oval to slightly biconical, but without horns or spinesArmored gonyaulacoid type cell about 50 µm in length, with asymmetrical plate pattern with an apical pore complex that typically lacks distal end of the cingulum (“x” plate) or canal plate of the peridinoids. Chain former species, usually short (4-6 cells) but also found in single cells. Usually with a small ventral pore at the apex of the 1’ where the 1’, 2’, and 4’ plates meet (according to Kofoidian System of plate nomenclature: (’) – apical plates (STEIDINGER & JANGEN, 1997). The sulcal plate (“sp”) is distinctive in shape, size and location of the pap. The posterior “sp” is concave and recessed with radial raised markings. Distinct from other chain formers by displaced 1’ and anterioposterior compression of cells and chains. Plates are thin and difficult to discern.



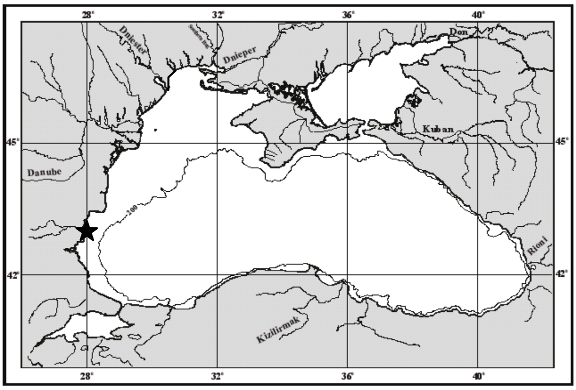
A. monilatum: total view of the cell and cyst of this species. Scale = 10 µm. (Redrawn from STEIDINGER & JANGEN, 1997).

Probable origin. Coastal and estuarine areas of the Gulf of Mexico, Caribbean Sea, the Atlantic Ocean off Florida, Chesapeake Bay, and Ecuador.

Possible way of introduction. Either by shipballast waters (more likely for *Ph. pouchetii*) or through the Mediterranean water exchanges (more likely the case with *A. monilatum*) or both.

Distribution. Since 1985 was found in the Mediterranean Sea (*L. ignatiades*, pers. comm. GOTSIS-SCRETAS & FRILIGOS, 1990). In the Black Sea found for the first time in September 1991, in density $2.67x10^6$ cells/l. Bloom densities recorded also during 1994 ($1.7x10^6$ cells/l) and 1998 (about $1.0x10^6$ cells/l) in Varna Bay (MONCHEVA *et al*.,1995; MONCHEVA & KRASTEV, 1997; MONCHEVA *et a*l., 1999).

Habitats. One of the surface water blooming species of the phytoplankton, which was registered in Varna Bay.



First registration of *Alexandrium monilatum* in the Black Sea

Impact on native species. The genus of *Alexandrium* has extensive synonymy due to continual scrutiny of toxic species causing public health, economic and ecological problems. *A. monilatum* is a toxic species in its place of origin (STEIDINGER & JANGEN, 1997), but there is no toxicity related to *A. monilatum* which has been detected in the Black Sea (MONCHEVA *et al.,* 1995). In present time, its possible impact is very close to those of other blooming species (see *Phaeocystis pouchetii*, for example).

Compiled by B. Alexandrov

Desmarestia viridis (Müll). (Lamouroux, 1813)

Synonym: *Fucus viridis* Müller, 1782 .

Common names: Soft sour weed (Eng) .

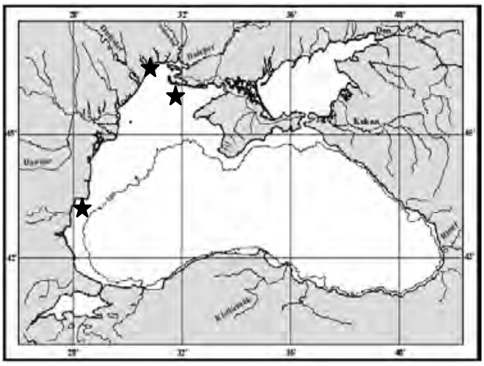
Taxonomy: Class- Phaeosporophyceae
Order- Desmarestiales
Family- Desmarestiaceae

Distinctive characteristics. Bushy, main branches opposite and regularly spaced, with abundant fine, terminal branchlets, and covered in spring with fine hairs. Pale brownish but fading rapidly out of water to yellowish olive. Sour smelling especially when out of water. Usually to 40 cm, main axis 1.6-3 mm.

Desmarestia viridis

Probable origin. The North American Atlantic coast, North Sea.

Possible way of introduction. In ships' ballast waters and/or hull fouling.



First registrations of *Desmarestia viridis* in the Black Sea

Distribution. Firstly discovered in Odessa Gulf in 1992 by MINICHEVA & EREMENKO (1993). Later was found in the Karkinitsky Gulf and in Bulgarian coastal waters (pers. comm. from K. Dencheva). Mass development of this alga occurs in the winter and spring seasons, when the water temperature does exceed 10^0C. It is especially abundant in the Odessa Gulf and adjascent waters of the north-western Black Sea.

Habitats. On rocks and shells at 1-15 m depth.

Impact on native species: Needs to be investigated, taking into consideration that acridic cell sap is distinctive of this alga and its destructive action to other weeds is described (GOSNER, 1978).

Compiled by G. Minicheva & Yu. Zaitsev

Gymnodinium uberrimum (Allman) (Kofoid et Swezy, 1921)

Synonyms: *Peridinium uberrima* Allman, 1854; *Melodinium uberrimum* Saville-Kent, 1880; *Gymnodinium mirabile var. rufescens* Penard, 1891; *Gymnodinium rufescens* Lemmermann, 1900; *Glenodinium uberrimum* Remil, 1913

Common names: No

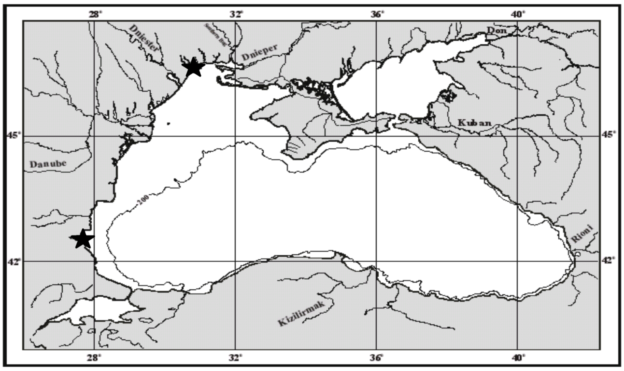
Taxonomy: Class- Dinophyceae
Order- Gymnodiniales
Family- Gymnodiniaceae

Distinctive characteristics. Cell is 30-51 µm in length and 20-42 µm in width. Roundish or egg-shaped form, episome is equal hyposome or little bit above. Cell's fascia is deep and well appreciable. It ends are displaced hardly more than on width of furrow. Longitudinal furrow is significant narrow than fascia and look like narrow cleft. Furrow touch with episome, on hyposome extends and reaches to the lower ending. A roundish nucleus is located at the center of the cell. Cell has yellow-brown chloroplasts. The formation of cell's chain is the very characteristic of this species (MATVIENKO & LITVINENKO, 1977).

Probable origin. Fresh water species, ponds, lakes, bogs, occasionally reservoirs. It is found in fresh waters of Europe.

Possible way of introduction. It can be inadvertently introduced when their viable or resistant resting stages are discharged with ballast water and sediment of cargo vessels. *G. uberrimum* is able to form resting stages during unfavorable conditions what remain viable for long period of time.

Gymnodinium uberrimum: total view of the cell and cell chain of this species.



Registrations of *Gymnodinium uberrimum* in the Black Sea

Distribution. For the first time *G. uberrimum* was registered in the Black Sea in April, 1999 in Odessa Gulf, although this species was mentioned as blooming microalgae near Bulgarian coast in 1994 (MONCHEVA *et al.*, 2000). Density of the population was low. Maximal abundance reached $3.6x10^4$ cells/l. The condition of the water during *G. uberrimum* registration was: T= 12-18 ^oC, S= 9.7-14.0 ‰, pH= 8.1. In October 2000 it was found in small number during *Gymnodinium sanguineum* blooming in Odessa Bay (TERENKO & TERENKO, 2000; TERENKO, 2000; TERENKO, in press).

Impact on native species. Insufficiently known.

Compiled by L. Terenko & B. Alexandrov

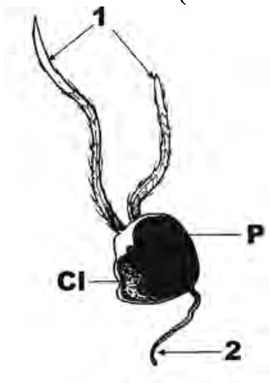
Mantoniella squamata Manton & Parke (1960)

Synonym: *Micromonas squamata* Manton & Parke (1960).
Firstly, this species was identified to Chrysophyceae and described as *Chromulina pusilla* Butcher (Manton, 1959). Later this species in the Black Sea was identified as *Mantoniella squamata*, but has been identified to Chrysophyceae again (Mihnea, 1997).

Common names: No

Taxonomy: Class- Flagellata
Order- Phytomastigina
Family- Prasynophyceae

Distinctive characteristics. Cells are very tiny 2.0-3.1 µm in length and 1.3-2.6 µm in width. Cells are ovoid-ellipsoidal in shape and slightly compressed, usually provided with one backward oriented attached flagellum. A considerable thickness of flagellum is an outstanding feature and may have 2-3 subequal or unequal flagella. Cell and flagella are covered by organic, thin scales. Flagellum is covered with overlapped caducous hairs. The cells are pale yellow-green in color and have one stigma into the unique chloroplast that contains also a large pyrenoid (pyrenozome). Specific structure for the genus *Mantoniella* is mitochondrion, which situated in the internal (concave) cavity, approximately at the same level with the pyrenoid. It has a c horseshoe-like curved (MIHNEA & DRAGOS, 1997).

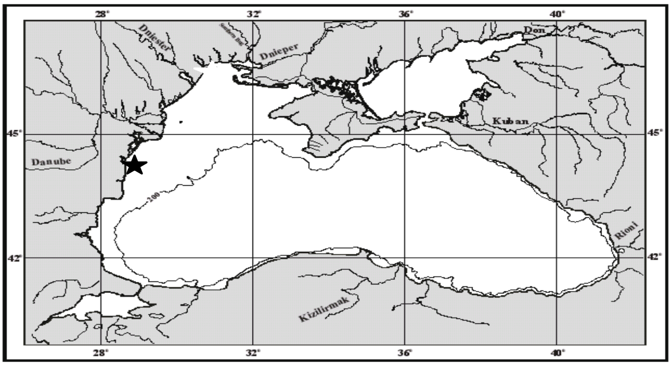


Mantoniella squamata: General view of the cell (drawn on the base of the photos from MIHNEA & DRAGOS, 1997). Note: 1 – two unequal flagella covered by scales and thin hairs; 2 – third atypical flagellum; Ch – single chloroplast, having a large pyrenoid (P).

Probable origin. Insufficiently known.

Possible way of introduction. By ship ballast waters, because the maximal abundance of this species have been founded in port of Vechi and very close to Port Constanta (Romania).

Distribution. For the first time *M. squamata* was found in phytoplanktonic samples in the early 1980s along the Romanian inshore area. Its position could not be established, but the counting of all chrysophytes included this species, because it had been thought to belong to this group before the electron microscopy studies were performed. Species attributed to chrysophytes increased their numbers during 1986 and 1996, usually fluctuating within a range of 10^5 cells·l^{-1}, but maximal concentrations up to $276.56x10^6$ cells·l^{-1} have been found in semi-enclosed area as harbors. Since 1992 till 1994 the maximum density of *M. squamata* strongly increase from $5.97x10^6$ to $12.48x10^6$ cells·l^{-1} and reached the blooming level in 1996. It was one of the circumstances when it eliminated almost all chrysophytes by competition. The peak abundance during this period was about $7.5x10^6$ cells·l^{-1} (MIHNEA, 1997; MIHNEA & DRAGOS, 1997)



First registration of *Mantoniella squamata* in the Black Sea

Habitats. One of the blooming species of the plankton along the Romanian inshore area. *M. squamata* develops during June-October, thereby competing for the first or the second rank position in the hierarchy of association of phytoplanktonic community (MIHNEA, 1997).

Impact on native species. Taking into account the presence of the third flagellum, very similar to haptonema, *Mantoniella* could be supposed to consume organic compounds also directly by absorption (MIHNEA & DRAGOS, 1997). The presence of *M. squamata* into ecosystem could be due to their ability to produce glycoproteins that are defensive compounds and to use the organic fractions existing at high level in the Black Sea water (POPA et al., 1985). Thus a possible impact on marine ecosystem is more efficiently transformation of organic matter and the influence on aquatic organisms is very close to these of other blooming species.

Compiled by B. Alexandrov

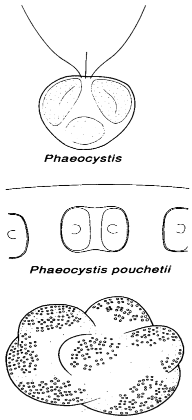
Phaeocystis pouchetii (Hariot) (Lagerheim, 1893)

Synonym: *Phaeocystis globosa* Scherf .

Common names: No

Taxonomy: Class- Prymnesiophyceae
Order- Prymnesiales
Family- Phaeocystaceae

Distinctive characteristics. Motile stage – Prymnesium like cell with spherical or oval form, 4.5-8 μm in length and 5-6 μm in width. Each cell have short haptonema, two flagella (1.5 cell length), and two yellow-brown chloroplasts. Non-motile cells (4-8 μm in length), lacking haptonema and flagella, two chloroplasts with pyrenoids, embedded in round or lobed jelly colonies (total diameter 0.8-2.0 mm; each colony consist of 250-400 cells). *P. pouchetii* is foam and dimethyl sulfide producing (DMSP) species, the water becoming milky and opal (KONOVALOVA *et al.,* 1989).

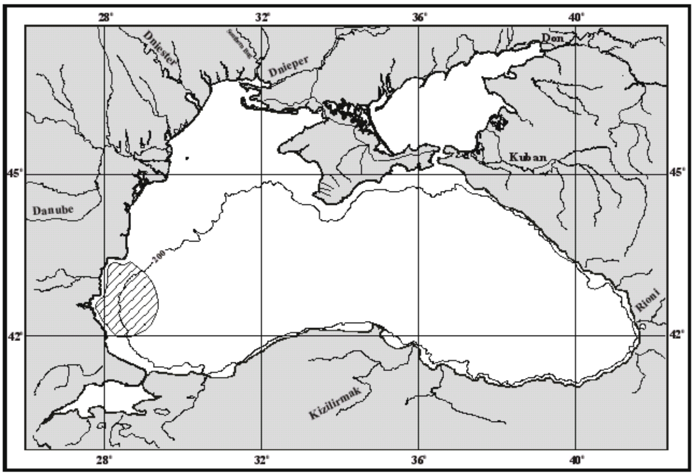


Phaeocystis pouchetii: motile cell, non-motile cell, colony (redrawn from Yahn Throndsen, in TOMAS, 1997).

Probable origin. Coastal and oceanic species.The Arctic, Antarctic, Atlantic, Pacific and North Sea. Frequent and extensive blooms in the North Sea.

Possible way of introduction. With ballast water of cargo ships.

Distribution. Found for the first time in blooming densities in the Aegean Sea in February-March, 1989 (GOTSIS-SKRETAS & FRILIGOS, 1990). In the Black Sea found for the first time in summer 1989, in coastal and open water off Bulgaria (PETROVA-KARADJOVA, 1990; MONCHEVA, 1991). Blooms with algae concentrations more than million cells per litre have been recorded in: 1990- $10.1X10^6$ cells·l^{-1}, 1991 - $90.0X10^6$ cells·l^{-1}, 1993 - $8.8X10^6$ cells·l^{-1}, for both motile cells and colonies (MONCHEVA *et al.*,1995; MONCHEVA & KRASTEV, 1997; MONCHEVA *et al.*, 1999).



Distribution of *Phaeocystis pouchetii* in the Black Sea

Habitats. One of the most frequently registered plankton species during summer blooming period in Varna Bay and 3-mile coastal zone in front of Cape Galata. At present , there is no information about this species in other places of the Black Sea. But the fact, that *Ph. pouchetii* has been the common species in the Aegean Sea since 1989 and that there are no regular particularized (with phytoplanktonic investigations) expeditions, which cover the Sea of Marmara and the Black Sea in front of the Bosphorus , give a permit that this species occurs on this whole area.

Impact on native species. *P. pouchetii* is one of the blooming species of the Black Sea. Therefore, will be dangerous in big concentration in different aspects. Species vegetating in densities over $5X10^6$ cells·l^{-1}, or producing large biomasses over 30 g·m^{-3} are considered to be harmful, since hyperproduction of phytoplankton to influence carrying capacity of the ecosystem and which may result in severe economic losses to aquaculture, fisheries and tourism operations. This species proved toxic only for pelagic copepod *Paracalanus parvum*. The suspected physical effect related to *Ph. pouchetii* is asphyxia and gill irrigation related to *Chetoceros* and *Nitzschia* species (MONCHEVA *et al.*, 1995). According to MONCHEVA & KRASTEV (1997), *Ph. pouchetii* blooming has resulted in physical effect (foam) on fish due to DMSP. For example, in 1991 the concentration of this species was $90x10^6$ cells/l and the production of DMSP was 260 μMcm^{-3} per unit cell volume (MONCHEVA & KRASYEV, 1997).

Compiled by B. Alexandrov

Rhizosolenia calcar- avis (M. Schultze, 1858)

Synonyms: No

Common names: Rhizosolenia ptichia shpora (Rus), Rhizosolenia ptashina shpora (Ukr)

Taxonomy: Class- Centrophyceae
Order- Bacillariophyta
Family- Soleniaceae

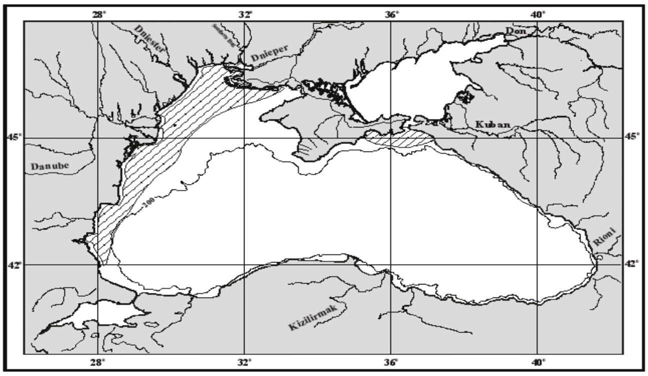
Distinctive characteristics. The cells are long, cylindrical and baculiform. Valves have the appearance of eccentric, conic cap (calyptra) with thorn (calk) on the top. There is a fistular, rough and sharp thorn, which is slightly curved like pounce, on each tip of the valves. Single cells are 0.30-1.34 mm in length and 0.05-0.06 mm in cross-section. Testae are very thin with rows of delicate dots. There are 22-24 dots on each valve.

Rhizosolenia calcar- avis

Probable origin. A neritic, thermophilic species from subtropics and temperate zones of the Atlantic and Pacific Oceans (PROSHKINA-LAVRENKO, 1955).

Possible way of introduction. In ships ballast waters.

Distribution. For the first time *R. calcar avis* was described in the Sea of Azov in 1924, in the Black Sea (northwestern part) in 1926 (USACHEV, 1928). According to MOROZOVA-VODIANITSKAYA (1948), this species penetrated to the Black Sea and the Sea of Azov during 1908-1928. In the northwestern part of the Black Sea it was registered in huge amount only during 1924-1926 and in the 1950s, when its density reached 2.4-4.5 million cells per liter. Now it is a mass, but not a dominant species in the brackish coastal waters of the Black Sea (PROSHKINA-LAVRENKO, 1955, 1963; PROSHKINA-LAVRENKO & MAKAROVA, 1968).



Distribution of *Rhizosolenia calcar avis* in the Black Sea

Habitats. A mass species of the plankton of the northwestern part of the Black Sea, the Sea of Azov, especially after eutrophication (IVANOV, 1965). It is common in coastal waters, bays and gulfs and more rare in the open sea.

Impact on native species. *Rhizosolenia* is one of the blooming species of the Black Sea. Because of its large size and specific body shape, it has no special significance in the food of invertebrates and fish. Pelagic fish shoals (e.g. Anchovy) avoid areas of *Rhizosolenia* blooms.

Compiled by B. Alexandrov

Invertebrates

Acartia tonsa (Dana, 1849)

Synonym: *Acanthacartia tonsa* Dana, 1849

Common names: no

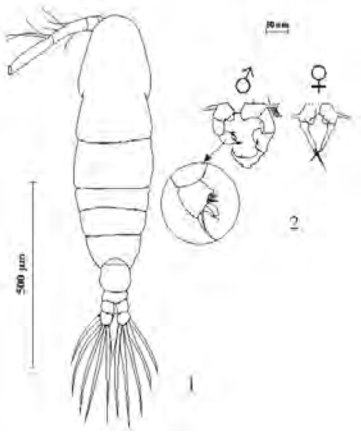
Taxonomy: Class- Crustacea
Order - Copepoda
Family- Acartiidae

Distinctive characteristics. Body slender, oblong, cephalothorax length three times more than its width. Cephalothorax is distinctly separated from the first thoracal segment. Last thoracal segments are merged. There are 5 cephalothorax segments. Body is transparent. Adults from the Black Sea were smaller than those from the

Mediterranean Sea (Sacca di Goro, Adriatic Sea). The total length of females varies 821-980 μm, that of male is 786-840 μm (BELMONTE *et al*., 1994).

Female has very short abdomen (not longer than 1/4 of cephalothorax). Posterodorsal borders of female's metasome with cluster of 6 spines. All urosome segments and furcal rami had spinules, spines, and bristles on dorsal side. There are spiny dorsal rims on genital and following segments. On ventral side, ornamentation is evident only on the genital segment (BELMONTE *et al*., 1994).

One of the accurate diagnostic characteristics of *A. tonsa* is the description of the fifth pair of thoracic legs of the male .The third segment (3) of the left appendage carries at its extremity a long and curved needle (c.n.). It also carries on its inner side a curved "finger" (c.f.) fringed with a thin lamella (l.) directed towards the front part of the animal. As it is articulated, this "finger" process might be considered to be the real terminal segment of the appendage and to constitute part of a pseudochela together with the curved needle (BRYLINSKI, 1981).

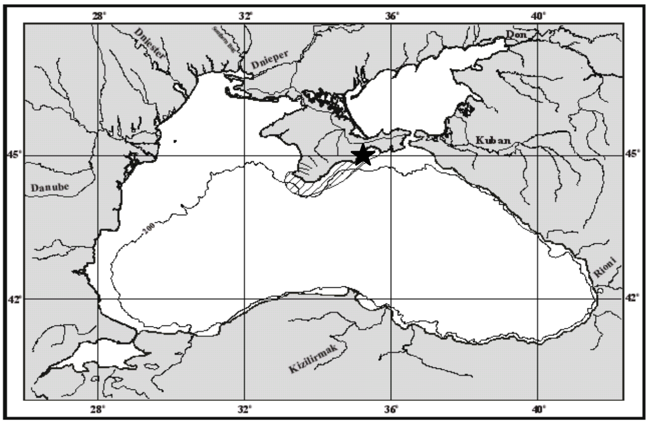


Acartia tonsa. General body shape of adult female (1), structure of the fifth legs (2). (Redraw from BRYLINSKYI, 1981 and BELMONTE *et al.,* 1994).

Probable origin. Coastal species of the West Atlantic and Indo-Pacific Oceans (BRYLINSKI, 1981).

Possible way of introduction. In ballast water in two stages: as adult planktons or resting stages (ZILLIOUX & GONZALES, 1972). According to REMY (1927), this copepod has been possibly transported among the fouling covering the hull of ships crossing the oceans or in the bilge water of tankers. Transport by ships, however, has success only if the captured species are discharged in habitats similar to those from which they come. The Black Sea is ecologically different in many features from the Mediterranean Sea for example it has very low salinity, less than 21 ‰. Recent construction of dams across important European rivers that flow into the Black Sea is another possible way of *A. tonsa* penetration (MORAITOV-APOSTOLOPOULOU, 1985).

Distribution. *A. tonsa was* firstly registered in coastal waters of Europe in 1914 (SILINA, 1989). It is probably a newly introduced species in the Mediterranean Sea, where it has only recently been reported for the first time in the 1980s (GAUDY & VINAS, 1985). A first record of *A. tonsa* in the Black Sea dates back to September 1990 for Karadag, south-eastern Crimea (BELMONTE *et al.*, 1994). Later special investigations have shown relatively large number of this species in southern part of the Black Sea and in Sevastopol Bay (GUBANOVA, 1997). It is necessary to note that *A. tonsa* was not registered in the north-western part of the Black Sea, which is closer to this species native habitat Possible explanation of this considering difference between genus *Acartia*'s. In particular, analysis of old zooplankton samples from collection of Institute of Biology of the Southern Sea showed that correct date of the first registration of *A. tonsa* was 1976, in Sevastopol Bay (GUBANOVA, 1997).



Distribution of *Acartia tonsa* in the Black Sea

★ - Areas of the first registration

Habitats. The genus *Acartia* comprises species that are very common in coastal and brackish water. Temperature is the factor that controls the geographical distribution of *A. tonsa* in the world (CONOVER, 1956). The reproduction of this species occurs of indeed very low temperature under 10^{o}C in estuaries of the temperate zone of the earth (JEFFRIES, 1962). This species dominates in summer and autumn in warm waters in upper layer of 0-20 m. For example, in the Baltic Sea mass development of *A. tonsa* occurs in June-September at the temperature 16-17^{o}C and salinity 4-5 ‰ (SILINA, 1989). *A. tonsa* prefers eutrophic waters (GREEN, 1968).

Impact on native species. Insufficiently known, because of low density of this species. Laboratory experiments were made to investigate the trophic activity of *A. tonsa*, which may consume detrius, phytoplankton, ciliates and small copepods. The ingestion rates of macrophyte's detritus increased with the detritus concentration from 50 to 1,700 mu g C·l^{-1} (ROMAN, 1984). The ingestion rate of the dinoflagellate, *Heterocapsa triquetra*, and the tintinnid ciliate, *Favella* sp. increased with increasing dinoflagellate density to a maximum at 6650 cells·ml^{-1} and with increasing *Favella's* density from 3.4 cells·ml^{-1} (STOECKER & SANDERS, 1985). Wild adults of *A. tonsa* prey at significantly higher rates on nauplii of other species than on their own conspecifics regardless of prey reconditioning (LONDSALE *et al*., 1979). Besides it is well known that *A. tonsa* is used in aquaculture as feed for example, in turbot rearing (KUHLMANN *et al.*, 1981; TURK *et al.*, 1982; STOETTRUP *et al*., 1986).

Compiled by B. Alexandrov

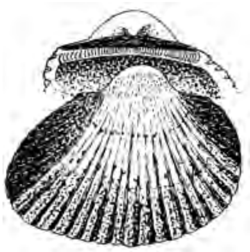
Anadara inaequivalvis (Bruguière, 1789)

Synonyms: *Arca inaequivalvis* (Bruguiere, 1789), *Scapharca inaequivalvis* (Bruguière): Ghisotti & Rinaldi, 1976. Misidentification: *Scapharca cornea* (Reeve, 1844)

Common name : Kum kabugu (Tur)

Taxonomy: Class- Bivalvia
Order- Mytilida
Family- Anadaridae

Distinctive characteristics. It is rather similar to *Cerastoderma lamarcki* from the Black Sea, but having a thick and heavy white shell, somewhat rectangular, with broad ligament. The presence of haemoglobin in the haemolymph of this bivalve can be one of the reasons for its grater tolerance to seasonal hypoxic conditions on the north-western Black Sea shelf (GOMOIU, 1984). Grows up to 57 mm long.



Anadara inaequivalvis

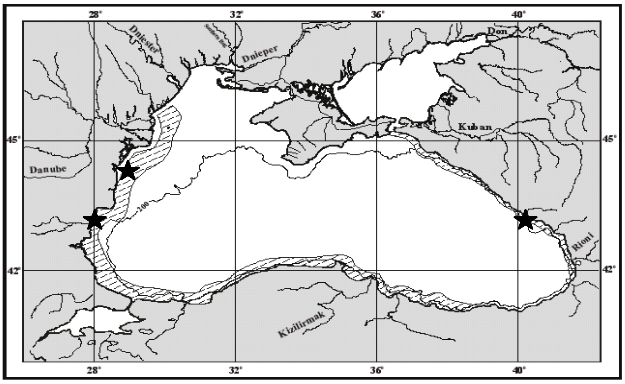
Probable origin. The North Adriatic Sea, where it was first discovered in 1969 (GHISOTTI & RINALDI, 1976). In the Adriatic Sea it was introduced from the Pacific Ocean, possibly from the Philippines coastal waters.

Possible way of introduction: Ship's ballast waters.

Distribution. First discovered in the Black Sea on the Caucasian shelf by ZAIKA *et al*. (1992), then on the Bulgarian coast in 1982, identified as *Anadara* sp. Later on the north-western shelf in Romanian waters as *Scapharca inaequivalvis* (GOMOIU, 1984) and in Ukrainian waters as *Cunearca cornea* (ZOLOTAREV & ZOLOTAREV, 1987). Now is quite widespread in the Black Sea along the Bulgarian, Romanian, Ukrainian, Russian, Georgian and Turkish shelves and in the southern Sea of Azov (ZOLOTAREV, 1996, DÜZGÜNEŞ,1995, ZAITSEV & MAMAEV, 1997). Inhabits coastal waters to 40 m depth and reaches densities of 100 ind·m^{-2} and a biomass exceeding 1 kg·m^{-2} (MARINOV, 1990).

Habitats. Soft muddy, sandy-muddy, shelly-muddy bottoms till 40 m depth.

Impact on native species. Insufficiently known.



Distribution of *Anadara inaequivalvis* in the Black Sea

★ - Areas of first registration

Compiled by Yu. Zaitsev & B. Öztürk

Balanus eburneus (Gould, 1841)

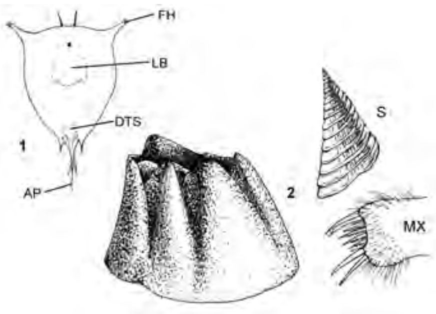
Synonyms: No

Common names: Ivory barnacle (Eng), morskoy zholud (Rus), morskiy zholud (Ukr)

Taxonomy: Class- Crustacea
Order- Cirripedia
Family- Balanidae

Distinctive characteristics. Adults. Species of genus *Balanus* have 6 fixed tablets (rostrum, carina, paired lateral and carinolateral tablets). Rostrum have radiuses, carina have wings. External surface of *B. eburneus*'s scutum (S) have longitudinal streakiness (micro furrows). Middle teeth of maxilla I (MX_1) serrated from below. Barnacle shell have conical form with thick tablets. Smooth and ivory white; scuta grooved lengthwise, radii fairly wide. Tergum deeply notched. It is quite a large barnacle with maximal height and diameter of the shell up to 30 mm.

Larvae. Larval development of *B. eburneus* as the typical thoracican cirripeds consist of six naupliar and one cyprid stage. The larvae of *B. eburneus* and *B. improvisus* are very similar both in size and morphology. The shield of nauplii is plain in all stages, lacking dorsal or lateral shield spines. Morphological changes at each molt follow the normal pattern (symbols in the text and on figure are the some as for *B. improvisus*). The FH are moderate in length and, beginning with stage II, are directed forward. The shield outline is smoothly elliptical. The DTS is distinctly longer than the AP in all stages. Abdominal spination is typical; one median spine is present in stages IV and V. The LB is trilobed with a distinctly longer median lobe. Although the median lobe margin may have minor denticulation, no distinct teeth are present (LANG, 1979).

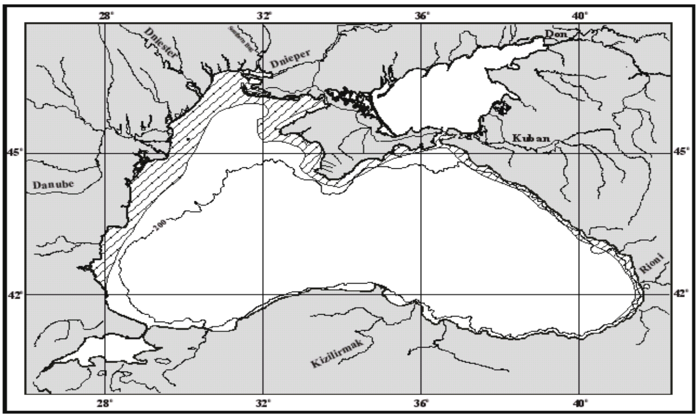


Balanus eburneus: 1- nauplius in stage IV (**FH**- frontolateral horns, **LB**- labrum, **AP**- abdominal process, **DTS**- darsal tharacic spine); 2- general view of adult individual (**S**- scutum, **MX_1**- maxilla 1).

Probable origin. The Atlantic coast of America from New Engand to Brazil in Shallow waters to 37 m depth (HENRY & McLAUGHLIN, 1975).

Possible way of introduction. Total duration of larval development of the barnacles depends on water temperature, and in the Black Sea it is to 9-48 days at T= 22-10°C (ALEXANDROV, 1988). Adult organisms may survive for a long time in their shell ("latent phase") in the air, or in fresh water. Thus there are two ways of possible introduction of this barnacle: in ballast waters at the stage of pelagic larvae and in hull fouling as adult organisms. *B. eburneus was* introduced into the Black Sea probably in the late 19th century (OSTROUMOV, 1892).

Distribution. There is no information about this species in the Sea of Azov. This may be due to the difficulties to distinguish this species from *B. improvisus.* In contrast to *B. improvisus,* this species is rare in the Black Sea. Larvae and adults of *B. eburneus* are found in single numbers. Usually, nauplii are seen in summer season (June-August).



Distribution of *Balanus eburneus* in the Black Sea

Habitats. Adult organisms inhabit surfaces of hard natural (stones, rocks etc.) and artificial substrates (ship's hulls, hydrotechnical constructions, etc.) in the sublitoral zone . Larvae are distributed firstly in the upper 10 m of water in the coastal zone of 10 km wide (main concentration). This species can live in polluted area; endures low salinity close to fresh water and prefers low surf areas.

Impact on native species. Needs to be investigated, because the ivory barnacle is not a mass species the Black Sea.

Compiled by B. Alexandrov

Balanus improvisus (Darwin, 1854)

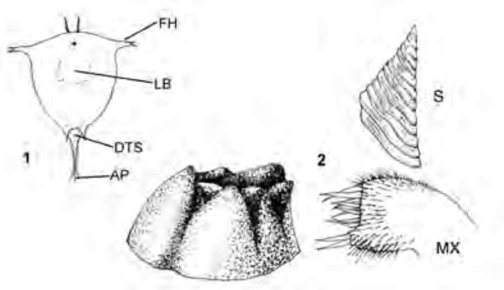
Synonyms: No

Common names: Acorn barnacle, Bay barnacle (Eng), Morskoy zholud (Rus), Morskiy zholud (Ukr)

Taxonomy: Class- Crustacea
Order- Cirripedia
Family- Balanidae

Distinctive Characteristics. Adults. Species of genus *Balanus* have 6 fixed tablets (rostrum, carina, paired lateral and carinolateral tablets). Rostrum with radii, carina with wings. External surface of *B. improvisus*'s scutum (S) is without longitudinal streakiness (micro furrows). Middle teeth of maxilla I (MX_1) are smooth (not serrated from below). Barnacle shells in their mass settlement have cylindrical or lily type form. Maximal height of the barnacle shell is 22 mm (PARTALY, 1980). In the Black Sea and the Sea of Azov *B. improvisus* come to maturity in three months. Total fertility of one individual is about 8000 eggs (RZHEPISHEVSKY& KUZNETSOVA, 1981).

Larvae. Larval development of *B. improvisus* as the typical thoracican cirripeds consist of six naupliar and one cyprid stages. A remarkably uniform pattern of cirriped larval development is evident. Adults release newly hatched nauplii which, within a short time (some hours) span, molt to stage II nauplii. Further development (usually dependent on proper diet) produces four additional naupliar stages and the cyprid. The nonfeeding cyprid will select a substrate, settle, and undergo final metamorphosis to a juvenile. The shield of nauplii is without lateral or dorsal spines in all stages. The frontolateral horns (FH) of stage II nauplii may extend nearly perpendicular to the carapace midline. In stage III larvae, the FH base extends at a slight forward angle, however, the top curves back. Stage IV nauplii have five Antenna 2 endopod terminal setae, as opposed to four setae in *B. eburneus*. The abdominal process (AP) spination is typical. One pair of lateral series two spines and small median spine are present in stage IV and V. The furcal stem is long; the AP and dorsal thoracic spine (DTS) are nearly equal in length in stage IV and VI. The labrum (LB) is trilobed; the median lobe extends beyond the lateral lobes; two-four smaller median teeth are also present in earlier naupliar stages (LANG, 1979).

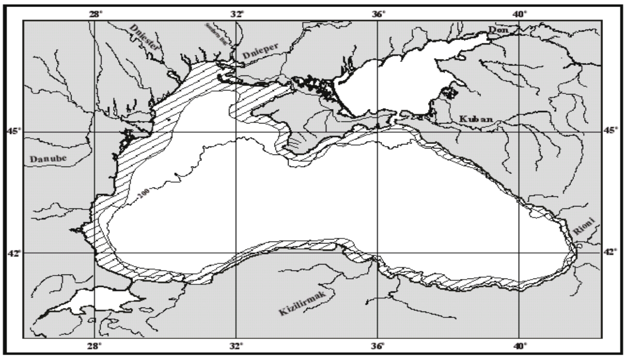


Balanus improvisus: 1- nauplius in stage IV; 2- general view of an adult individual (the symbols are the same as for *B. eburneus*).

Probable origin. The Atlantic and Pacific Oceans, Mediterranean Sea. *B. improvisus* occurs along the entire coast from the intertidal zone to 46 m (HENRY & McLAUGHLIN, 1975).

Possible way of introduction. Total duration of larval development of the barnacles depends on water temperature and in the Black Sea it is 9-48 days at T= 22-10°C. The sedimentation of barnacle larvae has been observed from April till October (ALEXANDROV, 1988). Adult organisms can survive for a long time out of water or in fresh water ("latent phase"). Thus there are two ways of possible introduction of barnacles into the Black Sea: in ballast waters on the stage of pelagic larvae and in hull's fouling as adult organisms. *B. improvisus* was introduced into the Black Sea in 1844 (GOMOIU & SKOLKA, 1996).

Distribution. In the coastal zone of the Black Sea this species is the next edificator of benthic communities after the mussel, *Mytilus galloprovincialis*. About 3% from total biomass of fouling community is that of *B. improvisus* in the seashore of Romania (ȚIGANUS, 1991/92), 4% - along the coast of Ukraine (ALEXANDROV & KHODAKOV, 1999), 5-10% in the coast of Russia (MILOVIDOVA, 1969) and up to 29% in the coastal area of Bulgaria (MARINOV, 1990).



Distribution of *Balanus improvisus* in the Black Sea

Habitats. Preferes salinities less than 20‰. Besides natural hard substrates usually attached to concrete, bricks or debris. It is the mass and very typical organism in pelagic and benthic communities of the Black Sea. Larvae (nauplius 1-6 stages of development) is typical pelagic organisms. They are distributed firtly in the upper 10 m layer of the coastal zone . Their average density in the northwestern part of the Black Sea during 1989-1995 was 1100 ind·m^{-3} (ALEXANDROV & ZAITSEV, 1998). Maximal biomass along the Bulgarian coast is more than 7 kg·m^{-2} (MARINOV, 1990).

Impact on native species. *B. improvisus* is a typical organism of fouling communities, which have significant role in self-purification processes of aquatic ecosystem (ALEXANDROV, 1994). Barnacles larvae (nauplii) are the prevalent component of ration numerous species of fish (for example, silverside, sprat, anchovy, shad and others). Empty barnacle shells are inhabited about 18 species of bottom invertebrates. Some of these organisms (for example, by amphipods *Gammarus locusta*, *Stenothoë monoculoides*, *Jassa ocia*) breed inside of the shells (ZAKUTSKY, 1965).

Compiled by B. Alexandrov

Beroe cucumis (Fabricius, 1780)

Synonyms: *Idya cucumis*, *I. borealis*, *Medec fulgens*, *M. arctica* Lesson, 1843; *Idya roseola* Agassiz, L., 1860; *Beroe roseola* Leidy, 1890.

At First it has been identifiyed in the Black Sea as *Beroe cucumis* (Zaitsev, 1998), later on as *B. ovata* (Konsulov & Kamburska, 1998; Nastenko,&Polishchuk, 1999; Romanova *et al*., 1999; Vinogradov *et al*., 2000).

Common names: beroe

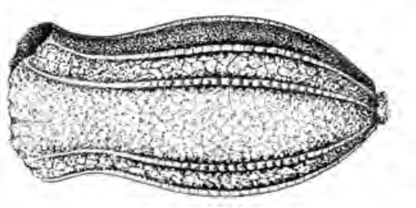
Taxonomy: Class - Tentaculata
Order - Lobata
Family - Beroidae

Distinctive characteristics. Well-known specialists in ctenophore systematic have stated the absence of clear differences between *Beroe* species (MATSUMOTO& HARBISON, 1993). Based on the structure of gastrovascular system of the Black Sea *Beroe* and comparing morphology of this organism with special description of this genus presented by L. SEVARIN (1995), some authors, for example, KOCHINA (1999) consider this species as identical to *B. ovata* from the Mediterranean Sea.

This species is miter-shaped and the lateral compression is very marked, the broad lateral diameter being fully twice the width of the narrow one . The 8 rows of cilia extend about three-quarters the distance from the apical sense-organ to the mouth and each is composed of about 100 combs. The body has well expressed mouth-circling rim. Ciliated belts are laid meredionally and linked with crosswise arches. It is distinguished from *Beroe ovata* by the fact that the peripheral network does not anastomose and that none of these vessels join the two lateral paragastric canals. The pink color of the stellate pigment cells of the meridional canals does not appear until the young individuals is about 25 mm long and after the side branches have grown out from the sides of the meridional vessels. When young , the animal is transparent with a faint yellowish tinge to the canal-system. The side branches do not begin to develop until the animal is 19 mm long. When about 23 mm long, it begins to lose its transparence and assume the translucent milky hue of an adult. This species attains a length of 60 to 100 mm (MAYER, 1912). According L.N.

SEAVIN (1995) a basic systematical characteristic of *B. cucumis* is absence of junction of the lateral branches of the meridional canals.

The size of the Black Sea *Beroe*'s egg is 300-350 μm with gelatinous capsule 0.9-1.0 mm in diameter. Abundance of the eggs in one laying depend on the size of Comb jelly. The ctenophore with length 5-6 cm has 2000-3000 eggs, individuals with length 8-10 cm have 5000-7000 eggs. An equation for determination of wet weight (W, mg) on the base of the total length (L, mm) of the body is: $W = 5.84 \cdot L^2$ (VINOGRADOV *et al.*, 2000).

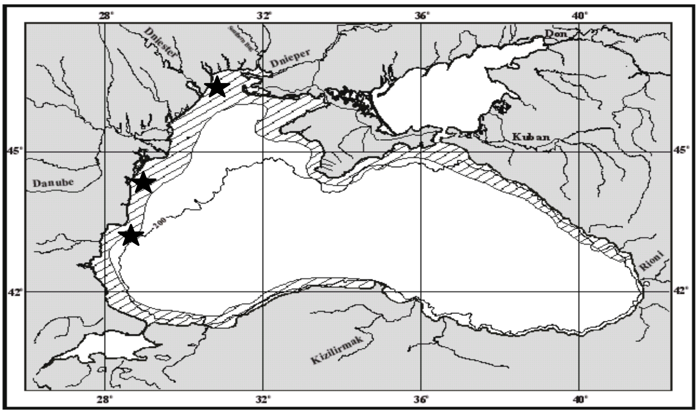


Beroe cucumis

Probable origin It is circumpolar in distribution. It extends along the coast of New Engand, Greenland and is common in the Labrador current. It is abundant in the North Sea and off the coast of Scotland, Pacific coast of North America. This species inhabits the eastern coast of Japan and also the Antarctic, Pacific and Indian oceans (MAYER, 1912).

Possible way of introduction. There are some hypotheses about introduction of *Beroe* into the Black Sea. The possible mechanism of penetration of this comb jelly into the Black Sea is probably the same as for *Mnemiopsis*. In the ballast waters *Beroe* most likely transferred from the estuaries along the North Atlantic Ocean where this species is tolerant to lower salinity and is a native predator on *M. leidyi*. It is quite possible as a hypothesis for *Mnemiopsis* (GESAMP, 1997) that *Beroe* had been initially introduced earlier into the Black Sea basin, and after a period of adaptation to have been successfully naturalized, produces the recent outbursts (KAMBURSKA *et al.*, 1999). Additional support to this point of view is one of the first description of *Mnemiopsis* in the Black Sea as *Bolinopsis infundibulum* (ZAITSEV *et al.*, 1988). Another hypothesis is that *Beroe* which lives in the Mediterranean and Marmara Sea penetrated and had a chance to acclimatize itself the Black Sea, because abnormal worm winters 1997/1998 and 1998/1999 have been promoted of this adaptation. In particular, in summer 1999 in the north-eastern part of the Black Sea (near Gelendzhik), firstly were registered several warm water zooplankton species from the Mediterranean Sea. They were copepods *Rhinocalanus nasutus, Scolecithrix danae, Pleuromamma gracilis* and *Euchaeta marina*. It is possible that these organisms were transported by the lower Bosphorus current (VINOGRADOV *et al.,* 2000).

Distribution. For the first time, adult specimens of *Beroe* were found in the Black Sea in the Odessa Gulf in October 1997 by A.V. CHERNYAVSKY and determined as *B. cucumis* (ZAITSEV, 1998). Practically at the same time in the vicinity of Shabla (Bulgarian coast), this comb-jelly was identified as *Beroe ovata* (KONSULOV & KAMBURSKA, 1998). KONSULOV (1999) stated that "it is logical to expect under this trophic status of the Black Sea the arrival of *Beroe cucumis* species." First registration of the density of *Beroe* was 12 ind·m^{-3}, with mature (70%) and non-mature (30%). During May-August 1998, it was registered that reproduction and mass development of this species occurred in the northwestern part of the Black Sea along the coastal zone of Romania (per. comm. GOMOIU) and Ukraine from the Danube river mouth to Odessa Bay (NASTENKO & POLISCHUK, 1999). During this period, the density *Beroe* was 35-1500 ind·m^{-3}. The main part were at the early development stages with sizes of 0,2-9,0 mm. In 1999 this species of comb-jelly was widely distributed in the coastal area not only in the northwestern part of the Black Sea, but along Crimea from the Cape Tarhankut to Sevastopol Bay (KOCHINA, 1999; ROMANOVA *et al.,* 1999). From September 26 till October 6, 1999. *Beroe* was found in a fair amount in the southern part of the Sea of Azov. During the day, in stationary net installed in the 2-3 m depth and about 300 m from the shore line, have been caught about 2 tons of comb-jelly of 2-7 cm in length (GRISHIN *et al*., 1999). In August-September 1999 *Beroe* was registered in the coastal water of the northeastern part of the Black Sea near Gelendzhik and Golubaya Bay (VINOGRADOV et al., 2000).



Distribution of *Beroe cucumis* in the Black Sea

★ - Area of the first registration

Habitats. In present time *B. cucumis* predominantly inhabit 30 mile width of the coastal zone of the Black Sea and the Sea of Azov 30 miles wide. Most probably reproduction of this species takes place in open waters. About 70% of individuals seen in open sea had the length of 0,1-1,0 cm with the average density 50 ind·m^{-3}. Near the shore (not more than 100-300 m from the coast) predominate large adult speciments 5-8 cm in length with medium distance between each other 5-10 m (personal observations). *B. cucumis* is found mainly in the temperature 13-22°C.

Impact on native species. Most scientists considered that *Beroe* feeds itself (during all of its development stages) exclusively with other comb jellies (NELSON, 1925; KAMSHILOV, 1955). It is known that during one month one individual of *Beroe* with length 35 mm may consume 44 individuals of *Bolinopsis* with length 10-35 mm and grows up to 44 mm (KAMSHILOV, 1960). The measurement made in the Black Sea showed that in average one individual of *Beroe* consumes 0.3 individual of *M. leidyi* of average size, or approximately 2.5 g of wet weight, or 2.5 mg C_{org} (VINOGRADOV *et al*., 2000). This is the reason for one of proposal to introduce *Beroe* into the Black Sea to stop *Mnemiopsis leidyi* invasion (GESAMP, 1997). Perhaps, its introduction into the Black Sea and the Sea of Azov will lead to the reduction of local comb jelly *Pleurobrachia rhodopis* quantity and to the inhibition of the early intruded and acclimatized species of *Mnemiopsis*, which strongly influences on the zooplankton and fish stocks. Obviously these two ctenophores are interacted in an “ecological feedback system” (an increase of *Beroe* population will result in a decrease of *Mnemiopsis*, followed by a successive increase of zooplankton and pelagic fish), a scenario more efficient in autumn in the Black Sea as evident from the preliminary results. Besides , *Beroe* is a food web dead-end due to the lack of natural enemies in the Black Sea. Thus either direct or indirect impact through the entire food web could well be expected , e.g. copying *Mnemiopsis*’s history and further adding to the problem of gelatinous species in the Black Sea. In any case the introduction of this species in the Black Sea is a warning for ecological concerns (KAMBURSKA *et al*., 1999).

Compiled by B. Alexandrov

Blackfordia virginica (Mayer, 1910)

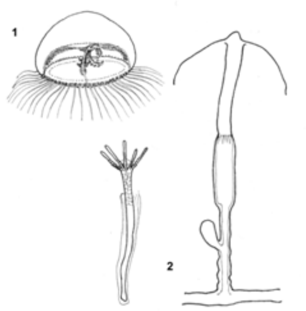
Synonyms: *Eugenia cimmeria* Iliyn, 1930, *Campanulina pontica* Valkanov, 1936

Common names: No

Taxonomy: Class- Hydrozoa
Order- Leptolida
Family- Campanulinidae

Distinctive characteristics.
Medusoid generation. Medusa has four radial channels and numerous (about 80-100) tentacles on the edge with 1-3 statocysts between each of two of them. Bell has a hemisphere form. Oral proboscis supply with four plicate lips. Mature medusa is about 15-18 mm in diameter.

<u>Polypoid generation</u>. Form prostrate or wildly ramified colony. Hydrotheca is sharply widen under the stalk. The walls of hydrotheca have longitudinal streakenes. The basis of polyp's tentacles connected by the web. Polyp has 12-26 tentacles (NAUMOV, 1960).

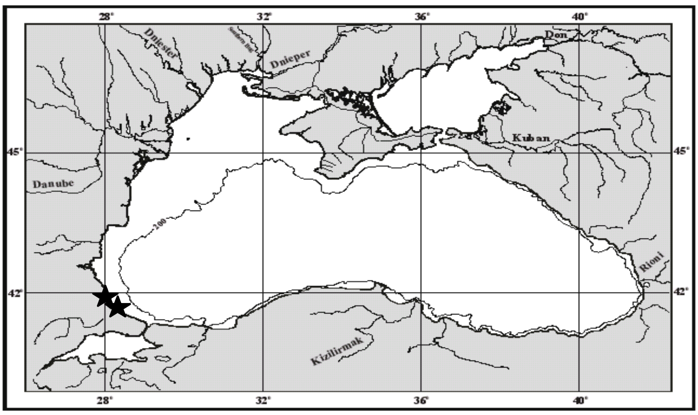


Blackfordia virginica: 1- hydromedusa; 2- young polyp (HT - hydrotheca of polyp colony).

Probable origin. The Atlantic coasts of North America.

Possible way of introduction. In hull's fouling or in ballast water.

Distribution. In the Black Sea it was first recorded in 1925 in Mandrensko Lake and estuaries of Ropotamo, Diavolska and Karagach Rivers not far from Bourgas Gulf of Bulgaria (VALKANOV, 1936).



Distribution of *Blackfordia virginica* in the Black Sea

★ - Area of the first registration

Habitats. Typical brackish water species which occurs in estuaries and near the river mouths. Prefers the salinity 3-18 ‰, but most optimal 7-8 ‰. Inhabits the talloms of macrophytes in shallow water. Medusae occur in the upper layer of the sea not far from the coast (NAUMOV, 1960). Communities of hydroids *Blackfordia virginica* and *Moerisia maeotica* are very typical for the low salinity waters of the Bulgarian coast (VALKANOV, 1936).

Impact on native species. Insufficiently known.

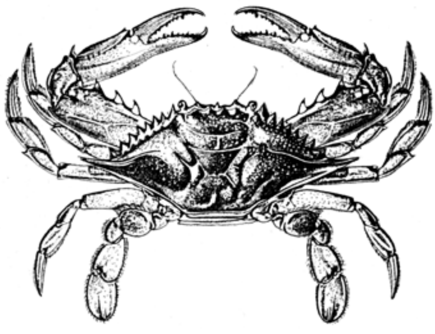
Compiled by B. Alexandrov

Callinectes sapidus (Rathbun, 1930)

Common names: Blue crab (Eng), Blakitny crab. (Ukr), Goluboy crab (Rus), Crabul albastru (Rom), Synyat rak (Bul), Mavi yengeç(Tur).

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Portunidae
(Except the blue crab, three genera, five species of this family are inhabiting the Black Sea.)

Distinctive characteristics. Last pair of legs paddle-shaped. Shell more than twice as wide as lits length. Four triangular teeth between eye sockets, and eight sharp and strong teeth between eye socket and large spine at side. To 20 cm wide, and 10 cm long. Usually olive or bluish-green on the dorsal side, claws bright blue.

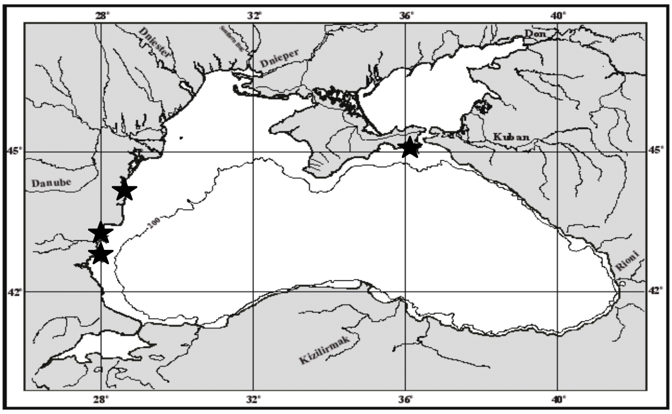


Callinectes sapidus

Probable origin. The North American coast of the Atlantic from Cape Cod to Florida and Gulf of Mexico.

Possible way of introduction. Ship's ballast waters and/or hull fouling. It is also Possible by its migration into the Black Sea from the Mediterranean Sea, where it was introduced by ships probably in the 1960s.

Distribution. Firstly it was discovered in 1967 on the Bulgarian shelf by BULGURKOV (1968). Later, in the 1970s, it was found in the Kerch Strait and in 1984 once again on the Bulgarian coast, but in each case only isolated individuals were observed. In 1998 a specimen of *C. sapidus* was collected in the southern part of the Romanian coast (GOMOIU & SKOLKA, 1998). This species probably has not yet established a self-maintaining population in the Black Sea.



Distribution of *Callinectes sapidus* in the Black Sea
★- Area of registration

Habitats. Shallow and brackish waters, sandy and muddy botoms.

Impact on native species. Insufficiently known.

Compiled by Yu. Zaitsev & B. Öztürk

Crassostrea gigas (Thunberg, 1793)

Synonyms: *Ostrea gigas* Thunberg

Common names: Japanese oyster (Eng), Gigantskaya ustritsa (Rus), Gigantska ustritsya (Ukr), Mavi yengeç (Tur).

Taxonomy: Class- Bivalvia
Order- Cyrtodontida
Family- Ostreidae

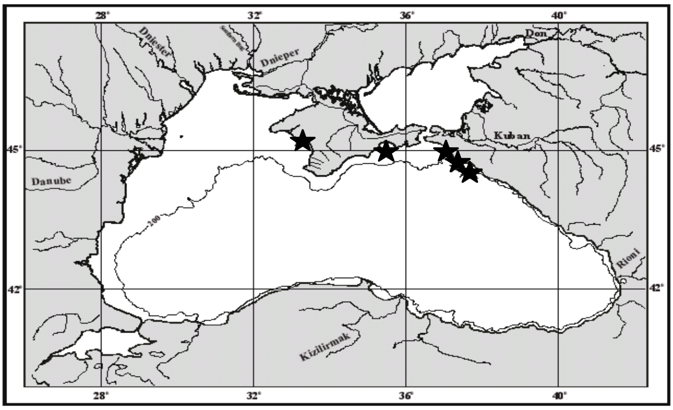
Distinctive characteristics. Extremely variable in shape. Shells massive, rough, and unequal. Lower valve cemented to any hard object available, upper valve smaller and flatter. A single violet muscle scar. To 180 mm high, 150 mm long and 60 mm wide.

Crassostrea gigas

Probable origin. The Sea of Japan.

Possible way of introduction. Accidentally introduced by ships in the beginning of the 20th century (SCARLATO & STAROBOGATOV, 1972), and intentionally, for cultivation, in 1980 from Posjet Bay of the Sea of Japan (ZOLOTAREV, 1996).

Distribution. Single specimens were found along the North Caucasian and Crimean coasts.



Distribution of *Crassostrea gigas* in the Black Sea

★ - Area of first registration

Habitats. Stony bottoms in coastal waters.

Impact on native species. Insufficiently known.

Compiled by Yu. Zaitsev

Doridella obscura (Verrill, 1870)

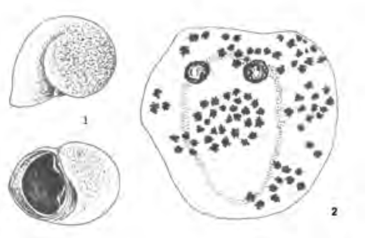
Synonyms: No

Common names: No

Taxonomy: Class-Gastropoda
Order- Nudibranchia
Family -Corambidae

Distinctive characteristics. Adults. By the 7th day after metamorphosis, juvenile specimens of *Doridella* are 2 mm long, had fully developed retractile rhinophores, and are darkly pigmented on the dorsal surface. The eyes are well visible. Six days later (at 25 ^{o}C), they grow to 4 mm and reach sexual maturity. Egg masses are laid as flat, dextral spirals of up to 4 complete coils. The maximum number of eggs is 2500 (MARCUS & MARCUS, 1960; MARCUS, 1972). Total length of the Black Sea individuals is 2.0-3.7 mm, wet weight 2-9 mg (SINEGUB, 1994).

Larvae. The planktonic larvae with spirally coiled protoconchs may show considerable shell growth prior to metamorphosis, but in *D. obscura* the mantle presumable remains attached to the shell aperture long after hatching. Veligers have shells measuring 95-110 µm across the maximum diameter. At hatching, veligers lack eyes, are unpigmented, and show no sign of a propodium. By the 5-6 th day, dark eye spots were visible, shell growth ceases, and the shells of most larvae measured 190-195 µm. Larvae grow no larger than 125-130 µm and die after 13 days (PERRON & TURNER, 1977).

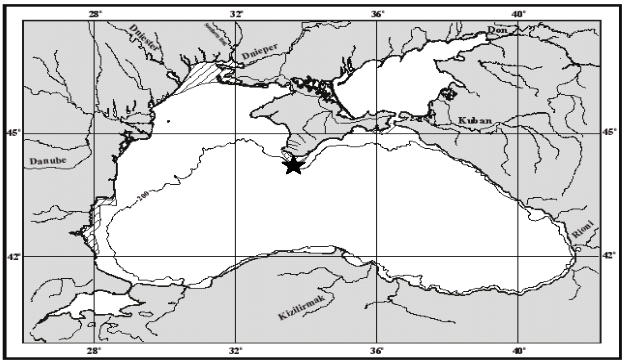


Doridella obscura. 1- larval shells: a, aperture view of cast shell; b, dorsal view of cast shell; 2- dorsal view of adult showing pigmented surface and rhinophores.

Probable origin. Endemic species of the Atlantic coast of North America. Distributed along the coasts of USA (Florida, Gulf of Mexico, Louisiana) and in the Caribbean Sea (MARCUS & MARCUS, 1960; MARCUS, 1972).

Possible way of introduction: Total durati of larval development of the molluscs depends of water temperature and is 9-18 days at 2-28^{o}C (PERRON & TURNER, 1977). There are two ways of possible introduction of *Doridella*: in ballast waters as planktonic larvae and in hull's fouling as adult organisms or eggs.

Distribution. It was firstly recorded in the Black Sea in Varna Gulf (Bulgarian coast) in July 1986. There were 4 individuals found in fouling on the shell of *Rapana thomasiana thomasiana* in the depth 2 m (SINEGUB, 1994). In January 1989 , this species was found in Laspi Gulf on the southern coast of Crimea (ROGINSKAYA & GRINTSOV, 1990). During 1986-1991 were revealed 12 individuals of *Doridella* in the coastal zone of the Black Sea from Bourgas Gulf up to the Kerch Strait (SINEGUB, 1994). *D. obscura* has been found in the Black Sea as single specimens in fouling communities on the depth 1-15 m in salinity 11.2-16.4‰. In its native habitat, this mollusc prefers low salinity areas of 2-23‰ (PERRON & TURNER, 1977).



Distribution of *Doridella obscura* in the Black Sea

★ - Area of the first registration

Habitats. *D. obscura* is a component of fouling communities of hard natural (stones and rocks) and artificial (naked hulls, hydrotechnical constructions) substrates. Other species in fouling communities are: green alga *Enteromorpha* sp., hydroid *Obelia longissima*, bryozoans *Electra crustulenta*, *Conopeum seurati*, bay barnacle *Balanus improvisus* and mussel *Mytilus galloprovincialis.* The larvae of *D. obscura* metamorphosed only on living colonies of bryozoans (*Electra*, *Membranipora*, *Schizoporella*).

Impact on native species. *D. obscura* is a stenophagous predator. It feeds on bryozoans *E. crustulenta*, *C. seurati* and others, which are common species along the Atlantic coast of North America and in the Black Sea (ROGINSKAYA &

GRINZOV, 1990; SINEGUB, 1994). The larvae are planktotrophic, such that they cannot grow and metamorphose in the complete absence of an external food source, for example, unicellular algae and sessile ciliates (PERRON & TURNER, 1977).

Compiled by B. Alexandrov

Eriocheir sinensis (Milne-Edwards, 1854).

Common names: Chinese mitten crab (Eng), Crabul-chinezesc (Rom) Mokhnatorukiy crab (Rus), Mokhnatorukiy crab (Ukr).

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Grapsidae

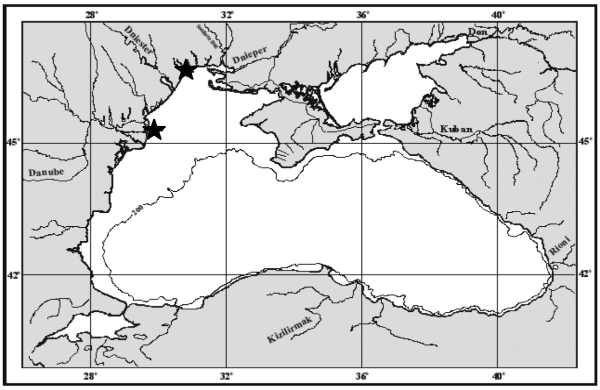
Eriocheir sinensis

Distinctive characteristics. The square shaped carapace of adult crabs clearly distinguishes it from other European brachyuran crabs. It can attain a carapace width of 5 cm. Males have a hair-like covering on the claws forming mitten-like claws. The colour varies from yellow to brown, rarely purple and red.

Probable origin. Originated from the eastern Asia estuaries and coastal marine waters (the South China Sea and Yellow Sea).

Possible way of introduction. This crab was accidentally introduced by ships in Europe (North Sea) in the early 20 th century. In ballast waters as larvae and/or in hull's fouling as adult specimens.

Distribution. In 1997, a female carrying eggs was captured in Musura Bay on the sea side of the Danube Delta (GOMOIU & SKOLKA, 1998). A male with the carapace width 5.5 cm was collected by S. Volkov in 1998 in Yuzhny Port at 20 km east of Odessa Gulf (ZAITSEV, 1998). Another crab (a female) was caught in 1999 near the Bolshoy Fontan Cape, south of Odessa Gulf.



Distribution of *Eriocheir sinensis* in the Black Sea

★ - Area of the first registration

Habitats. Sandy and muddy bottoms in brackish and fresh water.

Impact on native species. Insufficiently known.

Compiled by Yu. Zaitsev

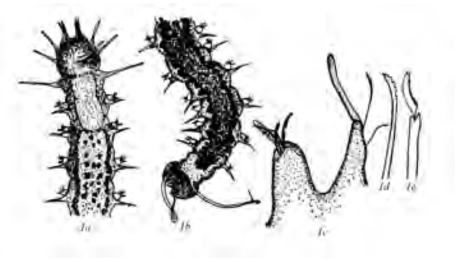
Hesionides arenarius (Friedrich, 1936)

Synonyms: No

Common names: No

Taxonomy: Class- Polychaeta
Order- Nereimorpha
Family- Hesionidae

Distinctive characteristics. A small worm up to 10-15 mm in shallow-water sandy beaches. No eyes. The proboscis is without jaws and has 10 papillae on the external edge. First two segments with cirri and without setae. Parapodia are biramous, the dorsal branche (notopodium) with a long cirrus and two long notosetae. The ventral branch (neuropodium) with a shorter cirrus and several, but not more than 4, complex neurosetae. Anal paddles of pygidium are adaptive characteristics for living in sandy bottom. Because of their small diameter is considered interstitial apecies (WESTHEIDE, 1971).



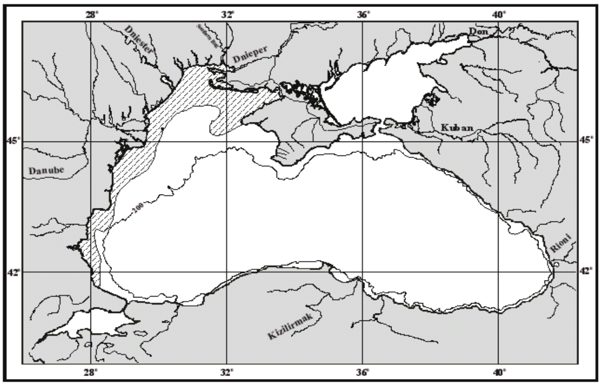
Hesionides arenaria

1a- anterior end of the body, 1b- posterior end of the body, 1c- parapodium, 1d and 1e- setae (1a and 1b from VALKANOV, 1954; 1c from FRIEDRICH, 1937; 1d and 1e from MARINOV, 1977)

Probable origin. The Atlantic and Pacific Oceans, the Mediterranean Sea.

Possible way of introduction. Via ships.

Distribution. A rare polychaete in the western and north-western shelves of the Black Sea.



Distribution of *Hesionides arenaria* in the Black Sea

Habitats. Coarse sand in supralittoral zone and up to 5 m depth in the sea (VOROBYOVA et al., 1992, VOROBYOVA, 1999).

Impact on native species. Insufficiently known.

Compiled by L. Vorobyova

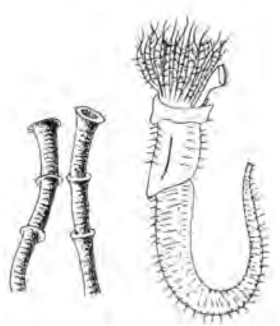
Mercierella enigmatica (Fauvel, 1923)

Synonyms: No

Common names: No

Taxonomy: Class- Polychaeta
Order- Serpulimorpha
Family- Serpulidae

Distinctive characteristics: Body in a calcareous cylindrical tube up to 5-8 cm in length. The cover was numerous chitin denticles. There are large curved setas with toothed edge on the first segment. The hook-like setas have one large bucket tooth and some more little denticles. Total length of the body up to 15 mm. The number of segments is not more than 65. Total number of gill branches is 10-14. There are 7 thoracic segments and the first of them has special large curved setae with toothed edges and thin hair-like setae (VINOGRADOV & LOSOVSKAYA, 1968).



1 2

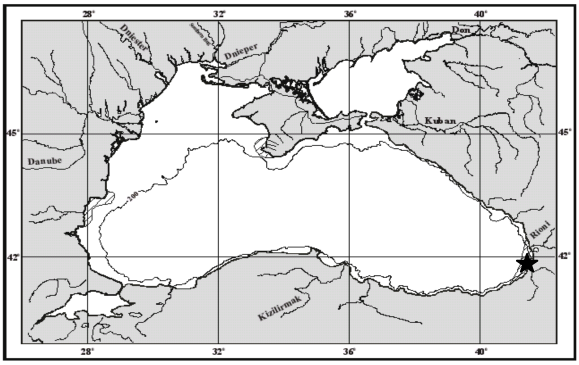
Mercierella enigmatica

1- calcareous tubes, 2 - the body of worm

Probable origin. Coastal lakes of India. According to RULLIER (1966) this species was transported from India to London Harbour during the First World War. For the first time it was detected by Prof. MERCIE in 1921 in Kaena Channel of Normandy (France) and transmited to P. FAUVEL for identification, who described a new genus and species *Mercierella enigmatica* (FAUVEL, 1923).

Possible way of introduction. In hull’s fouling. This is a typical fouling organism, which is found on the underwater surface of ships and hydrotechnical constructions. The attachment of *Merceierella* takes two hours, whereby the formation of branchial apparatus and tube was observed (DIMOV *et al.*, 1970b).

Distribution: For the first time this species has recorded in the Black Sea area by ANNENKOVA (1929) in Paliastomi Lake (Georgia). Now it is widely distributed in Paleostomi Lake, in Poti Port (Georgia), Gelendzhik Bay (MARINOV, 1977), in Kerch Port (LEBEDEV, 1961), near the Koparka and Cheornaya river mouth, Varna Lake (DIMOV *et al.*, 1970a). Maximal registered biomass in the Black Sea was 10 kg·m^{-2} in Kerch Port (LEBEDEV, 1961). After the middle 1960's the abundance of *Merceierella* decreased.



Distribution of *Mercierella enigmatica* in the Black Sea

★ Area of the first registration

Habitats. A euryhaline species which can stand the salinity from 0 to 55‰. The environmental conditions during the maximal activity of *Merceierella* are homothermy with average temperature 17,5^{o}C and slow current. It is known that the speed of the current more than 0,4 m·s^{-1} is a limiting factor for this species. In September the fouling consists mainly of *Merceierella* whose density reached 3 million specimens per square meter after a period of 15 days. Biomass of this type of fouling during this period was 1075 g·m^{-2} (in the conditions of Varna Lake). This type of fouling is common for about 4 months, from June till October. The other species in the fouling community are the green alga *Enteromorpha* sp. and invertebrates *Balanus improvisus*, *Polydora ciliata* and *Mytilus galloprovincialis* (DIMOV *et al.*, 1970a).

Impact on native species. Insufficiently known.

Compiled by B. Alexandrov

Mnemiopsis leidyi (Agassiz, 1865)

Synonyms: No
Bolinopsis sp. (Pereladov, 1988), *Bolinopsis infundibulum* (Zaitsev et al., 1988), *Leucothea multicornis* (Konsulov, 1990), *Mnemiopsis mccradyi* (Zaika, Sergeeva, 1990).

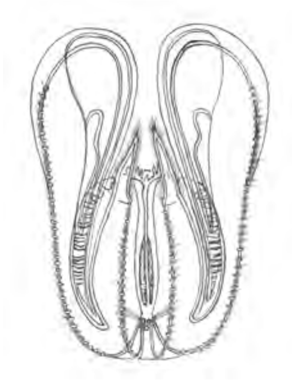
Common names: Rainbow comb jelly (Eng), Mnemiopsis (Rus, Ukr). Kaykay (Tur).

Taxonomy: Class - Tentaculata
Order - Lobata
Family - Mnemiidae

Distinctive characteristics. Lobatae have 2 oral lobes of medium size and 4 relatively short, simple auricles arise from the sides of the body immediately above the mouth and close to the sides of the oral lobes. The adult animal is about 100 mm in length, specimens larger than this being rare. When seen from the narrow side, the general outline of the body is almost ellipsoidal. A view of the broad side, however, shows a pear-shaped outline, this being due to the wide-flaring oral lappets. The oral lappets are each about two-fifths as long as the entire animal and are even wider than they are long. The 4 auricles are flat and ribbon-like, and about one-fourth as long as the body of the animal. Both sides of the long, slit-like mouth are bordered with a row of short, simple tentacles which are continuous with those of the deep, lateral furrows. The central tentacle on each side is longer than the others and gives rise to lateral filaments. The 4 rows of ciliated combs leading to the auricles are only about half as long as the 4 rows extending down the outer surface of the oral lobes. The axial funnel-tube is only about one-fifteenth as long as the stomodaeum. The ciliated combs sparkle with brilliant iridescence by day and glow with an intense green light when the animal is disturbed at night. As in other ctenophore, the animal is hermaphroditic, and the egg is spherical and is enveloped by a thin, structureless membrane which is widely separated from the surface of the egg.

This genus is closely related to *Bolinopsis*. Phylogenetically reasoning, *Bolinopsis* is simply an arrested form of *Mnemiopsis*, or *Mnemiopsis* an advanced condition of *Bolinopsis* (Mayer, 1912).

Mature specimens of *Mnemiopsis* spawn at night in summer temperatures of 20 to 23 ^{o}C in upper layer of the sea. Embryonic development takes about 20-24 hours. Size of the larvae 0,3-0,5 mm (ZAIKA & SERGEEVA, 1990). Average eggs production of *Mnemiopsis* in coastal zone of the Black Sea is very high and exceed 1000 eggs per individual during a day. Total number of the eggs in one laying are 2000-4000. Equations for determination of wet weight (W, mg) on the base of the total length (L, mm) of the body are: $W= 3.1 \cdot L^{2.22}$ for $L<45$ mm or $W= 3.8 \cdot L^{2.22}$ for $L>45$ mm (VINOGRADOV *et al.*, 2000).



Mnemiopsis leidyi

Probable origin of species. North American Atlantic coasts. *Mnemiopsis* is found in coastal waters of America from Cape Cod southwards to Carolina.

Possible way of introduction. *Mnemiopsis* is abundant in ports and harbors of the Americas and can be pumped (presumably as larvae or small juveniles) or gravitated (as adults as well) with ballast water into cargo ships. While sufficient zooplankton may be available to sustain comb jelly in ballast water on a voyage lasting 20 or more days from the Americas to the Black Sea, food resources are not necessary, as *Mnemiopsis* can live for three or more weeks without food, reducing body size at the same time (REEVE *et al.*, 1989). In common with other ctenophores, *Mnemiopsis* is a simultaneous hermaphrodite. This means, in theory, that a single animal could successfully invade a new area.

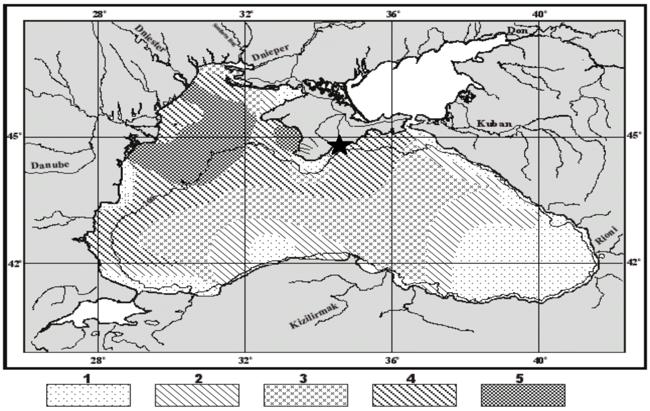
Distribution. The first record about *Mnemiopsis* appearance in coastal water of the Black Sea go back to 1982 (PERELADOV, 1988). First registration of this species in open water was in winter 1986-1987 (ZAITSEV *et al.*, 1988). The appearance of *Mnemiopsis* in the Sea of Azov was recorded first in August 1988. But in this area it does not survive in winter period. So the penetration of this species into the Sea of Azov from the Black Sea proceeds between April and July (VOLOVIK *et al*., 1993). From Stanislav Volovic (personal announcement) there were large number of *M. leidyi* in the Caspian Sea. In fact, rumors of fishermen catching “strange jellies” in their nets have been circulating since 1996, but were not confirmed so far. In November 1999 this new species for the Caspian Sea was registered by two scientists from Fisheries Research Institute of Russian Federation in Astrakhan (Dr. V.P. Ivanov and Dr. A.M. Kamakhin) during the expedition along the east coast of the Caspian, in the Turkmenistan and Kazakhstan sectors at 40°58’, 52°45’, on a shelf zone of 40 m depth. The massive growth in Black Sea populations started in 1988 and at first covered only bays, gulfs and coastal waters. Its abundance reached 10-12 $kg{\cdot}m^{-2}$ at several coastal areas (e.g., Anapa, the southwestern Bulgarian coast), but didn’t exceed 1,5-3 $kg{\cdot}m^{-2}$ in the open sea (VINOGRADOV *et al*., 1990;

SHUSHKINA, VINOGRADOV, 1991; ZAIKA & SERGEEVA, 1990). Maximal development of this species was registered in 1989 and 1990 (about 1200 $g{\cdot}m^{-3}$), but then the abundance of *Mnemiopsis* started to decrease (VINOGRADOV et al., 2000). For example,average biomass of *Mnemiopsis* during 1991-1994 in Romanian littoral zone was 2.2-3.5 $g{\cdot}m^{-3}$ and in 1995 decreased to 0.2 $g{\cdot}m^{-3}$ (RADU *et al*., 1996-97). The same quantitative distribution was investigated in the Dniper river influence zone of the Black Sea. Average biomass of *Mnemiopsis* during 1993-1997 was 3.2-5.1 $g{\cdot}m^{-3}$. Observations of 1991-1997 showed that *M. leidyi* as an intruder was in the planktonic community of the Black Sea region. Its population density during these years stabilized at 300 to 800 $g{\cdot}m^{-2}$ in the Black Sea and at 500 to 600 $g{\cdot}m^{-2}$ in the Sea of Azov (GESAMP, 1997; STUDENIKINA *et al*., 1998).

Detailed investigations on the interaction between these two exotic ctenophores along Bulgarian shore have shown that after *Mnemiopsis* outburst in the late 1980s its spring-summer abundance was the lowest in 1991-1992 (3-10 $ind{\cdot}m^{-3}$) and each year was higher and higher, reaching a maximum of 4000 $ind{\cdot}m^{-3}$ in 1998, despite of the newly introduced *Beroe* since 1997. And at the same period , average biomass of *M. leidyi* was maintained at a level 4 times more than that of the late 1980s.

The biomass of *Mnemiopsis* of the whole Black Sea was estimated to be 100 million tons in 1994 and about 17-18 million tons at the Sea of Azov in 1996-97 (maximal abundance – 30 million tons was registered in 1989).

The distribution maps of *Mnemiopsis* in the Black Sea had been prepared for different years and seasons. To make a generalized map, the model description of this comb jelly was used. This description was based on peculiarity of its biology (reproduction, growth, mortality) and water mass transportation in the Black Sea (LEBEDEVA, 1998). The map following generalized of *M. leidyi* distribution was made for the water layer of 0-30 m (typical inhabited layer for this species) for September .



Distribution of *Mnemiopsis leidyi* in the
Black Sea during the maximum development in September.
Range of biomass ($g \cdot m^{-2}$): **1**- <200; **2**- 200-600; **3**- 600-1000; **4**- 1000-1400; **5**- >1400.
★ - place of the first registration

Habitats. *Mnemiopsis* is usually found close to shore, in bays and estuaries, although they have occasionally been collected several hundred kilometers offshore. They are able to tolerate a wide range of salinity and temperature, and can live and reproduce in temperatures ranging between 1,3^{o}C and 32^{o}C and in salinities ranging between 3,4 and 75 ‰. They survive well in oxygen-poor environments. They are most abundant in brackish waters with high levels of particular material, and appear to be little affected by contaminants. The only factors which appear to restrict their rapid population growth are the temperature, the availability of food and the presence of predators (GESAMP, 1997).

Impact on native species. *M. leidyi* is the most striking example of the negative influence of exotic species on the Black Sea ecosystem. After its invasion, the structure of the planktonic communities in the coastal waters and the open part of the sea significantly changed. The general abundance of subsurface mesozooplankton declined 2-2,5 times or more on average, compared with the previous period. The biomass of some species (small copepods *Oithona*, *Paracalanus*, *Acartia*, *Pseudocalanus*) decreased 3-10 times or more. A pronounced decrease (approximately 2-10 times) of meroplankton in summer also occurred, showing the grazing impact of *Mnemiopsis* upon the larvae of benthic animals and thus upon the benthos. The subsequent decrease of the zoobenthos biomass by about 30% was estimated (VOLOVIK *et al.*, 1993).

Three main impacts of *Mnemiopsis* on the fisheries were identified: 1) predation on fish eggs and larvae; for example, in shelf waters the population of *Mnemiopsis* was estimated to graze up to 70% of total ichthyoplankton stock

(TSIKHON-LUKANINA *et al*., 1993); 2) feeding on larvae and adult fish food, thus causing starvation; 3) further accelerating of on going ecological change presently being experienced due to eutrophication (for example, direct environmental impacts on the pelagic and benthic systems (anoxia) due to massive precipitation of mucus and dead ctenophores to the bottom on the shallow shelf). All of these events related to the new predator resulted in a drastic decrease of fish production – of kilka 4-5 times and anchovy, over 10 times. There was a decline in the biomass of both populations and catch in about the same proportions, which caused large-scale damage to the fishery.

The annual loss of the fish catch attributed to the *Mnemiopsis* plague was calculated to be approximately 200 million USD in the Black Sea and 30-40 million USD in the Sea of Azov a year. (GESAMP, 1997).

Mass occurrence of *M. leidyi* appears to be one of the most important reasons for the sharp decrease of anchovy and other pelagic fish stoks in the Black Sea. *M. leidyi* was found also in the Mediterranean Sea (KIDEYS, 1994). *M. leidyi* also was found in the Mediterranean Sea however, its impact on the local fauna is not known.

Compiled by B.Alexandrov, A.Kıdeys

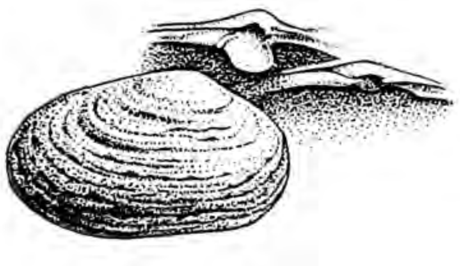
Mya arenaria (Linne, 1758)

Common names: Soft-shelled clam (Eng), Peschyanaya rakushka (Rus), Mya pisochna (Ukr).

Taxonomy: Class- Bivalvia
Order- Venerida
Family- Myidae

This is the only species of this family in the Black Sea.

Distinctive characteristics. Shells elongated, thin, oval, rounded in front, gaping. Hinge asymmetrical, left side with a tongue-like chondrophore, right with a heart-shaped pit. Chalky white with dull brownish or yellowish periostracum. Surface with rough, wrinkled growth lines. Siphons fused into a neck with tough, dark gray skin. In the Black Sea grows to 115 mm long.

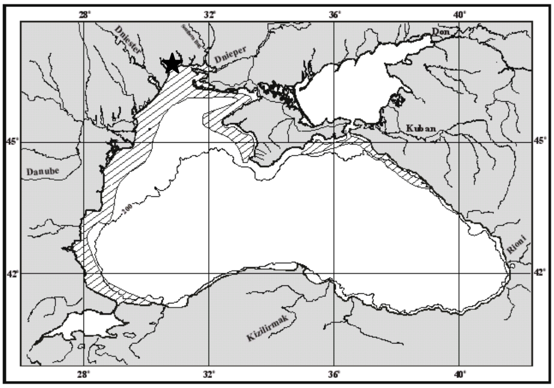


Mya arenaria

Probable origin. The North Sea or the Atlantic seashore of North America. In northern European seas was probably brought from North America, as early as the 11th or 12th century, by the vikings who used the clam as bait or food (GOLLASH & LEPPÄKOSKI, 1999).

Possible way of introduction. In ships' ballast waters.

Distribution. First discovered in Odessa Gulf in 1966 by BESHEVLY & KALYAGIN (1967). Now widespread on the Black Sea shelf, especially at low salinity areas (less than 15‰). During the initial stages of its invasion into the Black Sea, *Mya* had a biomass up to 15-17 $kg{\cdot}m^{-2}$. The total biomass of *Mya* on the north-western shelf up to 30 m depth in 1972 was evaluated as 570,000 t (IVANOV, 1986). Later its biomass became greatly diminished as a result of seasonal hypoxia. However, at a depth less than 7-8 m, where there is practically no hypoxia, the soft-shelled clam remains one of the major components of the zoobenthos on sandy and muddy bottom, its average biomass is 1 $kg.m^{-2}$. In many parts of the Black Sea shelf, this bivalve is a dominant species in a new *Mya arenaria* biocoenosis. In Odessa Gulf, for example, this biocoenosis has covered an area of 25 km^2, out-competing the local small bivalve *Lentidium mediterraneum*. On the Bulgarian shelf the density of *Mya* population reached up to nearly 5,000 specimens per m^2 (MARINOV, 1990). During each heavy gale thousand of tons of *Mya* are washed ashore on beaches. Such natural phenomenon can be frequently observed on the eastern (marine) side of Danube Delta islands in the Danube Delta Biosphere Reserve (Ukraine). Large amounts of washed molluscs on the beach attract their consumers: gulls, terns, crows, and other birds, rats, foxes, raccoon-dogs, wild boars and other mammals. *Mya*'s meat is rapidly devoured by hundreds of terrestrial animals and fractured shells became a part of sandy beach. On a distinct part of Romanian beach of 5 km, as an effect of a heavy storm, were thrown more than 117 millions of *Mya* specimens, weighing almost 1,900 tons (PETRAN & GOMOIU, 1972).



Distribution of *Mya arenaria* in the Black Sea
★ - Area of the first registration

Habitats. Sandy and muddy shallow bottom in the sea and coastal wetlands.

Impact on native species. It is a competitor for habitats with small local bivalve *Lentidium mediterraneum*, which avoids sandy bottoms siltated by *Mya arenaria*. Young specimens of *Mya* are an additional food source for bottom-living fish (gobies, flounder, turbot and sturgeons), gulls and other marine birds. Adult specimens of *Mya* are eaten by another exotic mollusc, *Rapana* (GOMOIU, 1972). Moreover, it became an additional biofilter in the coastal zone, which is quite important in eutrophicated water.

Compiled by Yu. Zaitsev

Perigonimus megas (Kinne, 1956)

Synonyms: *Bougainvillia megas* Kinne, 1956, *Bougainvillia ramosa* Less. (Hummelinck, 1936)

Common names: No

Taxonomy: Class- Hydrozoa
Order- Leptolida
Family- Bougainvillidae

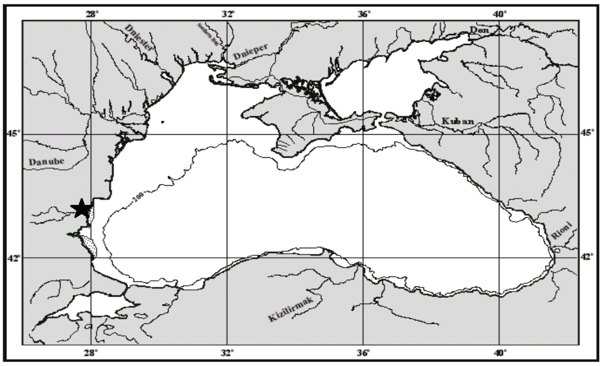
Distinctive characteristics. Polypoid generation form the branchy colonies up to 10-20 cm height. Polyps sit on the branches and have 7-15 tentacles. Free swimming medusae are not generated. Each polyp has up to 25 (more often – 15) medusoid buds on different stages of development. Lower part of the polyp's body sometime covered by psedohydroteca (NAUMOV, 1968).

Perigonimus megas: a fragment of polyp colony.

Probable origin. Coastal waters of the northern Atlantic Ocean.

Possible way of introduction. In hull's fouling.

Distribution. For the first time, it was recorded in the channel between Varna Lake and Varna Gulf in 1933 (PASPALEV, 1933). Later it was found in the Black Sea in the estuary of the Ropotamo River (TSVETKOV & GRENCHAROVA, 1979).



★ - Area of first registration of *Perigonimus megas* in the Black Sea

Habitats. Brackish waters in estuaries and near river mouths. Attached to hard natural and artificial substrates.

Impact on native species. Insufficiently known.

Compiled by B. Alexandrov

Potamopyrgus jenkinsi (Smith, 1889)

Synonym: *P. antipodarum, Hydrobia jenkinsi* Smith,

Common names: No

Taxonomy: Class- Gastropoda
Order- Discopoda
Family- Littoridinidae

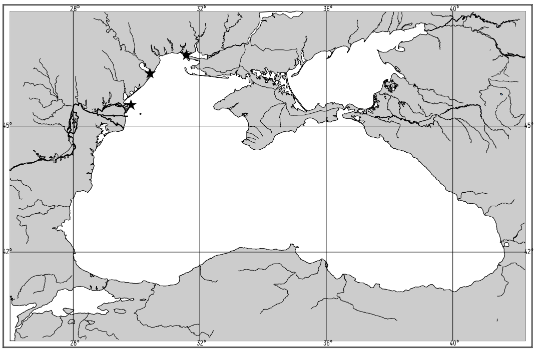
Distinctive characteristics. A small snail similar to *Hydrobia*. It has rather tall spire, with sutures deeply impressed. Nearly smooth, translucent, yellowish brown. To 4.5 mm high, and 2.6 mm widht.

Potamopyrgus jenkinsi

Probable origin. It is native in the New Zealand coastal waters (GOLLASH & LEPPÄKOSKI, 1999). In Europe, it was firstly observed in 1882 (Thames River estuary) and in Swedish waters in 1887, in the Baltic Sea in 1927, in the Mediterranean (Gulf of Marseille) in 1959, and in the Black Sea (Razelm-Sinoe lagoons) in 1952 (GOMOIU & SKOLKA, 1996). In the 1960s it was found in the limans of the Dniestr and Dniepr Rivers and in the Sea of Azov (MORDUKHAY-BOLTOVSKOY, 1972).

Possible way of introduction. Via ship's ballast waters.

Distribution. It is rather common in the freshwater and brackish water areas.



Distribution of *Potamopyrgus jenkinsi* in the Black Sea
★- Areas of the first registration

Habitats. Freshwater and brackish water wetlands, including extremely soft bottom habitats.

Impact on native species. Insufficiently known.

Compiled by Yu. Zaitsev

Rapana thomasiana (Crosse, 1861)

Synonyms: *Rapana tthomasiana thomasiana* Crosse, *Rapana bezoar* L., *Rapana venosa* (Valenciennes)

Common names: Rapana, Rapan (Bul, Geo, Rom, Rus, Ukr), Deniz Salyangozu (Tur)

Taxonomy: Class- Gastropoda
Order- Hamiglossa
Family- Thaididae

Except *Rapana*, only one species (*Stramonita haemastoma*) of this family is noted in the Black Sea and the Sea of Azov.

Distinctive characteristrics. Up to 190 mm long, and 160 mm wide. Black Sea specimens are smaller, 145 mm long and 50 mm wide. Shell solid. Light gray to yellowish outside, salmon-pink to orange inside. Rounded spiral ridges on the surface of the shell. Operculum brown, horny.

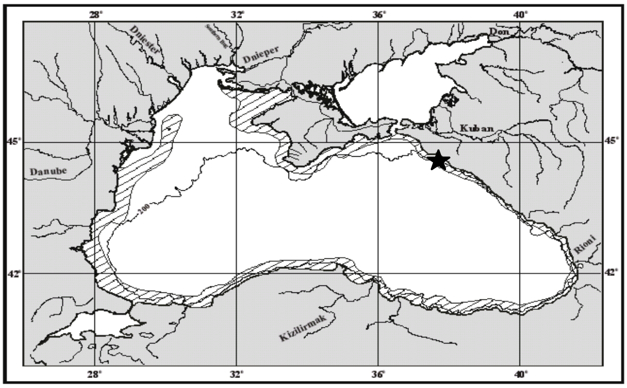
Rapana thomasiana

Probable origin. The Sea of Japan.

Possible way of introduction. Ballast waters and/or egg capsules attached to ships' hulls.

Distribution. First discovered by DRAPKIN (1953) in 1946 in Novorossiysk Bay. Now became widespread. On the north-western Black Sea shelf in the Zmeiny Island (Snake Island) coastal waters (a marine reserve) up to 14-15 individuals of *Rapana* per one m^2 can be observed. It is quite abundant in different areas of the Black Sea shelf. The total biomass of *Rapana* on the Caucasian shelf was estimated as 2,800 tons and on the north-eastern shelf in front of the Kerch Strait as 6,000 tons (GRISHIN & ZOLOTAREV, 1988). According to MARINOV (1990), more than 1500 specimens of *Rapana* can be caught in 15 minutes by a trawl in some areas of the Bulgarian shelf. On the Romanian shelf *Rapana* was recorded till 28 m depth, but more common at 4-10 m and the maximum density is 10-12 $ind{\cdot}m^{-2}$ (GOMOIU, 1972). This species was also investigated on biochemical aspects by GUVEN *et al*. (1991).

Stock assessment and growth studies were conducted by DÜZGÜNEŞ&FEYZİOGLU (1993) and *Rapana* fisheries and ecological impact were studied by BİLECİK (1990), CADDY & GRIFFITS (1990) and ÇELIKKALE *et al*. (1999).



Distribution of *Rapana thomasiana* in the Black Sea

★ - Area of the first registration

Habitats. Mussel and oyster beds till 40 m depth.

Impact on native species. A notorious predator that feeds on oysters, mussels and other bivalves. It exerts a major influence on the indigenous malacofauna. In the 1950s it depleted the Gudauta oyster bank in the Caucasus shelf including prevailing bivalves: oyster *Ostrea edulis*, scallop *Pecten ponticus* and mussel *Mytilus galloprovincialis* (CHUKHCHIN, 1984). Then, it began to feed on the mussels living near the southern shores of Crimea and along the Bulgarian coast. In the 1970s, it penetrated the Sea of Marmara. At first the only factor limiting *Rapana* population growth was the local souvenir industry which uses the shells.

In the prebosphoric area, *Rapana* is eaten by sea stars, but these animals are very rare and occur exceptionally in this area of the sea. Only in the 1980s was it discovered that there is a demand for *Rapana* meat in the Asian market and massive commercial catches of *Rapana* in the Black Sea were started. It is caught in Turkey, Bulgaria and Russia, and exported as frozen meat mainly to Japan and Korea. Along the Turkish Black Sea coast there are 9 temporary and 2 permanent factories prrocessing *Rapana* meat for export. For Turkey only the export of *Rapana* meat in the 1990s was over 1000 t per year. This exploitation severely reduced the influence of *Rapana* on bivalve populations.

Compiled by Yu. Zaitsev & B. Öztürk

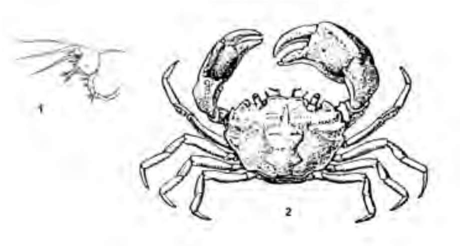
Rhithropanopeus harrisi tridentata (Maitland, 1874)

Synonyms: *Pilumnus tridentatus* Maitland, 1874; *Heteropanope tridentatus* De Man, 1892; *Rhithropanopeus harrisi*, Rathbun, 1930; *Rhithropanopeus harrisi tridentata*, Alida M. Buytendijk and Holthuis, 1949.

Common names: White-fingered mud crab (Eng), Golandsky krab (Ukr), Gollandsky krab (Rus), Crabul-olandez (Rom).

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Xanthidae
This is the only species of the *Rhithropanopeus* genus in the Black Sea.

Distinctive characteristics. Forehead slightly protruded, edge almost straight. Mid ditch triangular. On fore lateral edge 3 teeth. Male's telson squared with rounded corners. Moving legs long and thin. Fingers lighter than palm. Mud-colored on the dorsal side and white on the ventral. To 20 mm. Able for reproduction from 8 mm wide.

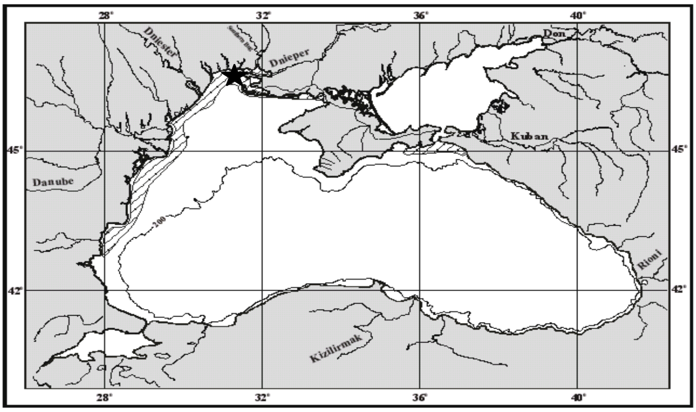


Rhithropanopeus harrisi tridentata: 1 - zoea, 2 – adult

Probable origin. The species is native to the American Atlantic coast from Cape Cod to Brazil. In the Black Sea it was introduced from Zuidersee Bay, North Sea.

Possible way of introduction. Ballast waters and/or ship hull fouling. Living exotic crabs of different species on ships hull fouling in empty shells of large barnacles in the Black Sea were observed.

Distribution. First it was discovered by A. MAKAROV (1939) in the liman (estuary) of the Dnieper and South Bug Rivers. Now it is widely distributed in the low salinity (less than 15‰) Black Sea areas and in coastal wetlands. Its density in some marine shallow water areas and especially in brackish-water limans reached up to 1-3, somethimes 5-10 specimens per one square metre of bottom.



Distribution of *Rhithropanopeus harrisi tridentata* in the Black Sea
★ - Area of the first registration

Habitats. Sandy and muddy bottoms, under stones and debris, on mussel beds, among algae.

Impact on native species. It is an epibenthic invertebrate, predator and scavenger. An additional food source for native bottom fish - gobies (Gobiidae), flounder (*Platichthys flesus luscus*), turbot (*Psetta maeotica*), sturgeons (Acipenseridae). In the Black Sea it is considered a more useful than a harmful settler.

Compiled by Yu. Zaitsev

Teredo navalis (Linne, 1758)

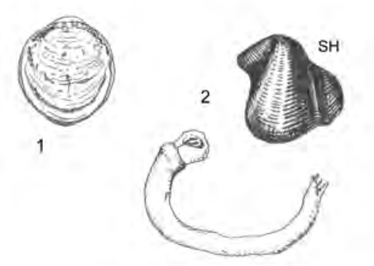
Synonyms: No

Common names: Shipworm (Eng), Korabelny cherv (Rus), Teredo drevotochets (Ukr).

Taxonomy: Class- Bivalvia
Order- Venerida
Family- Teredinidae

Distinctive characteristics. Adults. Allied to the pholads, the shell is reduced to a small but highly efficient wood-cutting tool held against the head of the boring by the foot which is sucker. Total length up to 25 cm. *T. navalis* is androgyne as other Teredinidae (SKARLATO & STAROBOGATOV, 1972).

Larvae. Characterized by their high, steeply slanting, narrow shoulders, narrow, knob-like umbones and short sharply curved bases. Broods of straight-hinge *Teredo* larvae appear at intervals from early June to early September. When released from the adult and larvae are approximately 0.080 x 0.095 mm. Settling larvae are about 0.250 x 0.220 mm. Strait-hinge *Teredo* are speckled black and white but with increasing size. They are yellow-green in color which deepens finally to olive green. The umbones begin to project above the hinge line when the larva is between 0.110 and 0.150 mm, bulging up as the larva grows until at settling they are heavy, prominent knobs. In the more advanced larvae, the posterior margin is distinctly longer and less sharply curved than the anterior margin. The slopes are about equal in length. At all sizes the larvae are characterized by a very bold, black shell outline and well-marked clear space between the visceral mass and the edge of the shell (SULLIVAN, 1948).



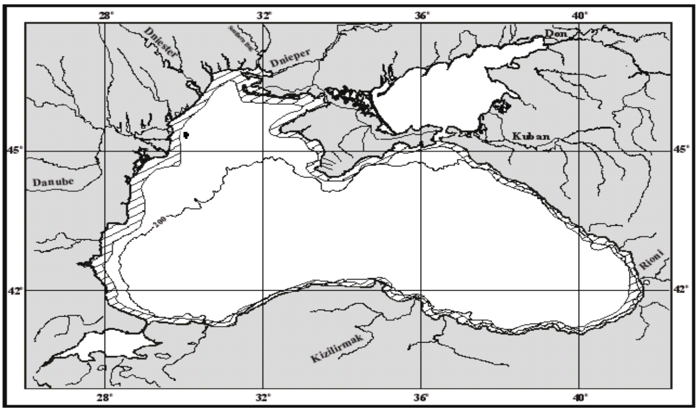
Teredo navalis: 1 – larva, 2 – adult (SH – shell)

Probable origin. Boreal parts of the Atlantic and Pacific Oceans.

Possible way of introduction. According to GOMOIU and SKOLKA (1996), it was introduced into the Black Sea in 750-500 B.C. during the Attic period of Greek conquests.

Distribution. Mass development and distribution of this species was directly linked with use of the wood in shipbuilding and waterworks (berths, bearings of stationary nets etc.). Because of replacement of wood by concrete and metallic underwater constructions, the shipworm became very rare.

Now pelagic larvae of *Teredo* are found from June till December as single specimens in the northwestern part of the Black Sea (ALEXANDROV, 1988). Maximal density of *Teredo* larvae (4000 individuals on 100 cm^3) was registered in Gelenzhik Bay in summer 1957 (RYABCHIKOV & NIKOLAEVA, 1963).



Distribution of *Teredo navalis* in the Black Sea

Habitats. The shipworms bore into wood. Some part of the energy used in boring comes from wood fragments which pass through the gut where cellulose is digested. Thus, they use wood not only as a habitat, but as food. *Teredo* is the filter-feeding organism and another essential component of its ration are pelagic organisms which enter the shipworms through the siphon. *T. navalis* is a relatively thermophilic and halophilous species. It survives in salinity more than 11‰. Larvae are more sensible than adults (RYABCHIKOV *et al*., 1963). Larvae (veliger, veliconcha) are typical pelagic organisms. They are distributed firstly in upper 10 m water of the coastal zone. A minimum settlement of larvae was observed at temperatures not less than 20-21^{o}C. Mass settlement occurred at a temperature ranging from 24 to 27^{o}C (RYABCHIKOV & NIKOLAEVA, 1963).

Impact on native species. Because of its small number, the impact can not be significant at present, but special investigations are needed. It is found as a wood boring organism in the Turkish waters of the Black Sea (BOBAT, 1995).

Compiled by B. Alexandrov

Urnatella gracilis (Leidy, 1851)

Synonym: *Urnatella dniestriensis* Zambriborsch

Common names: No

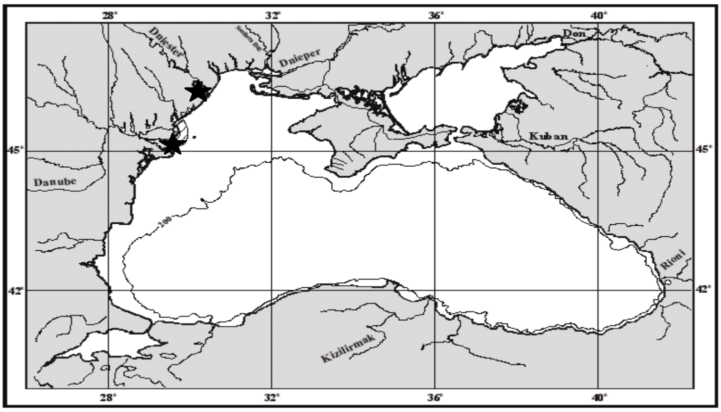
Taxonomy: Class- Entoprocta
Family - Urnatellidae

Distinctive characteristics. Minute, sessile, colonial moss-like organisms. Each animal consists of a compact mass at the end of a slender stalk 2-4 mm long; the former contains the viscera and has a circlet of 10-16 tentacles for feeding; digestive tract U-shaped. Only known fresh-water species of Entoprocta, all other Urnatellidae species are marine inhabitants.

Urnatella gracilis

Probable origin. Till 1938 it was known only for fresh waters of North America. Later it was discovered in Belgium fresh waters, and in 1954-1962- in the lower Danube, Dniestr and Don Rivers.

Possible way of introduction. Ballast waters and/or attached to ship's hull.



Distribution of *Urnatella gracilis* in the Black Sea

★ - Area of the first registration

Distribution. It is a rather rare species in fresh and brackish waters (salinity less than 5‰) of the Black Sea coastal wetlands.

Habitats. Rivers, deltas, limans, and brackish marine areas.

Impact on native species. Insufficiently known.

Compiled by Yu. Zaitsev

Fishes

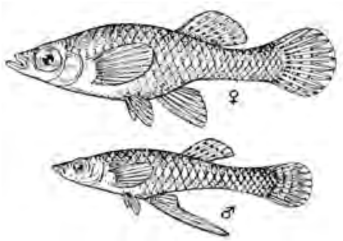
Gambusia affinis holbrooki (Girard, 1859)

Synonyms: *Gambusia holbrooki* Girard, *Heterandria holbrooki* Agassiz.

Common names: Mosquitofish (Eng), Gambuzya (Rus), Hambuzya (Ukr). Gambuzie (Rom), Sivrisinek Baligi (Tur).

Taxonomy: Class- Osteichthyes
Order- Cyprinodontiformes
Family- Poeciliidae

Distinctive characteristics. Small bony fish to 70 mm long (female), and 40 mm long (male). Rather robust, particularly females; compressed. Tan to olive above, pale yellowish below; scales have small, dusky spots near edges; dark bar below eye; many spots present on dorsal and caudal fins. Head depressed; mouth small, oblique, lower jaw projects beyond upper. One dorsal fin with 6-9, usually 8 (male) and 10-11 (female) soft-rayed spines. Anal fin is slender and elongated in males playing as a copulate organ. Lateral line from 28-32 scales. Small black spots on dorsal and caudal fins.

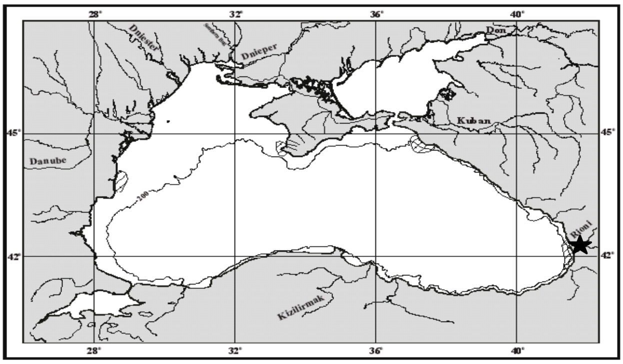


Gambusia affinis holbrooki

Origin. In 1925 the fish was brought from Italy and introduced to the Kolkhida wetlands (Caucasian coast of the Black Sea) to control mosquitoes. This species is originated from the southeastern North American wetlands. At the same time it was introduced into some wetlands in Turkey.

Way of introduction. In aquaria transported by ships.

Distribution. Some coastal wetlands and brackish areas of the Black Sea.



Distribution of *Gambusia affinis holbrooki* in the Black Sea
★ - Area of the first release

Habitats. An euryhaline species, living near surface in fresh and brackish water wetlands, and marine coastal waters at salinities of up to 15-17‰. It is rather common in some Black Sea coastal wetlands.

Impact on native species. In some low-salinity wetlands, *Gambusia* begins to compete for food with the fry of carp and other cyprinid fish.

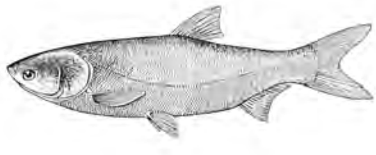
Compiled by Yu. Zaitsev & B. Öztürk

Hypophthalmichthys molytrix (Valenciennes, 1844)

Common names: Silver carp (Eng), Tolstolobyk (Rus), Tovstolobyk (Ukr).

Taxonomy: Class- Osteichthyes
Order- Cypriniformes
Family- Cyprinidae

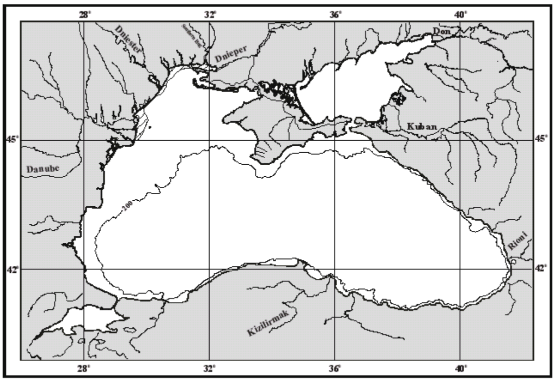
Distinctive characteristics. A large freshwater fish with pharingeal teeth and well developed gill rakers, which are interconncted to form a net to filter planktons. Abdomen conk blue-greenish above and silvery on sides and below. A plankton eating fish. To 1 m in length and 15 kg in weight.



Hypophthalmichthys molytrix

Origin. The lower Amur River and other Far-East rivers. In the early 1950s young fish from the Amur River area vere transported by plane and released in some ponds and limans of Ukraine. Now the silver carp is an important commercial fish in fresh waters. It can be observed in the sea not far from the river mouths.

Distribution. Low salinity areas of the Black Sea and its coastal wetlands. An important commercial fish.



Distribution of *Hypophthalmichthys molytrix* in the Black Sea

Habitats. A pelagic fish in fresh water ponds, lakes, limans and rivers. Adult fish can be observed in brakish limans and in the Black Sea. In Odessa Gulf large specimens of silver carp (0.4-0.8 m long) are sometimes caught in spring, when the water salinity is low (5-10‰).

Impact on native species. Insufficiently known. Some parasites of *H. molytrix* (9 species) are Far-East origin.

Compiled by Yu. Zaitsev

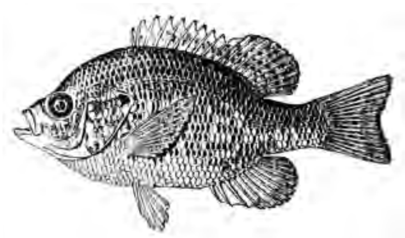
Lepomis gibbosus (Linne, 1758)

Synonyms: *Perca gibbosa* Linne, *Eupomotis gibbosus* Jordan & Evermann.

Common names: Sunfish, Pumpkinseed (Eng), Biban-soare (Rom), Solnechnaya ryba, Tsarek (Rus), Sonyachnyi okun’ (Ukr).

Taxonomy: Class- Osteichthyes
Order- Perciformes
Family- Centrarchidae

Distinctive characteristics. A percomorph fish, spiny and soft-rayed portions united into a single dorsal fin. Body deep, short, compressed: Brightly colored, dark greenish gold mottled with reddish orange, dorsally greenish yellow, mottled orange and blue-green laterally, yellow-orange ventrally. Head small; mouth extends to eye; opercular flap "ear" stiff, with spot, black anteriorly, bordered by white above and below, red posteriorly; cheeks with wavy bluish lines. Pectoral fin long, pointed; soft dorsal fin, edge yellowish to white; 3 anal fin spines. To 25, usually 12-15 cm.

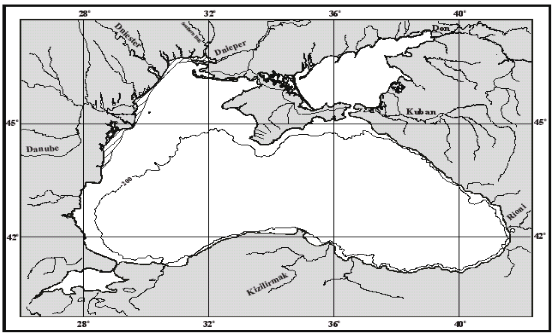


Lepomis gibbosus

Origin. In the 1920s aquarists brought *L. gibbosus* from the North American fresh waters to Europe. It soon began to appear in natural waters. By the 1930s it had already reached the Danube Delta.

Way of introduction. In aquaria.

Distribution. A numerous fish in the Danube and Dnieper River deltas, coastal wetlands, seldom in low salinity marine coastal waters.



Distribution of *Lepomis gibbosus* in the Black Sea

Habitats. Cool, quiet, shallow waters of slow streams, ponds, marshes, and lakes with dense vegetation. A rather euryhaline species, living in freshwater and brackish wetlands, and marine coastal waters at salinities of up to 14-15‰. A specimen 12 cm long was caught in Odessa Gulf of the Black Sea at 50 km from the Dnieper and South Bug River liman in marine water of salinity 16‰.

Impact on native species. A notorious predator, feeding on eggs and fry of local fish, especially of carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*).

Compiled by Yu. Zaitsev

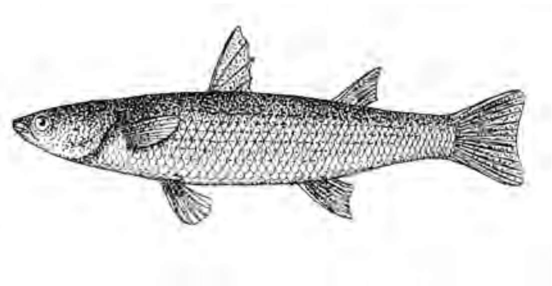
Mugil soiuy (Basilewski, 1855)

Synonyms: No

Common names: Haarder (Eng), Pelingas, Pilengas (Rus), Pilengas (Ukr), Rus kefali (Tur)

Taxonomy: Class- Osteichthyes
Order- Mugiliformes
Family- Mugilidae

Distinctive characteristics. Resembles the striped mullet *Mugil cephalus*, but adipose eyelid is not developed in either juveniles or adults. Body greyish above and silvery on sides and below. To 70 cm long and 10 kg in weight. Like the striped mullet, the haarder jumps, occasionally clearing the sea surface by as much as a meter. Unlike to the stenothermic warm-water *M. cephalus*, the haarder is tolerant of a wide range of ambient temperatures (eurythermic) and is the only grey mullet of the Black Sea wintering along the northern coast. Its pelagic eggs 0.8-0.9 mm in diameter, have large oil droplets, which constitute up to 23% of the eggs' volume. This is the reason of high floatability of haarder's eggs, which can develop in low salinity and dense marine waters and in some coastal wetlands.

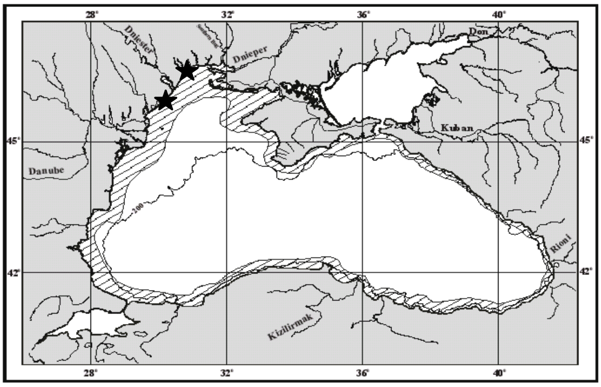


Mugil soiuy

Origin. Estuaries of the northern part of the Sea of Japan.

Way of introduction. About 50 000 fry of the haarder from the Amur River mouth area were transported airway by Ukrainian and Russian ichthyologists in 1972-1982 and released in some limans in the northwestern Black Sea and the Molochny Liman of the Sea of Azov. First breeding of naturalized fish in the Black Sea was noted in 1982. Commercial catches since 1988 (ZAITSEV & STARUSHENKO, 1997).

Distribution. Coastal waters of the Black and Azov Seas, the Sea of Marmara, Mediterranean Sea. An important commercial species, its annual catches in the Black Sea exceeds 10,000 tons.



Distribution of *Mugil soiuy* in the Black Sea

★ - Areas of the first release

Habitats. Shelf waters of the Black Sea and coastal wetlands. The species is tolerant of a wide range of salinity (euryhaline), living in from freshwater to 35‰ in some limans.

Impact on native species. Insufficiently known. The fry of the haarder are feeding on zooplankton and therefore can compete with local plankton-eating fish. Some specific parasites (Trematoda, Monogenea), associated with the haarder were introduced in the Black Sea and were found in the body of local grey mullets. The consequences of this need to be investigated.

Compiled by Yu. Zaitsev & B. Öztürk

Additional Information to Chapter 3

Some non-native species, obviously introduced in the Black Sea by human activities, were not included in the above-mentioned lists of exotics because of their short-term stay in the area, or belonging more to freshwater and terrestrial habitats than to marine ones, or because of information gaps.

Those are following plants and animals.

Diatom *Asterionella japonica* Cleve et Möller (Pennatophyceae, Araphinales, Fragilariaceae). Originated from the Atlantic and Pacific Oceans. First found in the Black Sea (Sebastopol area) in 1968 (SENICHEVA, 1971).

Diatom *Talassiosira nordenskjoldi* Cleve (Centrophyceae, Discinales, Thalassiosiraceae). Originated from the Northern Atlantic. First discovered in the Black Sea in 1986 (SHADRIN, 2000).

The aquatic ferns *Azolla caroliniana* and *Azolla filiculoides* (Polypodiopsida, Salviniales, Azollaceae), originated from tropical (possibly from South-East Asia) rivers, lakes and ponds. Probably accidentally introduced in ballast waters. Now these plants are mass species in the Danube Delta (ZAITSEV & PROKOPENKO, 1989). Sometimes they are carried out by river to the sea, but are unable to survive in marine water and washed ashore by waves.In many areas, *Azolla* species are used in rice culture, as a source of nitrogen.

Three planktonic Copepoda species *Euchaeta marina*, *Rhyncalanus nasutus* and *Pleuromamma gracilis* and one Ostracoda species, *Philomedes globosa* were discovered in the north-eastern Black Sea coastal waters (pers. commu. E. MUSAYEVA to S. VOLOVIK. These species are very common in the Mediterranean Sea (TREGOUBOFF & ROSE, 1957) and it is not clear if they have been penetrated into the Black Sea with the bottom water current of the Bosphorus Strait (if so, why so late?), or introduced by ships.

Black-eyed Hydromedusa *Tiaropsis multicirrata* (Hydrozoa, Leptolida, Mitrocomidae). Originated from the northern Atlantic Ocean. Epibiontic cold-water hydrozoan, found on mussels and algae in the late 1990s (GRISHICHEVA & SHADRIN, 1999).

Stick hydroids *Eudendrium annulatum* and *Eudendrium capillare* (Hydrozoa, Leptolida, Eudendriidae). Originated from the northern Atlantic Ocean. First found in the late 1990s in the Sebastopol area (GRISHICHEVA & SHADRIN, 1999).

Bristle worm *Ancistrosyllis tentaculata* Treadwell, 1941. (Polychaeta, Nereimorpha, Pilargiidae). Originated from the Atlantic Ocean (and the Red Sea?) and is lacking in the Mediterranean Sea (PERES & PICARD, 1964). *A. tentaculata* was first discovered in the Black Sea by KISELEVA (1964).

Bristle worm *Streblospio shrubsolii* (Buchanan, 1890). (Polychaeta, Spiomorpha, Cirratulidae). Originated from the northern Atlantic Ocean, found in the North and Baltic Seas. First described in the Black Sea by MARINOV (1957). As to possible way of introduction into the Black Sea, *S. shrubsolii* is a cryptogenic (CARLTON, 1996) origin species.

Bristle worm *Strebtocyllis varians* Webster et Benedict, 1884. (Polychaeta, Nereimorpha, Syllidae). Originated from the northern Atlantic Ocean, lacking in the Mediterranean Sea. In the Black Sea *S. varians* was first described by MARINOV (1966). A cryptogenic species.

Red-lined worm *Nephthis ciliata* (Müller, 1776). (Polychaeta, Nereimorpha, Nephthydidae). Distributed in northern Atlantic, North Sea, Engish Channel, Pacific Ocean, but lacking in the Mediterranean Sea (PERES & PICARD, 1964). *N. ciliata* was found in the Prebosphoric area of the Black Sea (MORDUKHAY-BOLTOVSKOY, 1972).

Bristle worm *Capitellethus dispar* (Ehlers, 1908). (Polychaeta, Drilomorpha, Capitellidae). Originated from the Indian Ocean and Yellow Sea, but lacking in the Mediterranean Sea (PERES & PICARD, 1964). In the Black Sea it was found in the Prebosphoric area (MORDUKHAY-BOLTOVSKOY, 1972).

The crab *Sirpus zariquieyi* Gordon, 1953. (Crustacea, Decapoda). A single specimen was found in the eastern Turkish Black Sea coast, not far from Rize.

In May 1961 more than 4 000 specimens of grass shrimps *Pandalus kessleri* (*P. latirostris*) from Possyet Bay in the Sea of Japan were released in the Khadzhibeysky liman near Odessa for maricultural purposes (SALSKY, 1964). The attempt was not successful.

For maricultural purposes, in the Black Sea and its coastal wetlands, in the 1960s-1970s, were released following invertebrates and fish: shrimp *Marsupenaeus japonicus* and fish species *Lateolabrax japonicus* (Serranidae), *Onkorhynchus gorbusha* (Salmonidae), *Plecoglossus altivelis* (Plecoglossidae) and some others. All these attempts were unsuccessful.

The Stone moroco *Pseudorasbora parva* (Schleg), a small cyprinid fish originated from Far East rivers and estuaries was deliberately released in the lower Dniester River and its liman (DEDIU, 1989) jointly with target species *Hypophthalmichthys molitrix* and *Mylopharyngodon piceus* from the same area.

A single specimen of the blue whiting, *Micromesistius poutassou* (Risso, 1826) was discovered on 19 January 1999 at 60 m depth nearly the southern coast of Crimea (BOLTACHEV et al., 1999). It was a young fish 17.5 cm long, weighing 26.8 g. It is a North Atlantic origin species and its first appearance in the Black Sea, according to authors' opinion, can be a result of a long migration. On the other hand, this fish, in form of larvae or young, can be transported in ballast waters. Thus, the way of penetration of blue whiting in the Black Sea is not yet clear.

Some mammals, both marine, fresh-water and semi-aquatic terrestrial species, can be also considered as exotic species, introduced in the Black Sea region by human activities. There are following animals.

The muskrat, *Ondathra zibethica* L. (Mammalia, Rodentia, Cricetidae), originated from North America, was introduced in the USSR in the 1930s, as a fur-bearing animal. It lives in marine coastal wetlands and it feeds chiefly on aquatic vegetation, but may eat mussels, and a little other aquatic invertebrates and young fish. It is a mass inhabitant of the Danube, Dniester and Dnieper river deltas.

The raccoon-dog, *Nyctereutes procyonoides* Gray (Mammalia, Carnivora, Canidae), originated from Eastern Asia, was introduced in the Black Sea wetlands in the 1930s, as a fur-bearing animal. It is omnivorous. May eat fish, crayfish, molluscs. In the Danube Delta, it eats also soft-shelled clams *Mya arenaria*, which are washed ashore in large numbers on windward sandy beaches (ZAITSEV & PROKOPENKO, 1989).

The white whale, *Delphinopterus leucas* (Pallas). (Mammalia, Cetacea, Delphinidae), was captured in the Sea of Okhotsk. Accidentally it was released from the Sebastopol marine aquarium (Crimea, Ukraine) in September 1991 (BIRKUN & KRIVOKHIZHIN, 1996). For several months, it was observed near Sinop (Turkey), but in April 1992 it was again caught and returned to Crimea. In November 1992, the same animal, during a storm, escaped again from the Crimean aquarium. It spents the winter 1992/1993 in the Dnieper-Bug liman (estuary) and it was observed many times by fishermen breaking the ice and hunting on fish in the areas of their wintering concentrations. In summer season 1993 this white whale migrated to the southern Black Sea coast (Turkey), where enjoyed a wide popularity and was named Aydin (light, clear). It was protected by the local authorities and general public. Aydin spents the winter 1994/1995 along the Bulgarian coasts and was nourished by people from an oil derrick. Further fate of this freedom-loving and friendly animal is unknown (BIRKUN & KRIVOKHIZHIN, 1996).

The northern fur seal, *Callorhinus ursinus* L. (Mammalia, Pinnipedia, Otariidae), was captured in the Komandorsky Islands area (Bering Sea). Accidentally released from one of the Black Sea public aquaria, it was observed along the Turkish coasts and in the Ukrainian waters of the southern Sea of Azov (BIRKUN & KRIVOKHIZHIN, 1996).

The Steller sea lion, *Eumetopias jubatus* (Schreber). (Mammalia, Pinnipedia, Otariidae), is originated from the Sea of Okhotsk, Bering Sea and adjacent waters of the North Pacific Ocean. Accidentally released from one of the Black Sea aquaria, two (?) specimens were observed on the Sebastopol and Sochi beaches (BIRKUN & KRIVOKHIZHIN, 1996).

All these freedoms after escapes from captivity were short-term ones and come to its end by a new captivity or by a lethal method: Except the dolphins, the Black Sea is not hospitable for large fish-eating marine mammals.

Chapter 4. The Sea of Azov

Physical Geography, Biology, Ecology

Geographical position

The Sea of Azov is an inland brackish body of water, bordering Ukraine to the south, west and north and the Russian Federation to the south, east and north. Its geographic co-ordinates are N 45° 16'- 47° 17'; E 33° 36'–39° 21' (BOGUSLAVSKY *et al.*, 1989). This is the smallest and the most shallow sea in the world, connected with the Black Sea by the Kerch Strait.

Geological evolution

In its geological past, the Sea of Azov was connected with the Caspian Sea (Sarmatic, Maeotic, Pontian basins) and the Black Sea . But sometimes it was not only isolated from the Black Sea but even drained. For example, during the post-Karangat regression of the Black Sea by 70-80 m in the late Pleistocene, resulted in the complete draining of the area covered by the Sea of Azov and the redeepening of the river valleys, such as that of the palaeo-Don River and its tributaries. During this period the bottom of the sea became dry land covered with steppe vegetation and with sparse forests along wide deep river valleys (BRONFMAN, 1995; PANOV & KHRUSTALEV, 1966). The delta of the palaeo-Don was in that period probably south of the Kerch Strait.

During the Post-Glacial age, because of a rise in the levels of the world ocean and the Black Sea, a kind of liman was probably formed in the area of the Kerch Strait and the southern part of the Sea of Azov. The beginning of active inflow of the Black Sea water into the Sea of Azov took place about 5,000-6,000 years ago, after the last connection of the Black Sea with the Mediterranean (BRONFMAN, 1995, ZAITSEV & MAMAEV, 1997). At the start of the first millenium A.D., climatic conditions, including atmospheric precipitation, river runoff and hydrological conditions of the sea, were similar to those at present (BRONFMAN, 1995). The Roman name of the sea in the first centuries was Palus Maeotis (Maeotic marsh), is emphasizing the shallowness and low salinity of this body of water.

Morphometry and climate

The total area of the Sea of Azov is 37,860 km^2, of which the least saline part, Taganrog Bay is 5,600 km^2, and the most saline part, the Sivash Lagoon is 2,600 km^2 (BRONFMAN, 1995). The mean depth, according to different authors varies from 6.9 to 7.4 m, the maximum depth, 14 or 15 m (BRONFMAN, 1995; BOGUSLAVSKY *et al.*, 1989). About 40% of the total area has a depth less than 8 m. The volume of the sea is about 320 km3 (ZENKEVICH, 1963).

The shore line of the Sea of Azov is about 2,500 km, of which the Ukrainian part is 1207 km and the Russian part about 1,300 km (SHUYSKY, 1989). The north-western coast has a peculiar characteristic a range of five bars formed by prevailing currents. These bars are oriented from northeast to southwest, and are composed of shells and sand. Their lenght is increasing toward the west up to 50 km.

The main gulfs and bays of the sea are Taganrog Bay in the northeast, Obitochny, Berdiansky, Belosarayski gulfs in the north, Temryuksky and Arabatsky Gulfs in the south. The main cape is Kazantip in the south. The Sivash Lagoon in the west is isolated from the sea by a long (about 100 km) and low bar from sand and shells.

Two large rivers, the Don and Kuban, drain into the Sea of Azov, together with about 200 small ones, most of which enter in the north (BRONFMAN, 1995). The Don forms a delta of 540 km^2 with well- developed channel network. The Kuban River Delta is 5,400 km^2 and has many shallow water limans near the sea shore. Radical changes in the river runoff began in 1953 after the construction of the Tsimlyanskoe reservoir and the Volga-Don shipping channel. The present average runoff of the Don is 27.9 km^3, and that of Kuban 11,1 km^3 yearly (BRONFMAN, 1995).

The Sea of Azov has a continental climate. It lies in temperate latitudes where short, fairly mild winters and warm, long summers prevail. Mean annual water temperature of the sea at the surface is 11.5^o C (BRONFMAN, 1995).

Main characteristics of the ecosystem of the Sea of Azov

Abiotic factors

The summer water temperature in the coastal zone can reach 30-31^{o}C. In the open sea it reaches 24-25^o C. In winter season it falls to 0^o and in some cases to –1.0^o C. (ZENKEVICH, 1963). Ice formation usually begins in Taganrog Bay, and it covers most of the sea except for the south areas, which are under influence of more warm Black Sea waters. The ice lasts, on average three days, but it can last for 55-75 days in some rigorous winters. The thickness observed was 70-80 cm near the coast and 35 cm offshore. The ice packs may reach height of 2 m above the sea bed on the coastal sand banks (BRONFMAN, 1995).

The average water transparency (Secci disk readings) in the Sea of Azov is 2-2.5 m, maximum in the southern part can reach to 10 m. During phytoplankton blooms, the water transparency decreased to 0 m (VOLOVIK, 2000).

The mean salinity from 1923 to 1951, that is before the considerable changes in the river runoff, was 10.4‰, varying from 9.1‰ (1932) to 11.8‰ (1939, 1951), (BRONFMAN, 1995). In 1976 the salinity in central and southern parts of the sea reached 14-15‰. The salinity of the large hyperhaline Sivash Lagoon is about 40‰ in the northern part and 150-200‰ on the south.

Dissolved oxygen is a special factor in the Sea of Azov. Due to intensive development of phytoplankton it can exceed 100% of saturation in the surface layer of water. But after the sedimentation of dead microalgae on the bottom, a sharp decline in oxygen in bottom layers occurs. The intensive consumption of oxygen in benthic zone causes rapid decreases in the concentration of oxygen near the bottom and the appearance of hypoxic and anoxic zones. The occurence of summer hypoxia and mass mortality of bottom invertebrates and fish was always a feature of the highly productyive Sea of Azov (KNIPOVICH, 1932; FEDOSOV, 1955;

ZENKEVICH, 1963). In this respect, the Sea of Azov was an unique marine body of water. Recently there is an unprecedent increase of hypoxic areas. According to A. BRONFMAN (1995), from 1960 to 1986 the benthic area over which the oxygen was below 60% of saturation in summer became 10,000 km^2, and in some years it reached 20,000-27,000 km^2, or even 34,000 km^2 that is 70-90% of the total area of the sea. According to BRONFMAN & KHLEBNIKOV (1985), the reasons of the recent increasing of hypoxia in bottom are under three factors: a) formation of a sharp pycnocline in the sea, because of the reduction of the river runoff; b) increasing in concentration of organic substances in the water; and c) a long-term diminishing of wind activity and increase of water temperature. According ZAITSEV (1998), the main factor is the increasing man-made eutrophication, a global environmental process, the consequences of which are especially pronounced in meromictic water bodies, such as the Sea of Azov.

The mean annual influxes of the main nutrients, nitrogen and phosphorus into the Sea of Azov are 88,500 and 7,000 tons respectively. This is mostly riverine input. The major source of nutrients loss is the bottom current in the Kerch Strait, directed from the Sea of Azov in to the Black Sea.

Biotic factors

The biota of the Sea of Azov is composed of following elements.

Pontian or Caspian relics are originated from the brackish Sarmathian and Pontian basins of the Tertiary period. These species are inhabiting now mainly the low salinity areas of the sea, especially Taganrog Bay and some limans. Among Pontian relics in the Sea of Azov, there are the Hydrozoan *Cordylophora caspia*, Polychaete *Hypaniola kowalewskyi*, Bivalves *Hypanis colorata*, *Theodoxus pallasi*, and *Dreissensia polymorpha.* The last species is the notorious recent settler in the Great Lakes of North America, named zebra mussel. To Pontian relics belong many crustaceans, for example, *Pterocuma pectinata* (Cumacea), *Mesomysis kowalewskyi* (Mysidacea), *Dikerogammarus villosus, Chaetogammarus ischnus, Pontogammarus maeoticus* and other amphipods.

Arctic origin species are not common the Sea of Azov, because of its shallowness and high summer temperature of water. In spring and autumn, the arctic origin fish, sprat, *Sprattus sprattus phalericus* and whiting, *Merlangius merlangus euxinus* can be observed.

The main part of the biota of the Sea of Azov is composed by Mediterranean origin species. Among them there are representatives of different taxons: *Aurelia aurita*, *Rhizostoma pulmo* (Scyphozoa), *Harmothoe reticulata, Nereis diversicolor, Nephthis hombergii* (Polychaeta), *Bowerbankia imbricata* (Bryozoa), *Labidocera brunescens, Acartia clausi, Oithona minuta* (Copepoda), *Gastrosaccus sanctus* (Mysidacea), *Idothea baltica basteri, Synisoma capito* (Isopoda), *Nototropis guttatus, Melita palmata, Orchestia gammarella* (Amphipoda), *Palaemon elegans, P. adspersus, Crangon crangon, Upogebia pussilla*, *Brachynotus sexdentatus* (Decapoda). Mediterranean origin species are distributed in the central and southern parts of the sea.

Various fresh water origin plants, invertebrates and fish are rather common in low salinity areas of the Sea of Azov. Huge amounts of halophylous flagellate *Dunaliella salina*, insect *Chironomus salinarius* (Diptera), and brine shrimp *Artemia salina* (Crustacea) populate the ultrahaline Sivash Lagoon.

The ichthyofauna of the Sea of Azov belongs to the same groups of organisms. Among Pontian relics there are sturgeons, Acipenseridae (e.g. *Acipenser güldenstädti*, *A. stellatus, Huso huso*), Clupeidae (e.g. *Clupeonella delicatula*), Gobiidae (e,g. *Neogobius melanostomus, N. fluviatilis, N. ratan*). Arctic origin fish species are the spiny dogfish, *Squalus acanthias*, sprat, *Sprattus sprattus phalericus*, whiting, *Merlangius merlangus euxinus*, and flounder *Platichthys flesus luscus*, but all of them in small numbers. Mediterranean origin fish are the Azov Sea subspecies of anchovy, *Engraulis encrasicholus maeoticus*, garfish, *Belone belone euxini*, silverside, *Atherina mochon pontica*, gray mullets (Mugillidae), red mullet *Mullus barbatus ponticus*. The most common freshwater fish in the sea are the richer *Vimba vimba*, bream, *Abramis brama*, sabrefish *Pelecus cultratus* and *Rutilus rutilus heckeli*. The total number of fish species in the Sea of Azov is 115 (VOLOVIK *et al*., 1993).

The phytoplankton of the Sea of Azov is composed merely by Dinoflagellata (*Peridinium cordatum, Prorocentrum micans*), Cyanophyta (*Microcystis aeruginosa*, *Aphanizomenon flos aquae*, *Anabaena knipowitschi*), and Bacillariophyta (*Skeletonema costatum, Thalassiosira nana, Leptocylindrus danicus*), and Xanthopyta (ZENKEVICH, 1963). The total number of phytoplankton species and subspecies in the 1920s reached up to 413. But in the 1980s, species diversity was sharply reduced and over 70 species found earlier were absent (VOLOVIK *et al*., 1993). The biomass of phytoplankton in summer season is about 1-10 $g.m^{-3}$, but in exceptional cases it reached up 250-380 $g.m^{-3}$, from PROSHKINA-LAVRENKO&MAKAROVA, 1968). In the late 1980-early1990s, because of the reduction of the river runoff, increased salinity and pollution, there was a clear tendency to decline in phytoplankton biomass as low as 0.4-1.0 $g.m^{-3}$ (BRONFMAN, 1995).

The zooplankton of the Sea of Azov is composed of about 1170 species of Metazoa invertebrates. The most numerous are Rotatoria (*Brachionus quadridentatus, B. plicatilis, Synchaeta baltica*), Cladocera (*Evadne trigona, Cercopagis pengoi*), Copepoda (*Heterocope caspia*, *Acartia clausi*, *Oithona nana, Calanipeda aquae-dulcis*), and Mysidacea (*Macropsis slabberi, Mesomysis helleri*). Average biomass of zooplankton is 200-600 $mg.m^{-3}$, but it reached up to 1.5-2.0 $g.m^{-3}$ (ZENKEVICH, 1963).

The macrophytobenthos (bottom macroalgae) are reptesented by about 60 species of algae and higher plants (KALUGINA-GUTNIK, 1975). There are green algae (*Enteromorpha clathrata, E. linza, E. intestinalis, Cladophora siwashensis*), red (*Ceramium diaphanum, Polysiphonia opaca, P. denudata*), and brown (*Ectocarpus confervoides*, *Stilophora rhizoides*) algae (ZINOVA, 1967). There are also high plants- *Zostera marina, Z. noltii, Zannichellia pedunculata, Potamogeton pectinatus*. The sea grass *Zostera* is forming about 35% of the total bottom plants biomass in the Sea of Azov (ZENKEVICH, 1963).

The macrozoobenthos of the Sea of Azov is composed of about 200 species of invertebrates. The most diverse in species are Polychaeta (*Nereis diversicolor, N. succinea, Nephthys hombergi*), Gastropoda (*Hydrobia acuta, Theodoxus pallasi, Bittium reticulatum, Tritia reticulata*), Bivalvia (*Mytilus galloprovincialis, Mytilaster lineatus, Cerastoderma lamarki lamarki, Hypanis colorata*), Amphipoda (*Pontogammarus maeoticus, Ampelisca diadema, Melita palmata*). According to ZENKEVICH (1963), the leading species after which the main benthic communities of the Sea of Azov are named leading species, are: *Dreissena-Hypanis, Nereis diversicolor-Ostracoda, Pontogammarus maeoticus,* and *Cerastoderma lamarki lamarki*. The biomass of the macrozoobenthos varies between 1 and 1,000 $g.m^{-2}$, and the main part of this biomass is composed of the food of bottom-living fish.

Till the late 1980s, the Sea of Azov was a very productive body of water. The annual fish catch varied from 100,000 to 316,000 t, and was composed of diadromous, semidiadromous, freshwater and marine species (BRONFMAN, 1995). The most important commercial species, in terms of biomass, were the small pelagics kilka, *Clupeonella delicatula* (a Pontian relics) and the local subspecies of anchovy, *Engraulis encrasicholus maeoticus*, a Mediterranean origin fish.

The future of the Sea of Azov

The future of the Sea of Azov, as a recipient of exotic species, depends on changes in the marine ecosystem, and on the other hand, on preventive actions. Progressive increasing of salinity, as a result of irretrievable consumption of the river water, increasing of eutrophication and further development of shipping will lead to the intensification of the inflow of exotic species.

Exotic species

Plants

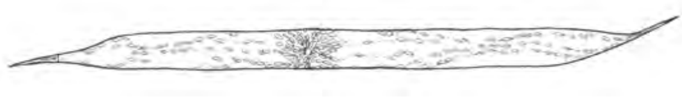
Rhizosolenia calcar-avis (M. Schultze, 1858)

Synonyms: No

Common names: rhizosolenia ptichia shpora (Rus), rhizosolenia ptashina shpora (Ukr)

Taxonomy: Class- Centrophyceae
Order -Bacillariophyta
Family- Soleniaceae

Distinctive characteristics. (See Chapter 3)

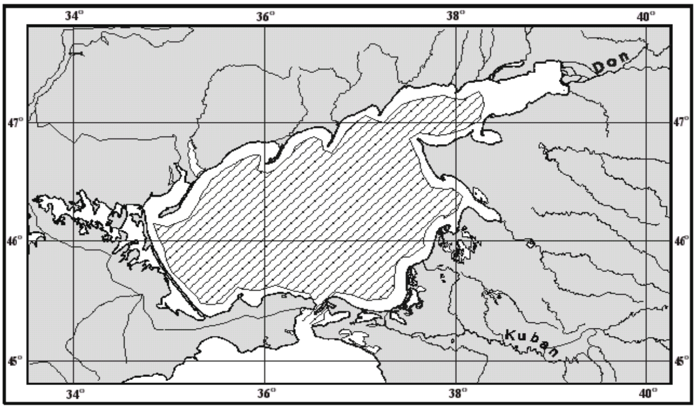


Rhizosolenia calcar avis

Probable origin. A neritic, thermophilic species from subtropics and temperate zones of the Atlantic and Pacific Oceans (PROSHKINA-LAVRENKO, 1955).

Possible way of introduction. Via ships and/or with flow of water from the Black Sea.

Distribution. For the first time *Rhizosolenia calcar avis* was described in the Sea of Azov in 1924 (USACHEV, 1928). According to MOROZOVA-VODIANITSKAYA (1948) this species penetrated to the Black Sea and the Sea of Azov during 1908-1928. Discovery of *Rhizossolenia* in the Sarmatic sediments of the Sea of Azov testifies to the repeated introduction of this species into the Black Sea basin (PROSHKINA-LAVRENKO, 1963). In the Sea of Azov it was registered in huge amounts only in 1924-1926 and in the 1950s, when its density reached up to 2.4-4.5 millions cells per liter. Now it is a mass, but not a dominant species in the brackish coastal waters (PROSHKINA-LAVRENKO, 1955; 1963; PROSHKINA-LAVRENKO & MAKAROVA, 1968). It is a mass species of summer in the Sea of Azov. It appear in in late April and May. Its mass development occurs in waters with salinity 10.4-12.9‰ and temperature 5.6-26^{0}C.



Distribution of *Rhizosolenia calcar avis* in the Sea of Azov

Habitats. It is common in the coastal waters, bays and gulfs and rare in the open sea.

Impact on native species. *Rhizosolenia* is one of the blooming phytoplankton species. Because of its large size and specific body shape it has no special significance as food of invertebrates and fish. According to some data, pelagic fish shoals (e.g. anchovy) avoid areas of *Rhizosolenia* blooms.

Compiled by B. Alexandrov

<u>Invertebrates</u>

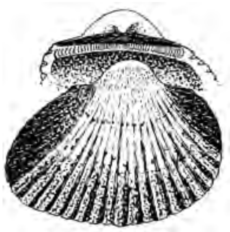
Anadara inaequivalvis (Bruguiere, 1789)

Synonyms: *Arca inaequivalvis* (Bruguière, 1789), *Scapharca inaequivalvis* (Bruguière): Ghisotti & Rinaldi, 1976, *Cunearca cornea* (Reeve)

Common names: Kum kabugu (Tur)

Taxonomy: Class- Bivalvia
Order- Mytilida
Family- Anadaridae

Distinctive characteristics. (See Chapter 3, 3.2.2.)

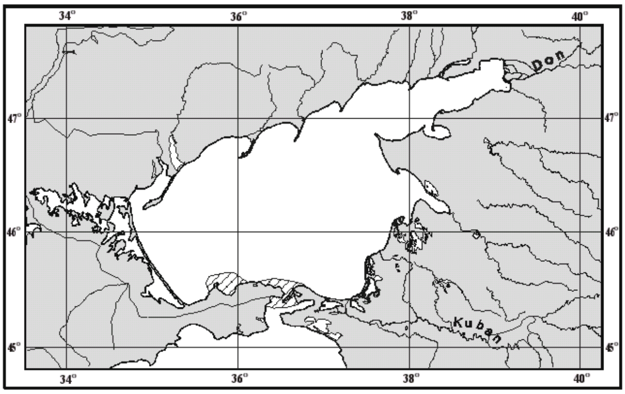


Anadara inaequivalvis

Probable origin. The North Adriatic Sea, where it was firstly discovered in 1969 (GHISOTTI & RINALDI, 1976). In the Adriatic Sea it was introduced from the Pacific Ocean, possibly from the Philippines coastal waters.

Possible way of introduction. Via ships and/or flow of water from the Black Sea.

Distribution. In 1989-1990 it was first sampled in the southern Sea of Azov (ZOLOTAREV, 1996).



Distribution of *Anadara inaequivalvis* in the Sea of Azov

Habitats. Soft muddy, sandy-muddy, shelly-muddy bottoms.

Impact on native species. Insufficiently known.

Compiled by Yu. Zaitsev

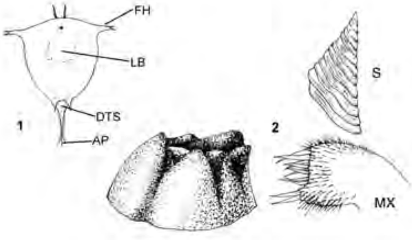
Balanus improvisus (Darwin, 1854)

Synonyms: No

Common names: Bay barnacle (Eng), Morskoy zholud (Rus), Morskiy zholud (Ukr)

Taxonomy: Class- Crustacea
Order- Cirripedia
Family- Balanidae

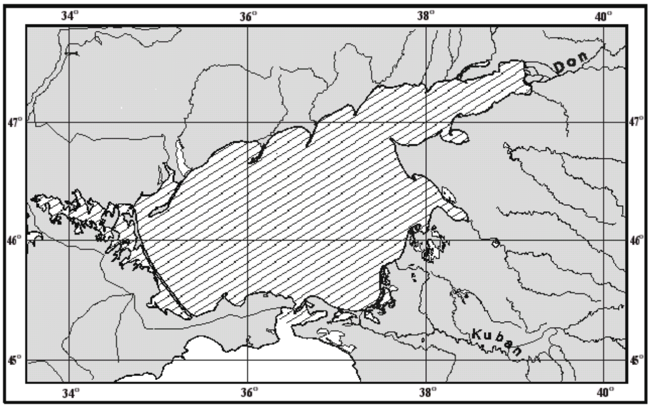
Distinctive characteristics. (See Chapter 3)



Balanus improvisus: 1- nauplius in stage IV; 2- general view of adult individual (the symbols are the same as for *B. eburneus*).

Probable origin. The Atlantic and Pacific Oceans and the Mediterranean Sea. It occurs along the entire coast from the intertidal zone to 46 m (HENRY & McLAUGHLIN, 1975).

Possible way of introduction. Via ships and/or with the flow of water from the Black Sea. The map of distribution of *B. improvisus* in the Sea of Azov was made on the based the latest data of STUDENIKINA *et al*., (1998).



Distribution of *Balanus improvisus* in the Sea of Azov

Habitats. Preferes salinities less than 20‰. Besides natural hard substrates, usually attached to concrete, bricks or debris. It is a mass and typical component of pelagic and benthic communities of the Sea of Azov. Nauplii at 1-6 stages of development are planktonic organisms. They are distributed first in the upper layer of coastal waters. Maximal biomass in the Sea of Azov exceeds 7 $kg \cdot m^{-2}$ (PARTALY, 1980).

Impact on native species. *B. improvisus* is a typical fouling organism, which has a significant role in the self-purification processes of aquatic ecosystem (ALEXANDROV, 1994). Barnacles larvae (nauplii) are the prevalent component of ration of numerous fish species (for example, silverside, sprat, anchovy and shad). Empty barnacle shells inhabit about 18 species of bottom invertebrates. Some of these organisms (for example, amphipods *Gammarus locusta*, *Stenothoë monoculoides*, *Jassa ocia*) breed inside of its shell (ZAKUTSKY, 1965).

Compiled by B. Alexandrov

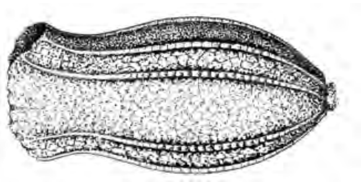
Beroe cucumis (Fabricius, 1780)

Synonyms: *Idya cucumis, I. borealis, Medec fulgens, M. arctica* Lesson, 1843; *Idya roseola* Agassiz, L., 1860; *Beroë roseola* Leidy, 1890

Common name: Beroe

Taxonomy: Class- Tentaculata
Order- Beroida
Family- Beroidae

Distinctive characteristics. (See Chapter 3)

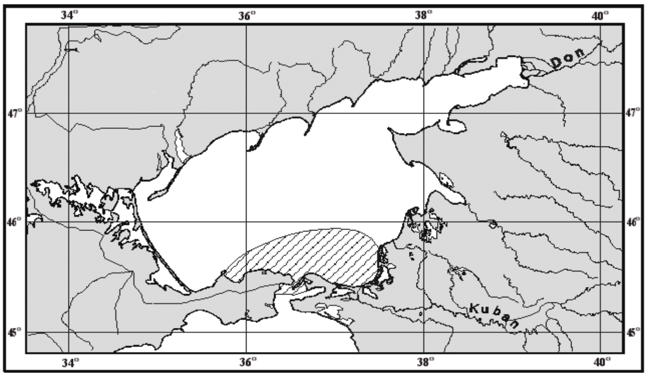


Beroë cucumis

Probable origin. Circumpolar in distribution.

Possible way of introduction. Via ships and/or with water current from the Black Sea.

Distribution. From September 26 till October 6, 1999, *Beroë* was found in large amounts in the southern Sea of Azov. During a day in a stationary net placed on the 2-3 m depth and about 300 m from the shore line were caught about 2 tons of *Beroe cucumis* of 2-7 cm long (GRISHIN *et al.*, 1999).



Distribution of *Beroë cucumis* in the Sea of Azov

Habitats. Inhabits predominantly coastal waters. About 70% of specimens in the open sea are 0,1-1,0 cm long with the average density 50 ind·m^{-3}. Near the shore (not more than 100-300 m from the coast) predominate large adult specimens 5-8 cm long. *B. cucumis* is found mainly in water temperature 13-22^{o}C.

Impact on native species. It is considered that *Beroë* feeds during all of its development stages exclusively on other comb jellies (NELSON, 1925; KAMSHILOV, 1955). Therefore, it is possible that its accidental introduction into the Sea of Azov will lead to the decline in the *Mnemiopsis* population.

Compiled by B. Alexandrov

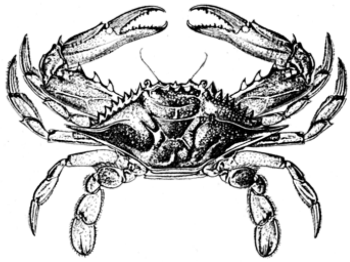
Callinectes sapidus (Rathbun, 1930)

Common names: Blue crab (Eng), Blakitny crab (Ukr), Goluboy crab (Rus), Crabul albastru (Rom), Synyat pak (Bul), Mavi Yengeç (Tur)

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Portunidae

Except the blue crab, three genera and five species of this family are inhabiting the Black Sea.

Distinctive characteristics. (See Chapter 3)

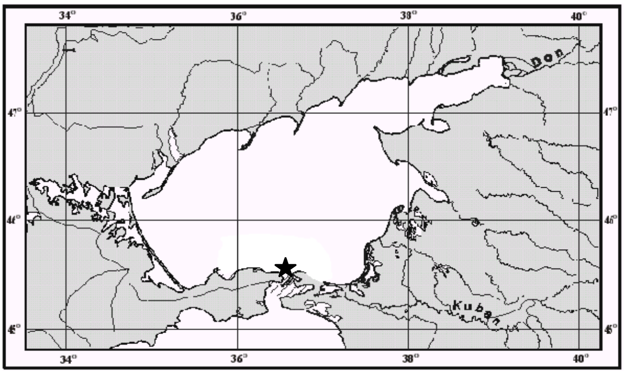


Callinectes sapidus

Probable origin. The North American Atlantic seashore from Cape Cod to Florida and the Gulf of Mexico.

Possible way of introduction. Ship's ballast waters. It is also possible that they migrated into the Sea of Azov from the Black Sea and from the Mediterranean Sea, where it was introduced by ships probably in the 1960s.

Distribution. In the Kerch Strait two specimens of blue crabs were discovered in 1975. One of them was 17 cm in width of carapace and 331 g in weig another, 20.5 cm and 585 g. (ZAITSEV, 1978). This species has not yet established a self-maintaining population in the Sea of Azov.



Findings of *Callinectes sapidus* in the Sea of Azov

★ - Area of the first registration

Habitats. Shallow and brackish waters, sandy and muddy bottoms.

Impact on native species. Insufficiently known.

Compiled by Yu. Zaitsev

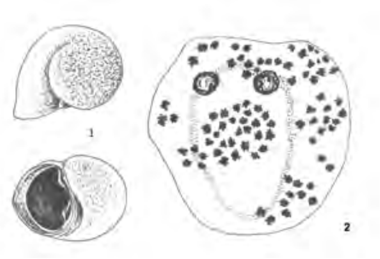
Doridella obscura (Verrill, 1870)

Synonyms: No

Common names: No

Taxonomy: Class-Gastropoda
Order- Nudibranchia
Family -Corambidae

Distinctive characteristics. (See Chapter 3)

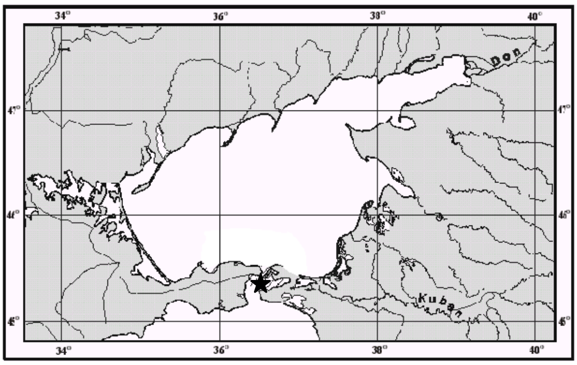


Doridella obscura. 1- larval shells: a, aperture view of cast shell; b, dorsal view of cast shell; 2- dorsal view of adult showing pigmented surface and rhinophores.

Probable origin. Endemic species of Atlantic coastal waters of North America.

Possible way of introduction. Via ships and/or with flow of water from the Black Sea.

Distribution. In 1986-1991, detected in the Kerch Strait (SINEGUB, 1994; ZOLOTAREV, 1996).



Findings of *Doridella obscura* in the Sea of Azov

★ - Area of the first registration

Habitats. *D. obscura* is a component of fouling communities on hard natural (stones and rocks) and artificial (naked hulls, hydrotechnical constructions) substrates. Other species in fouling communities are: green alga *Enteromorpha* sp., hydroid *Obelia longissima*, bryozoans *Electra crustulenta, Conopeum seurati*; bay barnacle *Balanus improvisus* and mussel *Mytilus galloprovincialis.* The larvae of *D. obscura* metamorphose only on living colonies of bryozoans (*Electra*, *Membranipora*, *Schizoporella*).

Impact on native species. *D. obscura* is a stenophagous predator. Its common food are bryozoans *Electra crustulenta*, *Conopeum seurati* and others (ROGINSKAYA & GRINTSOV, 1990; SINEGUB, 1994). The larvae are planktonic and they cannot grow and metamorphose in the complete absence of an external food source, for example, unicellular algae and sessile ciliates (PERRON & TURNER, 1977).

Compiled by B. Alexandrov

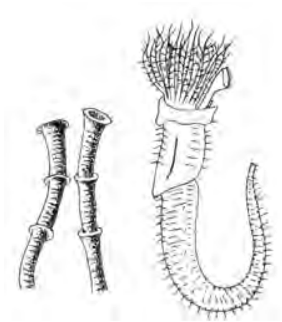
Mercierella enigmatica. (Fauvel, 1923)

Synonyms: No

Common names: No

Taxonomy: Class- Polychaeta
Order- Serpulimorpha
Family- Serpulidae

Distinctive characteristics. (See Chapter 3)

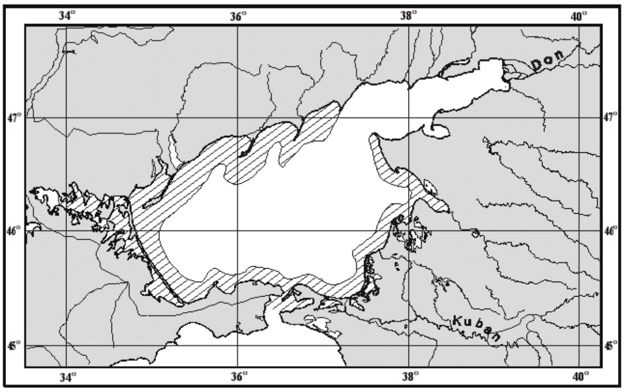


1 2
Mercierella enigmatica
1- calcareous tubes, 2- body of adult worm

Probable origin. Coastal brackish-water wetlands of India.

Possible way of introduction. In hull's fouling.

Distribution: The coastal waters of the Sea of Azov. Maximal biomas 10 kg·m^{-2} was recorded in Kerch Port (LEBEDEV, 1961). After the middle 1960s the abundance of *Merceierella* decreasea. In the middle 1970s its average density in the Sea of Azov was 0,05-0,10 ind·m^{-2} (PARTALY, 1980).



Distribution of *Mercierella enigmatica* in the Sea of Azov

Habitats. Coastal waters of the sea, including low salinity areas. This species can stand the salinity from 0 to 55‰.

Impact on native species. Insufficiently known.

Compiled by B. Alexandrov

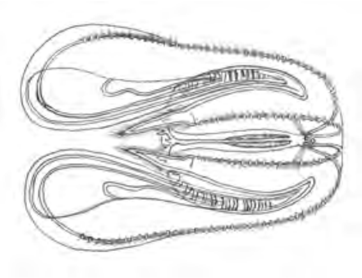
Mnemiopsis leidyi (Agassiz, 1865)

Synonyms: *Bolinopsis* sp. (Pereladov, 1988), *Bolinopsis infundibulum* (Zaitsev et al., 1988), *Leucothea multicornis* (Konsulov, 1990), *Mnemiopsis mccradyi* (Zaika, Sergeeva, 1990)

Common names: Leidy's comb jelly (Eng), Mnemiopsis (Bul, Geo, Rom, Rus, Tur, Ukr. Kaykay (Tur).

Taxonomy: Class- Tentaculata
Order- Lobata
Family- Mnemiidae

Distinctive characteristics. (See Chapter 3)



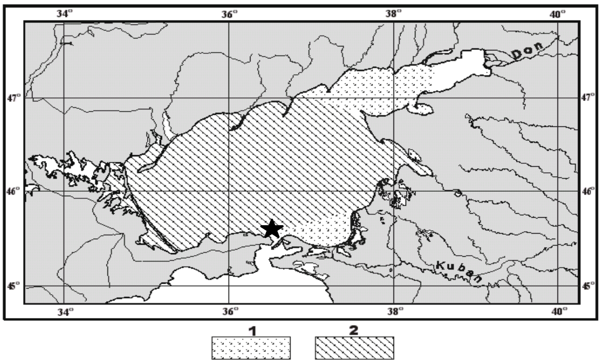
Mnemiopsis leidyi

Probable origin. The North American Atlantic coasts.

Possible way of introduction. Via ships and/or with flow of water from the Black Sea.

Distribution. The appearance of *Mnemiopsis* in the Sea of Azov was recorded first in August 1988. But in this sea it does not survive in winter period. Therefore the penetration of this species into the Sea of Azov from the Black Sea occurs between April and July (VOLOVIK *et al.*, 1993). Its total biomass in the Sea of Azov in 1996-1997 was about 17-18 million tons. Its population density in the Sea of Azov was 500 to 600 $g \cdot m^{-2}$ (STUDENIKINA *et al.*, 1998).

The distribution map of *Mnemiopsis* in the Sea of Azov was made according to VOLOVIK et al., (1996).



Distribution of *Mnemiopsis leidyi* in the Sea of Azov

Range of biomass ($g \cdot m^{-2}$): **1**- <200; **2**- 200-600

★-Area of the first registration

Habitats. All the Sea of Azov, but most abundant in gulfs and bays.

Impact on native species. *M. leidyi* feeds on zooplanktons and pelagic eggs and larvae of fish. A decreas in zoobenthos biomass in the Sea of Azov by about 30%

was estimated (VOLOVIK *et al*., 1993). Main impacts of *Mnemiopsis* on fisheries were identified: 1) predation on fish eggs and larvae; for example, in shelf waters the population of *Mnemiopsis* was estimated to graze up to 70% of total ichthyoplankton stock (TSIKHON-LUKANINA *et al*., 1993); 2) direct environmental impacts on the pelagic and benthic systems (anoxia) due to massive precipitation of mucus and dead ctenophores to the bottom on the shallow shelf. All of these events related to the new predator resulted in a drastic decrease of fish production – of kilka 4-5 times and anchovy, over 10 times. There was a decline in both biomass and catch by about the same proportions, which caused large-scale damage to the fishery in the Sea of Azov.

Compiled by B.Alexandrov

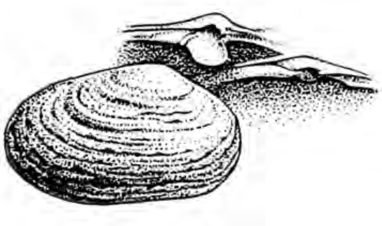
Mya arenaria (Linne, 1758)

Common names: Soft-shelled clam (Eng), Peschyanaya rakushka (Rus), Mya pisochna (Ukr)

Taxonomy: Class- Bivalvia
Order- Venerida
Family- Myidae

Mya arenaria is the only species of this family in the Black Sea.

Distinctive characteristics. (See Chapter 3)

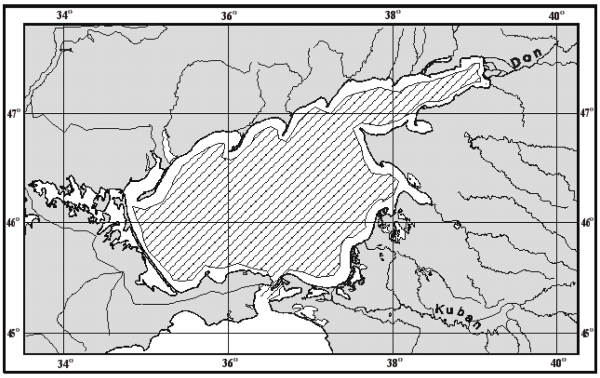


Mya arenaria

Probable origin. The North Sea or the Atlantic seashore of North America.

Possible way of introduction. Via ships and/or flow of water from the Black Sea.

Distribution. All the Sea of Azov.



Distribution of *Mya arenaria* in the Sea of Azov

Habitats. Sandy and muddy shallow bottom in the sea and coastal wetlands.

Impact on native species. A competitor of small local bivalves *Lentidium mediterraneum*, which avoids siltation of sandy bottom by *M. arenaria*. Young specimens of *Mya* are additional food source for bottom-living fish (gobies, flounder, turbot and sturgeons), gulls and other marine birds. Adult specimens of *Mya* are eaten by another exotic mollusc, *Rapana* (GOMOIU, 1972). Moreover, it became an additional filtering mollusc in the coastal zone, which is quite important in the conditions of increasing man-made eutrophication.

Compiled by Yu. Zaitsev

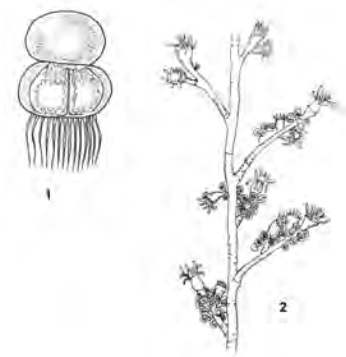
Perigonimus megas (Kinne, 1956)

Synonyms: *Bougainvillia megas* Kinne, 1956, *Bougainvillia ramosa* Less. (Hummelinck,1936), *Cordylophora caspia f. lacustris-f. typica* (Vervoort, 1946)

Common names: No

Taxonomy: Class- Hydrozoa
Order- Leptolida
Family- Bougainvillidae

Distinctive characteristics. (See Chapter 3)

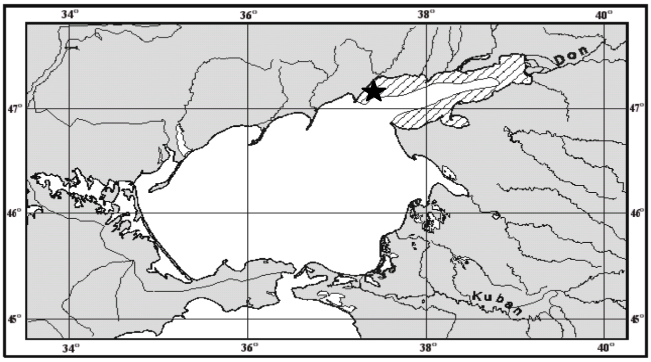


Perigonimus megas: 1- hydromedusa; 2- fragment of polyp colony.

Probable origin. The northern Atlantic coasts.

Possible way of introduction. Via ships and/or with flow of water from the Black Sea.

Distribution. For the first time was found in the Sea of Azov in 1959 near Mariupol. In 1961 it was registered in the Kerch Strait on the coast of Kamysh-Burun Peninsula (ZEVINA *et al.*, 1963). Larvae occurs in spring in water with temperature more than 15^{0}C. Its maximal biomass in June-July reached up to 10 kg·m^{-2} (SIMKINA, 1963).



Distribution of *Perigonimus megas* in the Sea of Azov
★ - Area of the first registration

Habitats. Prefers low salinity waters. In the Sea of Azov it was found in the zones with salinity about 3-5 ‰. Polyps become degraded below the temperature 9-15^{o}C. Prefers areas with high hydrodynamic. In the Sea of Azov it is one of the main species in the fouling communities (ZEVINA *et al.*, 1963).

Impact on native species. Possible impact on the marine biota is the consumption of pelagic copepods. Its main food is the copepod *Calanipeda aquae dulcis*. The dynamics of the hydroid numbers is caused by the variation of the abundance of food particles (PARTALY, 1974). *P. megas* is on of the main food sources for the nudibranch mollusc *Stiliger bellulus* and the crab *Rithropanopeus harrisii tridentatus*. There were found about 7,000 individuals of the molluscs on a hydroid colony with 100 g weight and about 1500 young crabs on one square meter of hard substrate with the *Perigonimus* type fouling (SIMKINA, 1963).

Compiled by B. Alexandrov

Rapana thomasiana (Crosse, 1861)

Synonyms: *Rapana tthomasiana thomasiana* Crosse, *Rapana bezoar* L., *Rapana venosa* (Valenciennes)

Common names: Rapana, Rapan (Bul, Geo, Rom, Rus, Ukr), Deniz Salyangozu (Tur)

Taxonomy: Class- Gastropoda
Order- Hamiglossa
Family- Thaididae

Except *Rapana*, only one species (*Stramonita haemastoma*) of this family is noted in the Black Sea and the Sea of Azov.

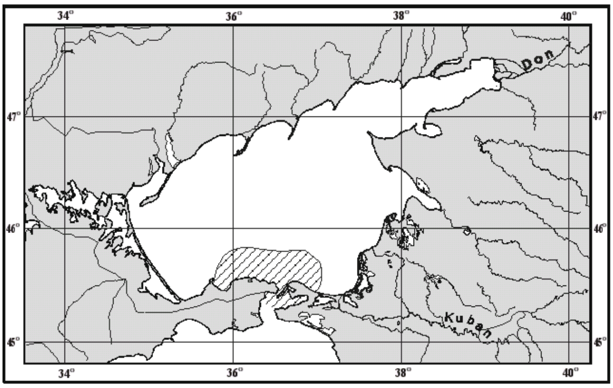
Distinctive characteristrics. (See Chapter 3)

Rapana thomasiana

Probable origin. The Sea of Japan.

Possible way of introduction. Via ships and/or with water current from the Black Sea through the Kerch Strait.

Distribution. The southern part of the Sea of Azov (ZOLOTAREV, 1996).



Distribution of *Rapana thomasiana* in the Sea of Azov

Habitats. Mussel and oyster beds.

Impact on native species. A notorious predator that feeds on mussels, oysters and other bivalves. It exerts a major influence on native malacofauna.

Compiled by Yu. Zaitsev

Rhithropanopeus harrisi tridentata (Maitland, 1874)

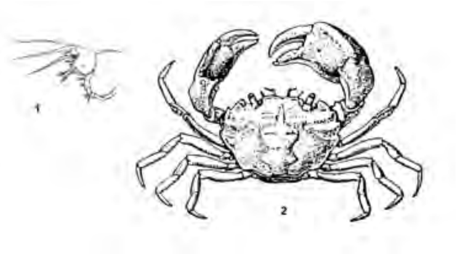
Synonyms: *Pilumnus tridentatus* Maitland, 1874; *Heteropanope tridentatus* De Man, 1892; *Rhithropanopeus harrisi*, Rathbun, 1930; *Rhithropanopeus harrisi tridentata*, Alida M. Buytendijk and Holthuis, 1949

Common names: White-fingered mud crab (Eng), Golandsky krab (Ukr), Gollandsky krab (Rus), Crabul-olandez (Rom)

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Xanthidae

This is the only species of the *Rhithropanopeus* genus in the Black Sea.

Distinctive characteristics. (See Chapter 3)

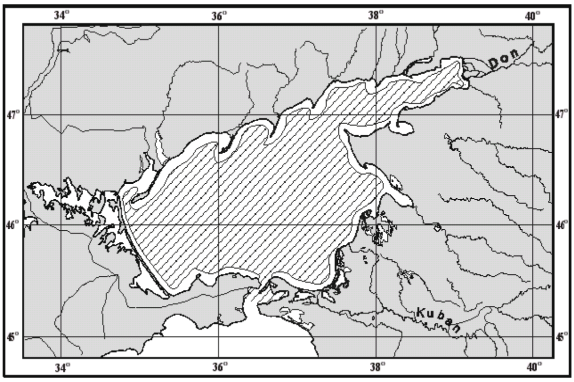


Rhithropanopeus harrisi tridentata: 1 - zoea, 2 – adult

Probable origin. The species is native to the American coast of the Atlantic Ocean.

Possible way of introduction. Via ships and/or with flow of water from the Black Sea.

Distribution. All the Sea of Azov. In marine shallow water areas and especially in brackish-water limans , its density reaches up to 1-3, sometimes 5-8 specimens per one square m of bottom. Larval stages, zoea and megalops of the white-fingered crab and of another crab *Brachynotus sexdentatus* (a native species) are among the most numerous components of the neustonic community in the Sea of Azov. Their numbers in the surface layer of water 0-5 cm reached up 18-19 zoea and megalops per litre or, correspondingly, 18,000-19,000 ind·m^{-3} (ZAITSEV, 1971).



Distribution of *Rhithropanopeus harrisi tridentata*
in the Sea of Azov

Habitats. Sandy and muddy bottoms, under stones and debris, on mussel beds, among algae.

Impact on native species. It is an epibenthic invertebrate predator and scavenger, and an additional food source for native bottom fish - gobies (Gobiidae), flounder (*Platichthys flesus luscus*), turbot (*Psetta maeotica*), sturgeons (Acipenseridae). In the Sea of Azov it is considered more useful than harmful.

Compiled by Yu. Zaitsev

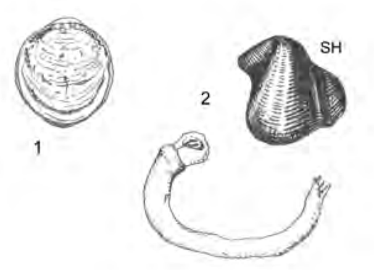
Teredo navalis (Linne, 1758)

Synonyms: No

Common names: Shipworm (Eng), Korabelny cherv (Rus), Teredo drevotochets (Ukr)

Taxonomy: Class- Bivalvia
Order- Venerida
Family- Teredinidae

Distinctive characteristics. (See Chapter 3)

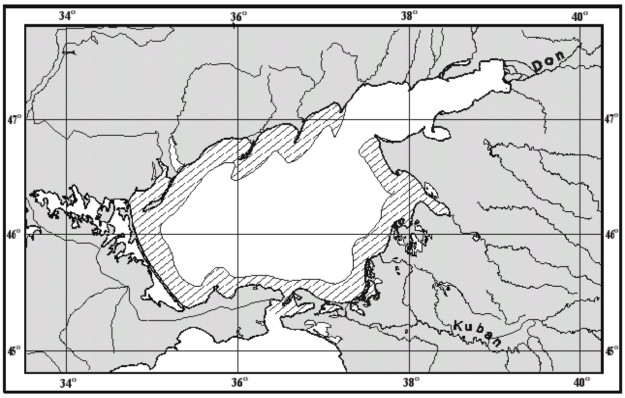


Teredo navalis: 1 – larva, 2 – adult (SH – shell)

Probable origin. Boreal parts of the Atlantic and Pacific Oceans.

Possible way of introduction. Via ships and/or with the flow of water from the Black Sea. Penetrated into the Sea of Azov in 1953-1955, owing to the increase of water salinity up to 11‰ (RYABCHIKOV *et al.*, 1963).

Distribution. Coastal waters.



Distribution of *Teredo navalis* in the Sea of Azov

Habitats. Wooden underwater constructions in the sea.

Impact on native species. Because of its small number, the impact cannot be significant at present, but it needs special investigations.

Compiled by B. Alexandrov

Urnatella gracilis (Leidy, 1851)

Synonym: *Urnatella dniestriensis* Zambriborsch

Common names: No

Taxonomy: Class- Entoprocta
Family -Urnatellidae

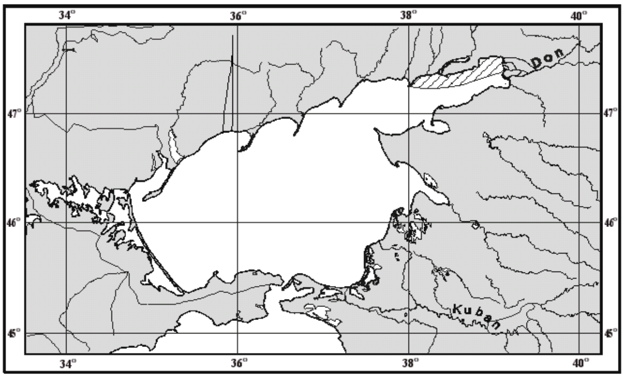
Distinctive characteristics. (See Chapter 3)

Urnatella gracilis

Probable origin. Till 1938 it was known only for the fresh waters of North America. Later it was discovered in Belgium fresh waters, and in 1954-1962 in the lower Danube, Dniester and Don Rivers. In 1962 it was found in the northeastern part of the Sea of Azov (Taganrog harbour) by R.G Simkina (MORDUKHAY-BOLTOWSKOY, 1968). In 1964 it was rather common in this area.

Possible way of introduction. Ballast waters, ship's hulls and/or with flow of water from the Black Sea.

Distribution. It is a not an abundant species in fresh and brackish waters (salinity less than 5‰) in the Sea of Azov.



Distribution of *Urnatella gracilis* in the Sea of Azov

Habitats. Rivers, deltas, limans, and brackish-water marine areas.

Impact on native species. Insufficiently known.

Compiled by Yu. Zaitsev

<u>Fishes</u>

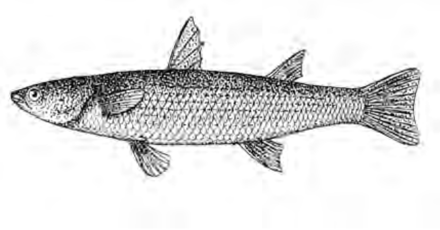
Mugil soiuy (Basilewski, 1855)

Synonyms: No

Common names: Haarder (Eng), Pelingas, Pilengas (Rus), Pilengas (Ukr), Rus kefali (Tur)

Taxonomy: Class- Osteichthyes
Order- Mugiliformes
Family- Mugilidae

Distinctive characteristics. (See Chapter 3).

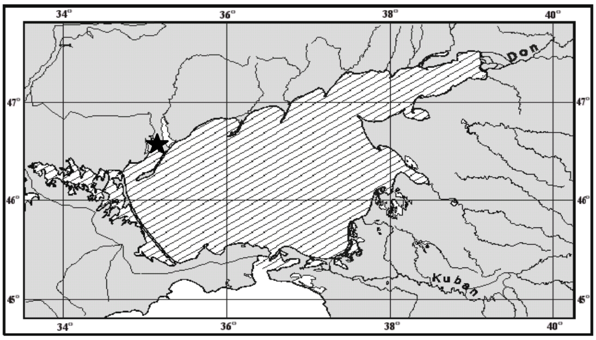


Mugil soiuy

Origin. The estuaries of the northern part of the Sea of Japan.

Way of introduction. About 50 000 fry of the haarder from the Amur River mouth area were transported by plane in 1972-1982 and released in some limans in the north-western Black Sea and in Molochny Liman of the Sea of Azov. The first breeding of naturalized fish in the Sea of Azov was noted in 1984. Commercial catches since 1988 (ZAITSEV & STARUSHENKO, 1997).

Distribution. All the Sea of Azov. It is an important commercial fish.



Distribution of *Mugil soiuy* in the Sea of Azov

Habitats. Shelf waters and coastal wetlands. The species is tolerant of a wide range of salinity (euryhaline), living from fresh water to 35‰ in some limans.

Impact on native species. Insufficiently known. The fry of the haarder are feeding on zooplankton and therefore can compete with local plankton-eating fish. Some specific parasites (Trematoda, Monogenea), associated with the haarder were introduced in the Black Sea and were found in the body of local grey mullets. The consequences of this need to be investigated.

Compiled by Yu. Zaitsev

Additional Information to the Chapter 4

Some non-native species introduced in the Sea of Azov by human activities, were not included in the above-mentioned list of exotics because of lack of information. These are the following species.

The Hydromedusa *Blackfordia virginica* (Mayer, 1910), (Hydrozoa, Leptolida, Campanulinidae). Originated from the Atlantic Ocean, is common in the low salinity areas of the Sea of Azov (NAUMOV, 1960).

According to GOLİKOV STAROBOGATOV(1972), the gastropod *Potamopyrgus jenkinsi* it exists in the Sea of Azov, but this species can be confused with another common gastropod *Hydrobia* sp.

Most likely, the ivory barnacle *Balanus eburneus* should be in the Sea of Azov, because it is present in the Black Sea and the Caspian Sea. The Chinese mitten crab *Eriocheir sinensis* H. Milne-Edwards, 1854 (Crustacea, Decapoda) was caught in May 1998 in the north-eastern part of the Sea of Azov. It was a male of 7.4 cm in width and 6.6 cm in length (MURINA &ANTONOVSKY, 2001).

Aristichthys nobilis Ricch. (Osteichthyes, Cypriniformes, Hypophthalmidae). Originated from the far east Asian rivers it was deliberatly released in the Sea of Azov in the 1950s (VOLOVIK & CHIKHACHEV, 1998).

Mosquitofish *Gambusia affinis* (Baird et Gir.). (Osteichthyes, Cyprinodontiformes, Poeciliidae). Originated from North America. Deliberate released in the coastal wetlands to combat malaria (VOLOVIK & CHIKHACHEV, 1998).

The Channel catfish *Ictalurus punctatus* (Osteichthyes, Ictaluridae). Originated from North American fresh waters. Deliberate released in the lower Don and Kuban Rivers as a commercial fish. (VOLOVIK & CHIKHACHEV, 1998).

Smallmouth Buffalo *Ictiobus bubalus* (Osteichthyes, Catostomidae). Originated from North American fresh waters. Deliberate released in lover Don and Kuban rivers as a commercial fish. (VOLOVIK & CHIKHACHEV, 1998).

Black buffalo *Ictiobus niger* (Osteichthyes, Catostomidae). Originated from North American fresh waters. Deliberately released in the lower Don and Kuban rivers (VOLOVIK & CHIKHACHEV, 1998).

The Striped bass *Morone saxatilis* (Walb.). (Osteichthyes, Serranidae). Originated from North American coastal waters of the Atlantic Ocean. Deliberately released in the 1960s in the Don River Delta (VOLOVIK & CHIKHACHEV, 1998).

Mozambique tilapia *Tilapia mossambica* Peters (Osteichthyes, Cichlidae). Originated from the East African fresh waters. Deliberately released in the lower Don and Kuban Rivers (VOLOVIK & CHIKHACHEV, 1998).

Medaka *Oryzias latipes* (Temmink et Schlegel). (Osteichthyes, Oryziatidae). Originated from the fresh waters South Eastern Asia. Accidentally released with target species in the lower Kuban River (VOLOVIK & CHIKHACHEV, 1998).

Paddlefish *Polyodon spatula* Walb. (Chondrichthyes, Polyodontidae). Originated from North American fresh waters. Deliberate released in the Sea of Azov as a commercial fish (VOLOVIK & CHIKHACHEV, 1998).

Setiobus cyprinellus. (Osteichthyes, Catastomidae). Originated from North American fresh waters. Deliberately released in the lower Don and Kuban Rivers (VOLOVIK & CHIKHACHEV, 1998).

Tribolodon brandti. (Osteichthyes, Cyprinidae) Originated from coastal waters of the Sea of Okhotsk and Sea of Japan. Deliberatly released in the Sea of Azov as a commercial fish (VOLOVIK & CHIKHACHEV, 1998).

Muskrat *Ondathra zibethica* L. (Mammalia, Rodentia, Cricetidae). Originated from the North America and introduced in URSS in the 1930s, as a fur-bearing animal. As a semi-aquatic mammal, it is common in the coastal wetlands of the Sea of Azov.

Raccoon-dog *Nyctereutes procyonoides* Gray (Mammalia, Carnivora, Canidae). Originated from Eastern Asia, introduced in the Black Sea wetlands in the 1930s, as a fur-bearing animal. It can be observed in coastal wetlands of the Sea of Azov.

Northern fur seal *Callorhinus ursinus* L. (Mammalia, Pinnipedia, Otariidae). Captured in the Komandorsky Islands area (Bering Sea). Accidentally released from the Black Sea aquaria, it was observed in the Southern part of the Sea of Azov (BIRKUN & KRIVOKHIZHIN, 1996).

Chapter 5. The Caspian Sea

Physical Geography, Biology, Ecology

Geographical position

The Caspian Sea is an intercontinental Eurasian sea, bordering the Russian Federation to the north and north-west, Azerbaijan to the west, Republic of Kazakhstan to the east, Turkmenistan to the south-east, and Iran to the south. Its geographic co-ordinates are N 47º 07’- 36° 33’ and E 46º 43’ - E 54º 50’ (KAPLIN, 1995). The sea is completely isolated from the world ocean, 500 km remote from the Sea of Azov and the Black Sea at.

Geological evolution

The geological history of the Caspian Sea is an alternation of its transgressions and regressions (FYODOROV, 1957). The first transgression of the Caspian Sea occurred in the late Pliocene from 2 to 3 million years ago (KAPLIN, 1995). That was an extensive transgression of waters flooding the Ciscaspian Lowland and the Volga river valley up to the mouth of the Kama River. These waters covered the present Krasnovodsh Peninsula, reaching far into the Kara Kum Desert down to the foothills of the Kopet Dag mountains.

The Khvalyn epoch, some 70,000-40,000 years ago, is characterised by the largest transgression in the Quaternary history of the Caspian Sea. The sea level reached up 46-48 m abs. The Early and Late Khvalyn transgressions were interrupted by the Yenotayevan regressive epoch, when the sea level was below its present mark (KAPLIN,1995).

Morphometry and climate

The Caspian Sea is about 1,183 km long from north to south, and 198 to 624 km wide from west to east (LEONOV, 1960). The total shoreline is about 7,000 km from which Kazakhstan has the longest shoreline, 2,700 km, the Russian Federation has 695 km, Turkmenistan 1,200 km, Azerbaijan 850 km, and Iran about 900 km. More than 50 islands of the Caspian Sea with a total area of about 350 km^2 have a total shoreline about 774 km (LEONOV, 1960, KAPLIN, 1995).

The area of the Caspian Sea within the limits of the 1969 shoreline is 378,400 km^2 (KAPLIN, 1995). According to LEONOV (1960), the sea area, except the islands, is 422, 112 km^2, and, according ZENKEVICH (1963), 436,000 km^2. The volume of water is about 78,000 km^3.

Both oceanographers and biologists distinguish three rather different parts of the sea: North, Middle and South Caspian Seas (LEONOV, 1960; ZENKEVICH, 1963; KAPLIN, 1995). The first is a shallow-water one with maximum depth of 20 m. It is limited to the south by the Mangyshlak Bank, and have an area of 91,900 km^2. Because of the recent sea level rising, the area of the North Caspian Sea has been substantially increased: in 1986-1990 it was 97,00 km^2 and in 1991-1995 reached up to 106,400 km^2. The Middle and South parts are separated by the Apsheron Bank, which is an underwater prolongation of the Apsheron Peninsula.

The maximum depth of the Middle Caspian Sea is 780 m (the Derbent Depression). The maximum depth of the South Caspian reached up 1,025 m (KAPLIN, 1995).

The shoreline of the Caspian Sea is not very ireegular or interrupted, the main gulfs are Kislyar, Lenkoran, Mangyshlak, Krasnovodsk and very specific Karabugaz Gulf. A large portion of the shoreline is occupied by the deltas of major rivers: the Volga, Ural, Terek, Sulak, and Kura. All these rivers are discharged into the northern and western coasts. None of rivers on the eastern coast reaches the shore.

The Caspian Sea lies within several climatic zones. The northern lies in a moderately continental climatic zone, its western coast lies in the moderate hot belt, the southwestern coast is touched by subtropical influence and a desert climate prevails on the eastern shores (KAPLIN, 1995).

Main characteristics of the Caspian Sea ecosystem

Abiotic factors

The water temperature of the Caspian Sea shows a considerable seasonal and spatial variation. In the winter season , the surface layer temperature in the northern part is about 0º C and in the southern part reaches up to 10.7º C. In summer time the variability is much less, 22º C and 27º C, respectively (KAPLIN, 1995).

Salinity fluctuations over the sea surface are the greatest in the North Caspian Sea, where the salt content increases from 0.1-0.2‰ near the estuaries of the Volga and Ural Rivers to 10-12‰ at the boundary of the Middle Caspian (THE CASPIAN SEA, 1986). The maximum salt content does not exceed 13.2‰ (KAPLIN, 1995). Karabugaz Gulf is an ultrahaline water body, its salinity in 1930-1950 varied from 210‰ to 358‰ (LEONOV, 1960).

The oxygen content in the surface Caspian Sea water varies from 5.01 $ml.l^{-1}$ to 9.39 $ml.l^{-1}$ and at 800 m depth from 1.54 $ml.l^{-1}$ to 3.14 $ml.l^{-1}$ (THE CASPIAN SEA, 1986). The oxygen concentration in the water is caused chiefly by the river runoff, by the infusion of molecular oxygen at the surface and by the photosynthesis of the phytoplankton.

The main sources of nutrients, especially in the Northern Caspian Sea, are the Volga and Ural rivers. The average perennial concentrations of these substances on the sea surface are (in $mcg\text{-}at.l^{-1}$) for inorganic phosphorus 0.16-0.17, ammonia-4.63-5.69, nitrite 0.04-0.12, and silicon 54-62 (KAPLIN, 1995).

A very important characteristic of the Caspian ecosystem is the sea level change. Since the beginning of instrumental surveis in 1837, the amplitude of the Caspian Sea level fluctuations has totaled 4 m, from –25.3 in the 1880s to –29 m in 1977. It is a clear correlation between the level of the Caspian and its water balance (GOLYTSIN & PANIN, 1985). Thus, the sharp decline in the level in 1933-1940 by nearly 1.72 m was caused by a diminishing of the river runoff (KAPLIN, 1995).

The rise of the sea level since 1978 is caused by climate change (ISAYEV, 1987). This level rising has deeply modified the coastal zone. For instance, in the area to the north of Makhachkala, the shoreline is retreating by 10-12 m per year

(KAPLIN, 1995). In the Lenkoran area, a single storm in October 1990 caused the shoreline retreat by 5 to 6 m.

Biotic factors

Biological diversity and origin of species

According to latest investigations, the Caspian Sea is inhabited by 1169 species of free-living animals (KASYMOV, 1987) and more than 500 species of plants (ZENKEVICH, 1963). As to origins, following faunal groups are distinguished (ZENKEVICH, 1963; KASYMOV, 1987).

The first group is composed of Autochthonous animals, or Relics, originated from the Sarmathian and Pontian basins of the Tertiary Period. This is the most numerous group, formed by 513 species or 43.8% of the total fauna. Among them are herrings, gobies, quite possible sturgeons, molluscs (e.g. *Dreissensia*, *Micromelania*), polychaetes (e.g. *Hypania, Hypaniola, Parhypania*), many species of decapods, cumaceans, mysids, amphipods, hydroids.

The second group are cold-water or Arctic species, which are common in northern seas. They have been entered the Caspian Sea in the post-glacial period, about 10-12 thousand years ago. The group is formed by14 species (1.2% of the total fauna). Among arctic species there are the polychaete *Mannayunkia caspia*, the crustaceans *Limnocalanus grimaldi, Mysis caspia, M. microphthalma, M. macrolepis*, *Pseudolibrotus caspius*, *P. platyceras*, *Pontoporeia affinis microphthalma*,the fishes *Stenodus leicichthys* and *Salmo trutta caspius*, and the Caspian seal *Phoca caspica*. These organisms have penetrate in the Caspian Sea through the rivers, possibly from the Arctic Ocean (ZENKEVICH, 1963).

The third group of Mediterranean or marine organisms is formed by 388 species of protozoans, 7 metazoan species, and one plant- the sea grass *Zostera noltii* (syn. *Z. nana*) (33.2%). Among the first ,there are 386 species of infusoria and two species of benthic foraminifers. The metazoans are represented by the polychaete *Fabricia sabella*, bivalves *Cerastoderma lamarki lamarki* and *C. isthmicus*, bryozoan *Bowerbankia imbricata*, fishes; the silverside, *Atherina mochon caspica*, the pipefish, *Syngnathus nigrolineatus caspius* and the goby *Pomatoschistus caucasicus* (ZENKEVICH, 1963; KAPLIN, 1995). These species entered the Caspian sea prrobably during the Late Khvalyn transgression about 18,000-12,000 years ago via the Kuma-Manych depression, which linked the Black and Caspian Seas on several occasions during the Quaternary (ZENKEVICH, 1963). According to CHEPALYGA and TARASOV (1997), at least some of these organisms may have been transported with ancient reed boats from the Black Sea to the Caspian Sea through the same Kuma-Manych depression.

The fourth group is composed of freshwater origin organisms. There are 226 species (19.3%), that entered the Caspian Sea in the late Tertiary Period (ZENKEVICH, 1963) through the river systems. There are representatives of different taxa of invertebrates and fish, inhabiting mostly the Northern Caspian Sea.

The fifth group of species is the youngest one and is formed by exotic marine organisms, accidentally or intentionally introduced by human activities.

The main part of them are originated from the Black Sea and the Sea of Azov, but some are from outside, mainly from the low salinity areas of the Northern Atlantic Ocean.

In the 1920s-1930s, into the Caspian Sea from the Black Sea and the Sea of Azov, accidentally introduced were the planktonic diatom *Rhizosolenia calcar-avis* (although PROSHKINA-LAVRENKO MAKAROVA (1968) suppose that this species was transported by birds), bivalve *Mytilaster lineatus*, shrimps *Palaemon elegans* (syn. *Leander squilla*) and *P. adspersus* (syn. *L. adspersus*). In the same period, intentionally were introduced commercial fishes, grey mullets *Liza aurata* and *L. saliens*, the flounder *Platichthys flesus luscus*, and in 1939-1940 benthic invertebrates the polychaete *Nereis succinea* and the bivalve *Abra ovata* (syn. *Syndesmya ovata*). The freshwater mosquito fish *Gambusia affinis* was introduced to combat malaria in the Georgian wetlands and reached the Lenkoran area with the Kura River runoff (ZENKEVICH, 1963).

In 1952 the Volga-Don Channel which linked the Sea of Azov and Caspian Sea was open and many exotic species penetrated with ballast waters and as hull's fouling (ALADIN & PLOTNIKOV, 2000). Among them there are hydrozoans *Perigonimus megas* and *Blackfordia virginica*, barnacles *Balanus improvisus* and *B. eburneus, Mercierella enigmatica* (Polychaeta).

For the Caspian Sea biota is very characteristic the absence of many large taxa of typical marine organisms, such as Radiolaria, Siphonophora, Scyphozoa, Corals, Polycladida (Turbellaria), Nemertea, Echiuroidea, Sipunculoidea, Priapulida, Brachiopoda, Chaetognarha, Pycnogonida, Amphineura, Scaphopoda, Cephalopoda, Echinodermata, Enteropneusta, Tunicata, Cephalocordata, Batoidea, Squali, Cetacea (ZENKEVICH, 1963). All of them are present in the Mediterranean Sea and some of them are rather common in the Black Sea. Mediterranean origin species which have been naturalized in the Caspian Sea are represented by few specimens, like Foraminifera, Cornacuspongida (Porifera), Hydrozoa, Polychaeta, Bryozoa and Decapoda.

As a general conclusion about the Caspian Sea biota, it follows that in the geographic range of intercontinental Eurasian seas of the AMBACS system, the Caspian Sea is the most rich in Caspian (Pontian) relics and freshwater origin species.

The phytoplankton flora of the Caspian Sea is composed mainly by blue-green algae, Cyanophyceae (18 species), Diatoms (20 species), and Dinoflagellate (more than 10 species). The biomass of accidentally introduced diatom *Rhizosolenia calcar avis* reached up 9 $g.m^{-3}$, and of Peridinean *Peridinium cordatum* up to 4.5-6.5 $g.m^{-3}$ (ZENKEVICH, 1963).

The bottom macroalgae are represented by 40 (ZINOVA, 1967) species of green, brown and red algae. According to ZENKEVICH (1963) their numbers reached to 83 species. These algae do not spread deeper then 25 m, because of low transparency of the Caspian Sea water. The total biomass of bottom macroalgae in the Caspian Sea reached up 3 million t (ZENKEVICH, 1963). Besides algae five species of benthic higher plants were recorded in the Caspian Sea. These are *Zostera minor* (*Z. noltii*), *Ruppia maritima*, *R. spiralis, Najas marina* and

Potamogeton pectinatus. The total biomass of the sea grass Zostera is about 70,000t.

Mass zooplankton species appertains to Rotatoria, Cladocera and Copepoda forming a biomass from 10-100 mg.m^{-3} to 200 mg.m^{-3} and more. The main biomass is encountered in the layer from 0 to 100 m.

The biomass of the zoobenthos reached up to100-500 and even 1000 g.m2 (ZENKEVICH, 1963) and is distributed over the sea till the maximum depths. For instance, the specimens of *Hypania invalida* (Polychaeta) were recorded at 960 m depth. The main biomass of macrozoobenthos is found in the North Caspian Sea at 10-15 m depth.

The future of the Caspian Sea

There are two groups of factors strongly influencing the Caspian Sea ecosystem at present. The first group is related with the sea level rising and the second one with increasing human impact.

The sea level rising is the reason of substantial change in the marine marginal (contour) habitats and the communities responsible for important ecological processes in coastal waters. On the land, the sea level rising endendered numerous environmental, economic and social problems.

The increasing human impact on the Caspian Sea is manifested through oil and chemical pollution, eutrophication and bacterial infection.

The navigation through the Volga-Don Channel will supply new settlers with ballast waters, sediments and hull's fouling. On one hand, low salinity of the Caspian Sea water is a barrier for many stenohaline marine species. But on the other hand, relatively low specific diversity of the Caspian Sea biota and paucity of antagonistic species are prerequisites for the naturalisation of new settlers. This flow of non-native organisms can be attenuated by special monitoring of exotics and by adequate actions, recommended by the International Maritime Organization.

Exotic species

Plants

Rhizosolenia calcar-avis (M. Schultze, 1858). (See Additional inform.)

Invertebrates

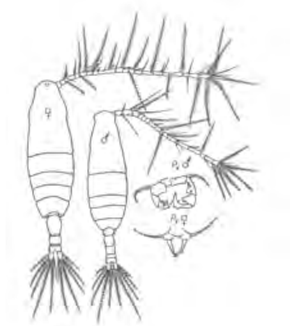
Acartia clausi (Giesbrecht, 1889)

Synonyms: No

Common names: No

Taxonomy: Class- Crustacea
Order- Copepoda
Family- Acartiidae

Distinctive characteristics. Body slender, oblong, cephalothorax length is in three times exceeds its width. Cephalothorax is distinctly separated from the first thoracal segment. Last thoracal segments are merged. There are 5 cephalothoracic segments. Female has abdomen with 3 segments, male has 5 with very small fourth segment. Furcal branches are short, there are 5 pairs of furcal setae. There are 17 segments on antennae-I of female. Body is transparent.

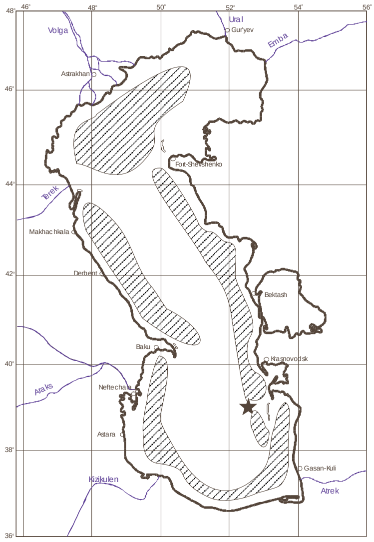


Acartia clausi

Probable origin. It is a native species in the Black and Azov Seas. For the first time was found in the eastern section of the South Caspian Sea in August 1981 (KURASHOVA & ABDULLAEVA, 1984).

Possible way of introduction. Accidentally introduced from the Black Sea or the Sea of Azov in ballast waters.

Distribution. Distributed all over the Caspian Sea, its density amounted to 780 ind·m^{-2} in the northern part of the Caspian Sea and 623 ind·m^{-2} in the Middle Caspian Sea. The quantity of *Acartia* in the western section of the Middle Caspian Sea was 40 times more than that in the eastern section. Its maximum development in the Middle Caspian was noted at a depth of 0-50 m (KURASHOVA & TINENKOVA, 1988). The Density of *Acartia* in the area Kamen Ignathia-Cheleken was more than 30,000 ind·m^{-3}, but the biomass was 99,4 mg·m^{-3} (KURASHOVA & ABDULLAEVA, 1984).



Distribution of *Acartia clausi* in the Caspian Sea

★ - Area of the first registration

Habitats. Eurythermic and euryhaline planktonic species. Mass development occurs in coastal (0-100m) waters. It feeds on diatoms and dinophlagellates and planktons, such as ciliates, rotifers, cladocerans, nauplii of copepods and barnacles.It is common food of pelagic fish.

Impact on native species. Decrease in the number of copepodes *Eurytemora grimmi* and *E. minor* is noted in the areas of mass development of *Acartia*. May be these phenomena are interrelated.

Compiled by A. Kasymov

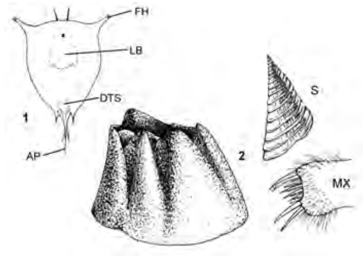
Balanus eburneus (Gould, 1841)

Synonyms: No

Common name: Ivory barnacle (Eng)

Taxonomy: Class - Crustacea
Order- Cirripedia
Family- Balanidae

Distinctive characteristics. (See Chapter 3)

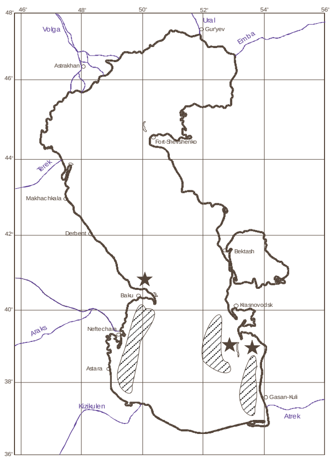


Balanus eburneus: 1- nauplius in stage IV (**FH**- frontolateral horns, **LB**- labrum, **AP**- abdominal process, **DTS**- darsal tharacic spine); 2- general view of adult individual (**S**- scutum, $\mathbf{MX_1}$- maxilla 1)

Probable origin. The Boreal Atlantic Ocean, common in the Black Sea.

Possible way of introduction. In the Caspian Sea was found in 1956 in the Krasnovodsk Gulf and the Island Ogurchinski (ZEVINA, 1957; TARASOV & ZEVINA, 1957) and in the area of Pirallashi Island in 1959. Penetrated into the Caspian from the Black Sea on the ship's hulls and in ballast water after the opening the Volga-Don shipping canal.

Distribution. The Island Ogurchinski and Krasnovodsk Gulf (TARASOV & ZEVINA, 1957). In some areas, multi-layer foulings of this species can reach 6 cm in thickness, settling on each other (BAGIROV, 1967).



Distribution of *Balanus eburneus* in the Caspian Sea

★ - Areas of the first registration

Habitats. Unlike *B. improvisus* which occurs in different bottom habitats, *B. ebuneus* does not endure water currents and usually occurs in stagnant waters.

Impact on native species. In terms of habitats, there is a difference between *B. eburneus* and *B. improvisus*. The former lives mainly on the bottom, preferring habitats protected from surf and current, whereas the latter lives in the water with high-velocity currents (ZEVINA & KUZNETSOVA, 1965). In the Southern Caspian Sea mass development of *B. eburneus* led to considerable decrease in the biomass of native species of molluscs and hydroids. Under the conditions of food shortage, it prevents the development of other organisms in the fouling. This competition is particularly severe in the larval stage. The larvae of *Balanus* sometimes reached up to 90% of all plankton in some areas of the Caspian Sea.

Compiled by A. Kasymov

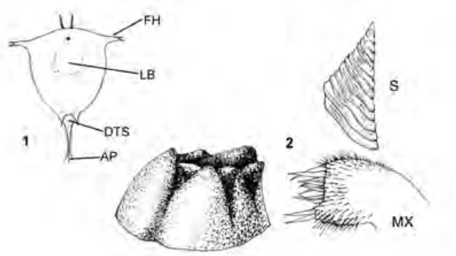
Balanus improvisus (Darwin,1854)

Synonyms: No

Common name: Bay barnacle (Eng)

Taxonomy: Class- Crustacea
Order- Cirripedia
Family- Balanidae

Distinctive characteristics. (See Chapter 3)

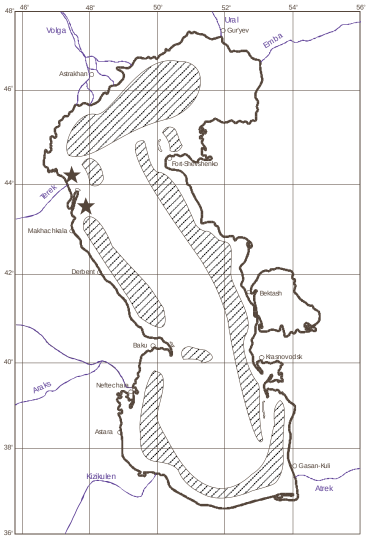


Balanus improvisus: 1- nauplius in stage IV; 2- general view of adult individual (the symbols are the same as for *B. eburneus*)

Probable origin. The North Atlantic Ocean, now common species in the Black and Azov Seas.

Possible way of introduction. Accidentally introduced into the Caspian Sea in 1954 from the Black Sea or the Sea of Azov.

Distribution. In 1954 was found on the fins of fish in Kizlyar Bay in the area of Bryansk Spit. In 1955 was distributed along the northern and western coasts of Middle Caspian, and in 1956 all over the area of Caspian Sea (ZEVINA, 1957). In Autumn 1959, was found out in the coastal waters of the Apsheron Peninsula. it has infested open coasts (MORDUKHAY-BOLTOVSKOY, 1968). Its biomass in the North Caspian amounted, to 15 $g \cdot m^{-3}$ and density 6000 $ind \cdot m^{-3}$ (SAENKOVA, 1956). In 1961 it was found, in the fouling communities of the Krasnovodsk Gulf In front of the mouth of the Kara-river the biomass of barnacles was 10.6 $g \cdot m^{-2}$ in 1979, and 40.1 $g \cdot m^{-2}$ in 1980 (KASYMOV, 1987 a). In the slightly polluted area near island Nargin the density of it changed, from 20 to 460 $ind \cdot m^{-2}$ in 1981-1982 (KASYMOV, 1988). In the southern-eastern section of the Southern Caspian it was 64.0 $ind \cdot m^{-2}$ (KASYMOV et all, 1974), in the eastern part of Middle Caspian 10.7 $g \cdot m^{-2}$ (KASYMOV &BAGIROV,1977) and in Gorgan Bay 0,3 $g \cdot m^{-2}$ (VLADIMIRSKAYA, 1973). It was also found in the region of Chirag field, in a quantity of 8,15 $g \cdot m^{-2}$ in 1997-1998.



Distribution of *Balanus improvisus* in the Caspian Sea

★ - Areas of the first registration

Habitats. Lives on stones, woods, branches of trees, piers, different hydrotechnical constructions, shells of molluscs, carapaces of crawfishes and crabs. It was found at the depths of 150-200 m in the region of "Gunashly" field (KASYMOV & ROGERS, 1996).

Impact on native species. Colonies of it serve as substrates for different species of algae, hydroids, bryozoans and molluscs. There is a competition between *B. improvisus* and *B. eburneus*, as a result of that *B. improvisus* lives on the hulls of ships and hydrotechnical constructions, but *B. eburneus* inhabits bottom hard substrates. *Balanus* increases the corrosion of metallic constructions in the sea, including oil pipes. Covering fish nets *Balanus* diminishes their catchability and floatation. Mass fouling of *Balanus* on piers considerably increases wave loading.

Compiled by A. Kasymov

Barentsia benedeni (Foettinger, 1887)

Synonyms: *Pedicellina benedeni* Foetinger, 1887, *Arthropodaria kovalevskii* Nassonov, 1926

Common names: No

Taxonomy: Class- Entoprocta
Family- Pedicellinidae

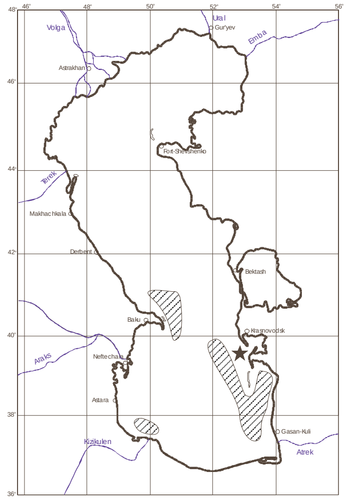
Distinctive characteristics. Calyx bell form, flattened on each side. Back side of disk with protuberance, where anal foramen opened. Mouth on the fore end . Number of palpi is changing from 8 to 20 and they are covered by cilia. Stalk 8-10. They fastened to stolon. Larva turns to sessile form after 24 hours.

Barentsia benedeni

Probable origin. The North Atlantic Ocean, Black Sea and Sea of Azov.

Possible way of introduction. In the Caspian Sea it was introduced by ships through the Volga-Don Canal from the Black and Azov Seas and it was first found the Krasnovodsk Gulf in 1962 (ZEVINA & KUZNETSOVA, 1965).

Distribution. The Krasnovodsk Gulf, the coastal waters of islands Oblivnoi, Pirallahi, Neft Dashlari, Shichov Spit (BAGIROV, 1989).



Distribution of *Barentsia benedeni* in the Caspian Sea

★ - Area of the first registration

Habitats. A thermophylous species, living in the foulings of ships and port constructions, which is the evidence of the fact that it stands the water pollution rather well. It prevents the development of the species in the fouling.

Impact on native species. Insufficiently known.

Compiled by A. Kasymov

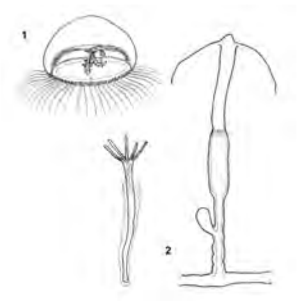
Blackfordia virginica (Mayer, 1910)

Synonyms: *Eugenia cimmeria* Iliyn, 1930, *Campanulina pontica* Valkanov, 1936

Common names: No

Taxonomy: Class- Hydrozoa
Order- Leptolida
Family- Campanulinidae

Distinctive characteristics. (See Chapter 3)

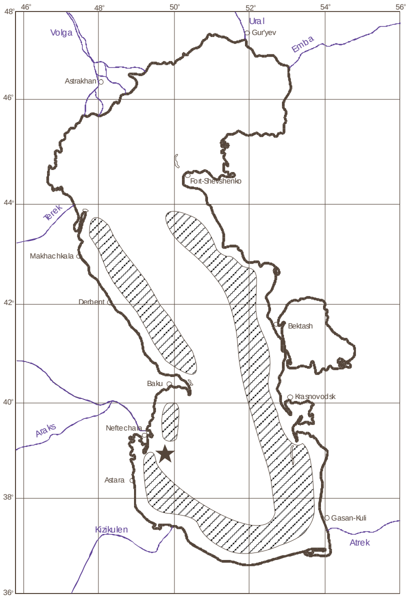


Blackfordia virginica: 1- hydromedusa; 2- young polyp
(HT - hydrotheca of polyp colony)

Probable origin. The Northern Atlantic Ocean, Black and Azov Seas.

Possible way of introduction. Penetrated into the Caspian from the Black or Azov seas through the Volga-Don Canal on hulls' fouling in 1956 (LOGVINENKO, 1959).

Distribution. The western and eastern coasts of the Middle and South Caspian Sea. In the northern part of the Apsheron Peninsula attains its mass development. Found also in the Greater Gizilagach (KASYMOV & BAGIROV, 1977; BAGIROV, 1989) and Northern Apsheron Gulfs.



Distribution of *Blackfordia virginica* in the Caspian Sea
★ - Area of the first registration

Habitats. Polyps settle on aquatic plants in shallow water, but its medusae are developing in surface layer coastal zones. A brackish water species, living in areas with the salinity from 3 to 18‰ (NAUMOV, 1968).

Impact on native species. It is a consumer of zooplankton, particularly copepods (*Eurytemora minor*, *Acartia clausi*). As a result, it is a food competitor of plankton-eating fish.

Compiled by A. Kasymov

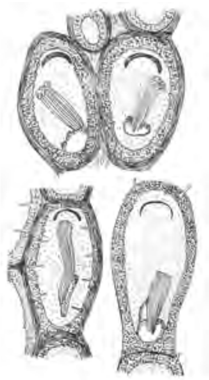
Conopeum seurati (Canu,1928)

Synonyms: *Nitschina seurati* Ganu, 1928, *Membranipora crustulenta* Abricosov, 1959, *Electra crustulenta* Zevina, 1959

Common names: No

Taxonomy: Class- Bryozoa
Order- Cheilostomata
Family- Membraniporidae

Distinctive characteristics. Oval crusts, the ratio of their length and width is 1,5-2,0. Zooids corners without triangular spaces. Larval stage lasts only 2-5 days.

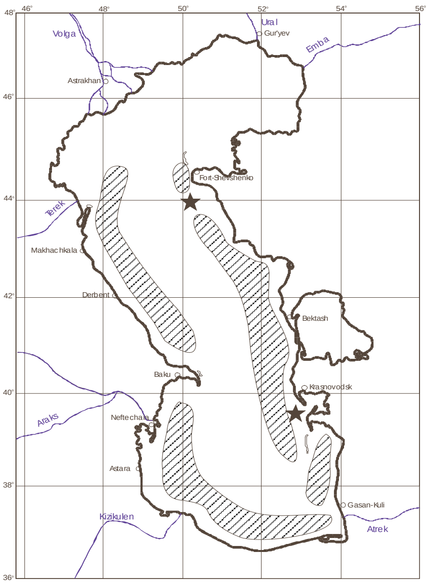


Conopeum seurati

Probable origin. The Atlantic Ocean, Mediterranean Sea and Black Sea.

Possible way of introduction. Accidentally introduced into the Caspian Sea, probably from the Black Sea by ships. Firstly was found in the Krasnovodsk Gulf in 1958 (ABRIKOSOV, 1959).

Distribution. The Middle and South Caspian Sea (BAGIROV, 1968). Planktonic larvae of *C. seurati* are short- living in the water column and the species is distributed by ships. In 1960, found in all ports of the Caspian Sea. Its biomass in the foulings of the Turkmenbashi Port was 0.3 kg·m^{-2} (BAGIROV, 1967). It often covered molluscs and barnacles but in its turn it is covered by *Barentsia benedeni*. It was also found out in the south-eastern part of the Southern Caspian Sea (KASYMOV *et al*., 1974), Krasnovodsk Gulf and in the eastern part of the Middle Caspian (KASYMOV, 1974; KASYMOV & BAGIROV, 1977), Chirag area in the South Caspian.



Distribution of *Conopeum seurati* in the Caspian Sea

★ - Areas of the first registration

Habitats. Occurs in and on the foulings of piers, ships and hydrotechnical constructions. In the South Caspian is found at the depths up to 150-200m.

Impact on native species. *C. seurati* does not share its ecological niche with other species in the Caspian Sea, but its impact on local biota is insufficiently known.

Compiled by A. Kasymov

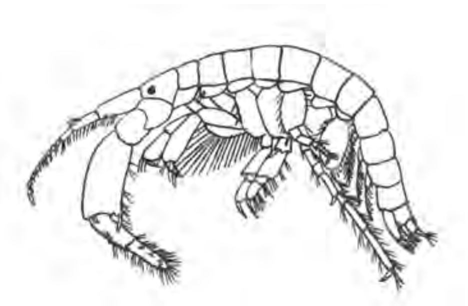
Corophium volutator (Pallas, 1766)

Synonyms: *Corophium longicorne* Latreille, 1806, *Corophium grossipes* G.O. Sars, 1894

Common names: No

Taxonomy: Class- Crustacea
Order- Amphipoda
Family- Corophiidae

Distinctive characteristics. Body length up to 7 mm, usually about 4 mm. At the base of the last but one segment of the second antenna stalk, a deep ditch, separating tooth from lower distal corner of segment. Tooth on the lower edge of the last segment of the second antenna 9 stalk absent. Telson apex protuberant.

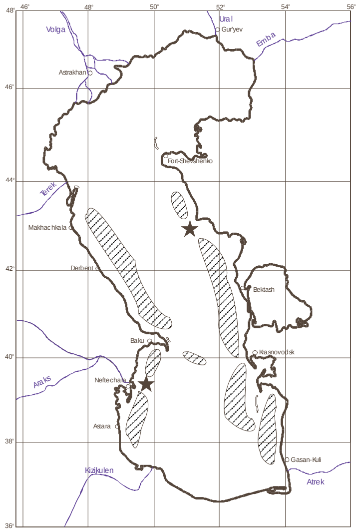


Corophium volutator

Probable origin. The Atlantic Ocean and Mediterranean Sea. A native species in the Black Sea and the Sea of Azov.

Possible way of introduction. According to BIRSHTEIN & ROMANOVA (1968), *C. volutator* penetrated in to the Caspian Sea from the Mediterranean Sea in ancient times. But it is very likely that it was accidentally introduced by ships from the Black and Azov Seas, where it is a mass species, or as a non-target species with the introduced invertebrates or fish.

Distribution. The Southern and Middle Caspian Sea (BAGIROV, 1968).



Distribution of *Corophium volutator* in the Caspian Sea

★ - Areas of the first registration

Habitats. The coastal waters of the South and Middle Caspian Sea on muddy bottoms and in fouling communities.

Impact on native species. Insufficiently known.

Compiled by A. Kasymov

Hypanis colorata (Eichwald, 1841)

Synonyms: *Adacna colorata* Eichwald, 1841, *Monodacna colorata* (Eichwald) Vest, 1876

Common names: No

Taxonomy: Class- Bivalvia
Order- Gastropemptia
Family- Cardiidae

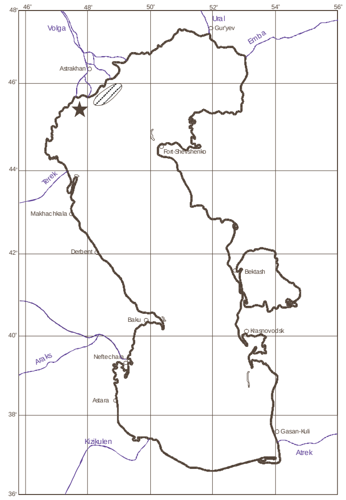
Distinctive characteristics. Length 40-41 mm, height 32 mm width 20 mm. Shell oval. Dorsal edge rounded, ventral one evenly rounded. Ribs, especially hind ones wide and divided by narrow spaces. Ribs number up to 28. Red or brownish-yellow in color .

Hypanis colorata

Probable origin. The Black Sea and the Sea of Azov.

Possible way of introduction. Via ships. Appeared in the Caspian in 1959 after the opening of the Volga-Don Canal (SAENKOVA,1956). In 1960, it was found in the lower Volga above Astrakhan City (KOSOVA, 1963) and in August 1961, in the Volga Delta and near Baranovsky Island.

Distribution. In front of the Volga River Delta, in the North Caspian Sea.



Distribution of *Hypanis colorata* in the Caspian Sea

★ - Area of the registration

Habitats. Muddy and muddy-sandy bottoms. KARPEVICH (1960) note, that *H. colorata* is well adapted to the Caspian Sea water salinity from 1 to 10‰. In the Volga River it occurs together with freshwater bivalves *Unio*, *Anodonta* and

Dreissena polymorpha at the depths of 20-50 m (KOSOVA, 1963). Feeds by filtration on green and diatom planktonic algae and detritus.

Impact on native species. It is an additional food for bottom-living fish, but its impact on other organisms needs to be investigated.

Compiled by A. Kasymov

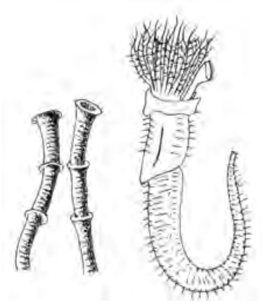
Mercierella enigmatica (Fauvel, 1923)

Synonym: *M. enigmaticus* (Hove and Weerdenburg, 1978)

Common names: No

Taxonomy: Class - Polychaeta
Order - Serpulimorpha
Family- Serpulidae

Distinctive characteristics. Body length 15-25 mm, segments 65-120, branchiate radials 10-20. Lid oblonged with compact stalk. Adults have several dark rings, pointed hooks on the frontal end of lid, lacking in young forms. Thoracal segments 7. Calcareous tubes curved and widened on the frontal end like funnel.

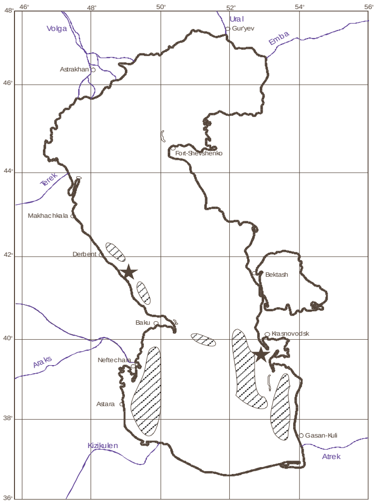


Mercierella enigmatica

Probable origin. Coastal waters of the Atlantic and Pacific Oceans, Metiterranean Sea, Black and Azov Seas.

Possible way of introduction. Accidental introduction by ships from the Black and Azov Seas. ZEVINA(1959) found this species for the first time in the Krasnovodsk Gulf and the port Mahachkala.

Distribution. In the Krasnovodsk Gulf, fouling with it occurs in small amount and average biomass in 1961 was 0.5 $kg \cdot m^{-2}$ (BAGIROV, 1967). In some years this species was found in the ships fouling, its biomass reached up 30 $kg \cdot m^{-2}$ (BOGORODITSKY, 1963). The biomass on the hydrotechnical constructions fouling is 0.30 -0.7 $kg \cdot m^{-2}$, and in the Chirag field 0.17 $g \cdot m^{-2}$.



Distribution of *Mercierella enigmatica* in the Caspian Sea

★ - Areas of the first registration

Habitats. Occurs in the fouling of ships and different hydrotechnical constructions. A brackish water species. In the Chirag field , found up to the depths of 150-200 m.

Impact on native species. In the areas of mass development of *M. enigmatica*, all the other species, both native and exotic, turned to be oppressed. But this question needs special investigations.

Compiled by A. Kasymov

Moerisia maeotica (Ostroumov, 1896)

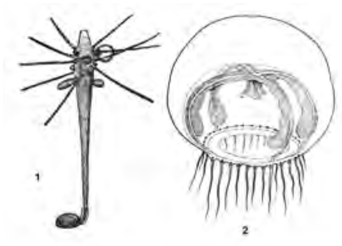
Synonyms: *Thaumanthias maeotica* Ostroumov, 1896, *Ostroumovia inkermanica* Valkanov, 1933, *Pontia ostroumovi* Paspalew, 1936

Common names: No

Taxonomy: Class- Hydrozoa

Order -Leptolida
Family-Moerisiidae

Distinctive Characteristics. Solitary polyps attached to substrate, or colonies consisting of 2-6 specimens. Number of pulpi from 3 to 12. Medusoidal gemmae developed between or under polyp pulps. Polyp height 4-5 mm. Medusa semispherical, umbrella height up to 12 mm, diameter up to 20 mm. Umbrella edge has up to 36 pulpi. Pulp base with an eye.

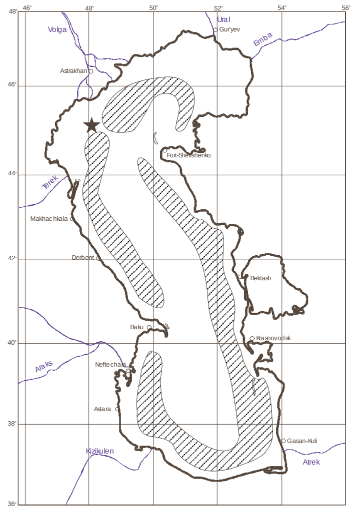


Moerisia maeotica: 1 – polyp, 2 - medusa

Probable origin. A Pontian relic species in the Black Sea and the Sea of Azov.

Possible way of introduction. Ballast waters and hull's fouling. For the first time found in the Northern Caspian Sea in 1960 (KARPEVICH, 1975).

Distribution. The north, Middle and South Caspian Sea. Occurs also in the Gizilagach and Northern Apsheron Gulfs.



Distribution of *Moerisia maeotica* in the Caspian Sea

★ - Area of the first registration

Habitats. Surface waters. In summer attains mass development.

Impact on native species. Competition for food with local planktophagous species.

Compiled by A. Kasymov

Mytilaster lineatus (Gmelin, 1790)

Synonyms: *Mytilus lineatus* Gmelin, 1789, *Myttilaster scaber* Krynicki, 1837, *Mytilaster monterosatoi* Dautz.-Milaschevich, 1916, *Brachyodontes lineatus* Thiele, 1935 *Brachiodontes lineatus* (Gm)- Grossu, 1962

Common names: No

Taxonomy: Class- Bivalvia
Order- Cyrtodontida
Family- Mytilidae

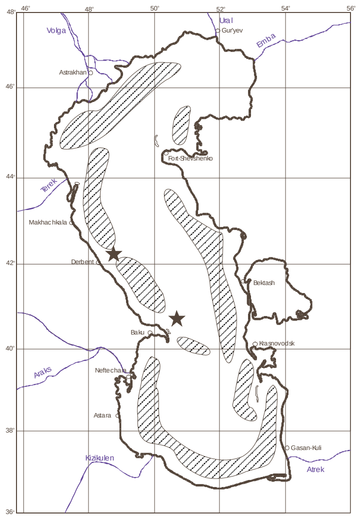
Distinctive characteristics. Length up to 25 mm. Crown on fore end of shell. Shell almost triangular, oblonged. Spinal edge protuberant, brown or violet. Abdominal edge straight or slightly concave. Bounded carina along valves close to abdominal edge. Inside surface of shell with violet tint. Key edge straight and consists of 2 or more visible fine teeth.

Mytilaster lineatus

Probable origin. The Mediterranean Sea.

Possible way of introduction. Accidentally introduced into the Caspian Sea (Baku Bay) during the civil war on the boats transported by railway from Batumy (BOGACHEV, 1928; LOGVINENKO, 1965). According to BOGACHEV (1928), it appeared in the Caspian Sea in 1919 and it penetrated here from the Black Sea.

Distribution. In a short time *Mytilaster* developed very successfully and after 1932 became a predominating species of benthos all over the Caspian Sea (LOGVINENKO, 1965). For the first time it was found by V.V. Bogochov near Derbent in the North section of Apsheron Peninsular in Baku Bay, Shikhov Spit near Baku City, on the rocks of Pirsagat Cape, Bandovan Cape, islands of the Baku Archipelago (BROTSKAYA & NITSENGEVICH, 1941). Total biomass in the Caspian Sea in 1958 amounted up to about 10 min tons, and total benthos in the coastal zones about 24 million tons (KARPEVICH, 1975). In the western section of the Southern Caspian the biomass of mytilaster was 1,05 kg·m^{-2} near Bandovan cape in 1964 (KASYMOV, 1970), 0,87 g/m^2 in the eastern section of Caspian in 1983, 6.18 g·m^{-2} in the western section. It is absent from the mouth of the Kura River but in the premouth area its biomass was from 4.0 to 18.2 g·m^{-2} in 1980 (KASYMOV, 1987 a,b), in the western section of South Caspian 4.7-10.8 g·m^{-2} in 1989 and 8.2-9.2 g·m^{-2} in 1991, in the eastern section 34.1 g·m^{-2} and 36.2, g·m^{-2} respectively. In the lightly polluted zone of Baku Bay near Nargin Island the density of it was 79-4600 ind·m^{-2} and biomass was 21.4-360.9 g·m^{-2} in 1981-1982 (KASYMOV, 1988).



Distribution of *Mytilaster lineatus* in the Caspian Sea
★ - Area of the first registration

Habitats. Lives in the waters with salinity from 7 to 13‰ it belongs to epifauna and lives on hard, stony and shelly grounds. Gobies, bream, vobla, kutum, zander, stellate sturgeon and sturgeon (BROTSKAYA & NETSENGEVICH, 1941). It was found at the depths of 150-200m in the oil field "Guneshli" (KASYMOV & ROGERS, 1996).

Impact on native species. After the appearance of *Mytilaster* in the Middle and South Caspian , the number of *Dreissena* species decreased considerably, mainly *D. polymorpha* was eliminated. After installation and distribution in the Caspian, *Mytilaster* invaded the habitats of *D. elata* and *D. caspia*. After mass development of *Mytilaster* the biomass of which attained several kilogrames for $1m^2$ at the depths down to 25-30m, these species of *Dreissena* have completely disappeared and they are considered to have died off at present. *Mytilaster* did not influence so strong on *D. polymorpha*, because the optimum zone of this species is in the lethal zone for *Mytilaster*. The competitive relationships between these species are not so clear. The optimum living zone of *D. rostriformis* is deeper than 25m and it inhabits on soft soils where the biomass of *Mytilaster* does not exceed some hundred grams for 1 m (LOGVINENKO, 1965). High oxyfility is typical for *Dreissena*, but *Mytilaster* extremely stands to unfavourable gas regime. That is why *Mytilaster* is able to form considerable biomass under the conditions where the number of oxyphilous species cannot be high. Forming a great aggregation, *Mytilaster* promotes oxygen deficiency by absorbing dissolved oxygen. This leads to deaths of oxyphilous animals. By firmly closing valves, *Mytilaster* can preserve viability for a long time (up to 20 to 24 hours), even at a complete lack of oxygen. The oxyphilous species are successfully developed in the same habitat with *Mytilaster* if the density of the latter is low (KARPEVICH, 1940, 1952).

Before the opening of the Volga-Don Canal, the fouling of water pipes in the South Caspian mainly consisted of *Mytilaster*, hydroids and Bryozoa. In water pipes taking water from the open sea, the fouling consisted of *Mytilaster* for 90% before 1961. After 1961, *B. impovisus* followed to *Mytilaster* (STAROSTIN, 1963).

Compiled by A. Kasymov

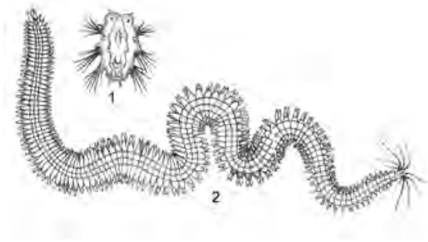
Nereis diversicolor (Muller, 1776)

Synonyms: *Nediste diversicolor* Malgren, 1876.

Common names: No

Taxonomy: Class- Polychaeta
Order- Nereimorpha
Family- Nereidae

Distinctive characteristics. Body up to 150 mm long. Four eyes on the head paddle, thorn shaped tentacles shorter than pulpi. Maxillae with 5-8 teeth. Abdominal branches of hind segments with common thickened bristles. Colour variates.

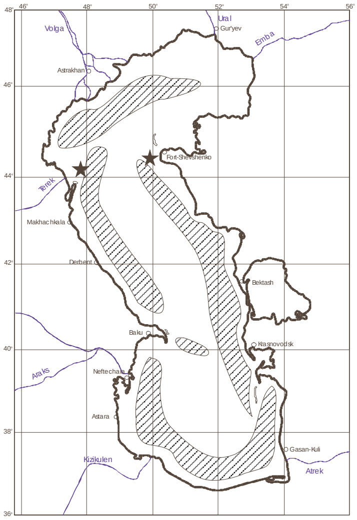


Nereis diversicolor

Probable origin. The Atlantic Ocean, Mediterranean Sea, Black and Azov Seas.

Way of introduction. Acclimatized in the Caspian Sea in 1939-1941. About 50,000 worms were introduced from the Sea of Azov in to the Caspian Sea. In the northern Caspian it was found in October 1944 in the stomachs of sturgeons caught near the Chechen Island. (ZENKEVICH, 1947) and in the benthos near Bautin (BIRSHTEIN & SPASSKI,1952).

Distribution. The largest amount of *N. diversicolor* was noted in 1946 near the Islands of Chechen, Tyule-nevity and Uralski Furrow. The average biomass of *Nereis* in the northern Caspian was 6,3 g/m^2 in 1948 and 4,1 g/m^2 in 1949 (BIRSHTEIN & SPASSKI, 1952). Decreasing in its biomass was observed in 1949, which is related with the intensive consumption by fish. In 1983, in the western part of the Middle Caspian, the biomass of this species was 0,31 g/m^2 (16 spec./m^2), 3,36 g/m^2 in the eastern part, 11,4 g/m2 in the west of south part Caspian 0,01 g/m^2 in the mouth of the Kura River, 0,8 g/m^2 in the premouth area of the Kura River (KASYMOV, 1987 a), 7,0 g/m^2 in the Gorgan Gulf (VLADIMIRSKAYA, 1973).The maximum biomass of *Nereis* in the western part of the Middle Caspian was 2,4 g/m^2 in July 1976 (KASYMOV, 1982). In the slightly polluted area of Baku Bay, near Nargin Island, the number of *Nereis* in 1981 was fluctuated from 60 to 180 spec./m^2 (KASYMOV, 1988). Decline in population of this species is connected with oil pollution of bottom sediments.



Distribution of *Nereis diversicolor* in the Caspian Sea

★ Areas of the first registration

Habitats. It is living in muddy bottom in U-shaped holes with rusty colour walls. Maximum development was noted at a salinity from 5 to 15,5‰. In the "Guneshli" field , *N. diversicolor* was found at the depths of 150-200m (KASYMOV & ROGERS, 1996). It breeds in summer. Trochofores are unpelagic ones, duration of life one year (KHLEBOVICH, 1968). Euryhaline and eurythermal species. Adult forms stand salinity changes from fresh water to 30‰. Resistent to oxygen depletion. Feeds on detritus, algae and bacteria on them.

Impact on native species. It was noted that the increasing in the number of *N. diversicolor* in 1940-1945 coincides with a sharp increasing in benthos biomass in the Northern Caspian (BIRSHTEIN & SPASSKI ,1952). Thus, the naturalisation of *Nereis* into the Caspian Sea did not influence negatively on other groups of benthos. During the period of stabilization of *Nereis* biomass, the increase in the biomass of molluscs (*Monodacna*, *Dressena*, *Adacna*, *Didacna*, *Cerastoderma*), crustaceans and chironomid larvae continued. It proves that the new settler did not begin to conflict with native species of the Caspian Sea benthos. Soft bottoms were inhabited in very little by Olygochaetes, Chironomids, and in a less degree by the mollusc *Adacna* before the introduction of *Nereis*. Therefore, the typical inhabitant of soft bottom *N. diversicolor* had first of all occupied areas poorly inhabited by other bottom dwelling animals. *Nereis* has also settled quickly along the Lesser Kizilagach Gulf and in 1948 it was the main component of the benthic community in the area (DYUNINA, 1949).

Compiled by A. Kasymov

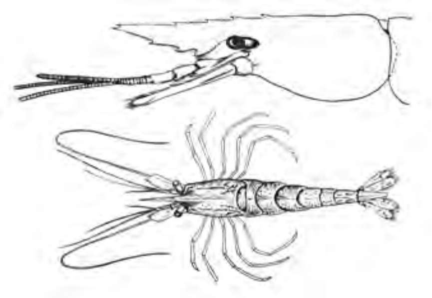
Palaemon adspersus (Rathke, 1837)

Synonyms: *Leander rectirostris* Zaddach, 1847, *Leander edwardsi* Czerniavsky, 1884

Common names: Shrimp (Eng.), Krevetka (Rus.), Karides (Tur)

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Palaemonidae

Distinctive characteristics. Length up to 70 mm. Rostrum usually goes behind scafocerits. On the upper edge 5-6, rarely 7 thorns, one of which behind eye sockets. Differs from similar shrimps by length of bill. Bill straight, end usually two-toothed. Living forms usually striped, and a blue stripe on palms of large claws more notible than a yellow one.

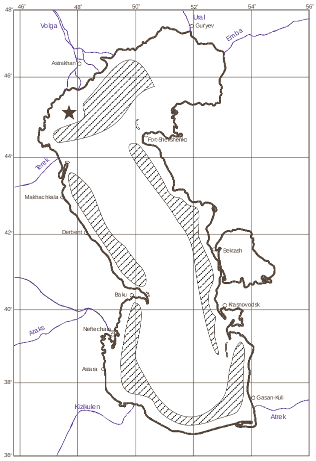


Palaemon adspersus

Probable origin. The Atlantic Ocean, Mediterranean Sea, Black Sea and the Sea of Azov.

Way of introduction. This shrimp was introduced into the Caspian Sea in 1930-1934 as a non-target species during acclimatization of the Black Sea grey mullets together with its fry. In 1937 it was caught in the Caspian Sea for the first time (KARPEVICH, 1975).

Distribution. The Middle and South Caspian, but do not occur in the low salinity areas of the North Caspian. They are numerous in the ports Mahachkala, Turkmenbashi, Baku, in Tyub-Karagack Bay and in the coastal waters of the Apsheron Peninsula.



Distribution of *Palaemon adspersus* in the Caspian Sea

★ - Area of the first registration

Habitats. Coastal marine and brackish waters. Inhabits mainly the silt-covered sandy soils and as well as stony ridges plays an important role in the food of herring *Alosa kessleri kessleri*. Feeding on this shrimp, the herrings keep zooplanktons for other planktophagous fish species.

Impact on native species. Naturalization of this shrimp has led to the improvement of the food reserve of some local fishes. Shrimps are additional food for herrings *Alosa caspica caspica, A. saposhnikovi, A. brashnikovi brashnikovi, Stilostedeon marina*, stellate sturgeon (*Acipenser stellatus*), beluga (*Huso huso*) and the Caspian seal (*Phoca caspica*).

Compiled by A. Kasymov

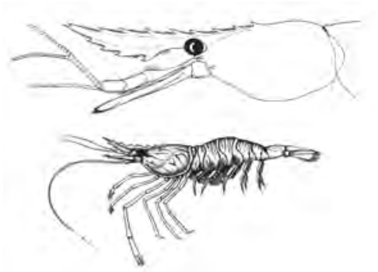
Palaemon elegans (Rathke, 1837)

Synonyms: *Cancer squilla* Forsk., 1775, *Leander squilla* Ostroumov, 1896.

Common names: No

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Palaemonidae

Distinctive characteristics. Length up to 50 mm. On the upper edge of rostrum and middle line of cephalothorax, testa 7-9 thorns, 2-3 behind eye-socket; lower edge of rostrum with 5-4 thorns and with 2 teeth. Lining forms spotty.A yellow stripe on large claws usually more visible than a blue one.

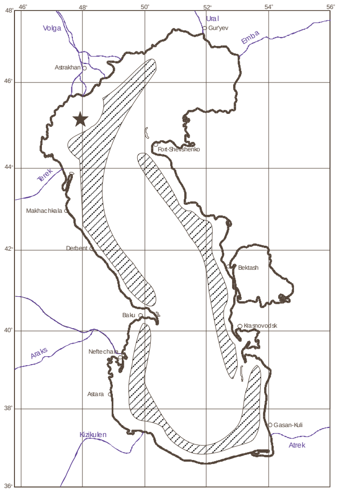


Palaemon elegans

Origin of species. The Atlantic Ocean, Mediterranean Sea, Black Sea and the Sea of Azov.

Way of introduction. In 1930-1934, during the transportation of Black Sea grey mullets into the Caspian Sea, larvae were brought accidentally as non-target species (LAVROV-NAVOZOV, 1939; KUDELINA, 1950). For the first time it was found in the Caspian Sea in 1957 (KARPEVICH, 1975).

Distribution. This species found favourable conditions in the Caspian Sea. Mass breeding of these shrimps on the Dagestan coast was noted in 1939. At present it lives in the Middle and South Caspian Sea but lacks in the low salinity areas of the North Caspian.



Distribution of *Palaemon elegans* in the Caspian Sea

★ - Area of the first registration

Habitats. Occurs mainly on the sandy, sandy-muddy bottoms and on algae. Embrional development in the Caspian Sea lasts 14 days at water temperature 21,2°C and 12 days at 25 °C. Newly hatched larvae are about 2 mm long. Some larvae finish pelagic stage at the 12th stage and the larva looks like a small shrimp after the 11th moulting. Sometimes the larva pass into bottom dwelling stage after the14th moulting. Sexual maturity is attained at one year old. Reproduction takes from May to September, females spawn twice a year in nature, but 7 times under laboratory conditions. Average fecundity of *P. elegans* was 238-755 eggs per one spawning (KUDELINA, 1950). These shrimps feeds animals detritus: remainders of gammarids, chironomids, and algae.

Impact on native species. Insufficiently known.

Compiled by A. Kasymov

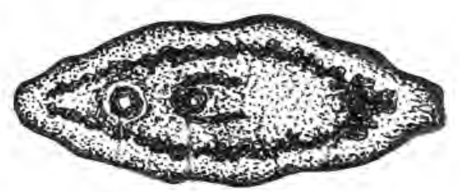
Pentacoelum caspicum (Beklemishev, 1954)

Synonyms: No

Common names: No

Taxonomy: Class- Turbellaria
Order- Seriata
Family- Dendrocoelidae

Distinctive characteristics. Length up to 1 mm, width 0,4mm. Back branches of intestine are not connected between themselves, each of them carry 3-5 sprigs in the middle part. Penis with penial glands. Body stretched, head ends rounded. Mouth at the distance of 1/7 of body length, both foremens are near back end of body. Copulative bags foramen is in front of sexual one. Body and two eyes are without pigments.

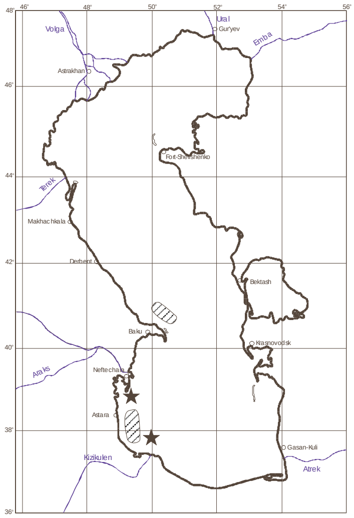


Pentacoelum caspicum

Probable origin. The Mediterranean Sea, Black Sea and Sea of Azov.

Possible way of introduction. First discovered in the South Caspian Sea in 1941. This species can be a Postpleiocene immigrant or probably it penetrated into the Caspian later. MORDUKHAY & BOLTOVSKOY (1968) supposed that, *Pemtacoelum* is a representative of Mediterranean fauna and in the Caspian Sea was accidentally introduced by human activities.

Distribution. The South and Middle Caspian Sea.



Distributiom of *Pentacoelum caspicum* in the Caspian Sea

★ - Areas of the first registration

Habitats. Lives in the fouling of piers, hydrotechnical constructions and rocks.

Impact on native species. Insufficiently known.

Compiled by A. Kasymov

Perigonimus megas (Kinne, 1956)

Synonyms: *Bougainvillia megas* Kinne, 1956, *Bougainviilla ramosa* Less. (Hummelinck,1936), *Cordylophora caspia f. lacustris-f. typica* (Vervoort, 1946)

Common names: No

Taxonomy: Class- Hydrozoa
Order- Leptolida
Family- Bougainvillidae

Distinctive characteristics. (See Chapter 3)

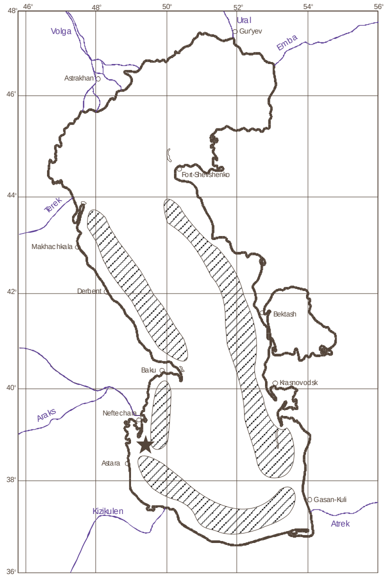
Perigonimus megas

Probable origin. The Coastal waters of the North Atlantic Ocean, Black Sea, Sea of Azov.

Possible way of introduction. It was accidentally introduced into the Caspian Sea after the opening of the Volga-Don Canal (ZEVINA, 1962). Probably it was transported on the ships' hulls. For the first time it was found in the Greater Gizilagach Gulf in the South Caspian in 1960.

Distribution. The western (Mahachkala) and eastern coasts of the South Caspian Sea. In the Chirag field its biomass was 0.06 $g \cdot m^{-2}$ in 1997. BAGIROV (1989) found it in a great number in the Great Gizilagach Gulf, and KASYMOV (1974) in Krasnovodsk Bay.

Habitats. Occurs in the foulings of ship's hulls, buoys, port constructions and water pipes intake system. In the Krasnovodsk Gulf and Makhachkala port developed in great number. It is a brackish water species and it was discovered down to 200 m in depth.



Distribution of *Perigonimus megas* in the Caspian Sea

★ - Area of the first registration

Impact on native species. This hydroid is forming considerable settlings on solid substrates and is hampering water currents in pipes.

Compiled by A. Kasymov

Pleopis polyphemoides (Leukart, 1859)

Synonyms: *Evadne polyphemoides* Leukart, l859, *Podon polyphemoides* Lilljeborg, 1900, *Podon mecznikovi* Czerniavsky, 1868

Common names: No

Taxonomy: Class- Crustacea
Order- Cladocera
Family- Podonidae

Distinctive characteristics. Body height 0,3-0,4 mm. Antennae short, last segment of both branches very small. Exopodits of pectoral legs comparatively abundant and according to this sign ,differed from other Caspian podonids with no more than 2 bristles on exopodit. Shell semispherical.

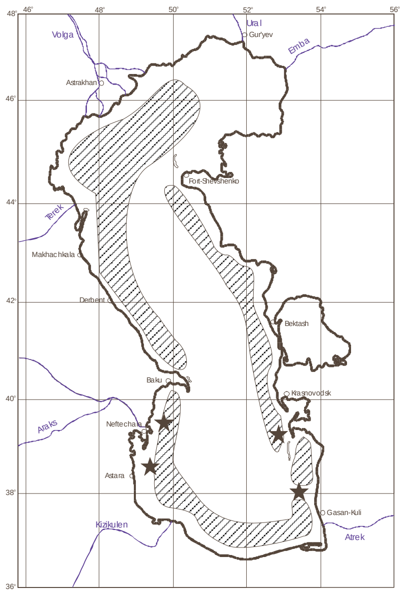
Head large, high. Caudal claws differ from those of other species very much. Male differs from female by large head and eyes.

Pleopis polyphemoides

Probable origin. The Mediterranean Sea, Black Sea and Sea of Azov.

Possible way of introduction. Via ships through the Volga-Don Cannal (MORDUKHAY-BOLTOVSKOY, 1960, 1968). First discovered in the Southern Caspian in 1957.

Distribution. The North, Middle and South Caspian Sea.



Distribution of *Pleopis polyphemoides* in the Caspian Sea

★ - Areas of the first registration

Habitats. Euryhaline and eurythermic plankton species living in surface waters with salinities up to 13‰. In summer attains its mass development.

Impact on native species. It is additional food for planktophagous fish.

Compiled by A. Kasymov

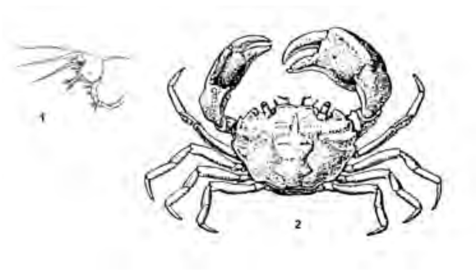
Rhithropanopeus harrisi tridentatus (Maitland, 1874)

Synonyms: *Pilumnus tridentatus* Maitland, 1874; *Heteropanope tridentata* Makarov, 1939; *Rhithropanopeus harrisi* Rathbun, 1930; *Rhithropanopeus harrisi tridentata* Alida M. Buytendyk and Holthuis, 1949

Common names: White-fingered crab (Eng), Golandsky crab (Rus)

Taxonomy: Class- Crustacea
Order- Decapoda
Family- Xanthidae

Distinctive characteristics. (See Chapter 3)

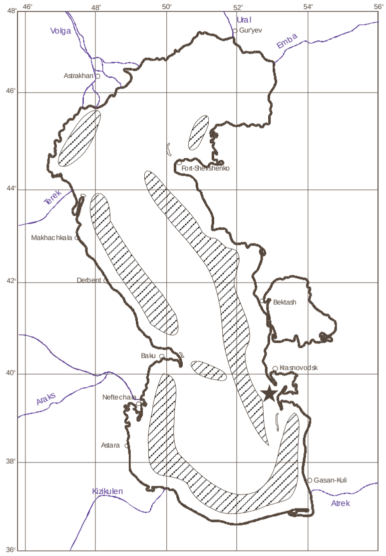


Rhithropanopeus harrisi tridentatus: 1 - zoea, 2 – adult

Probable origin. The Atlantic coasts of North America, Black Sea and the Sea of Azov.

Possible way of introduction. Accidentally introduced into the Caspian Sea by ships from the Sea of Azov via the Volga-Don Canal. Firstly discovered in the Caspian in 1958.

Distribution. In the southern Caspian (Krasnovodsk Gulf) found in 1961 (STAROSTIN, 1963). According to BAGIROV (1967), the density of crab amounted to 1000-5000 spec.m^{-2} in the benthos of this gulf in 1961, and 3,600 speciment.m^{-2} in the pipe foulings. In the south-eastern part of the Caspian its density was 760 spec.m^{-2} and biomass 12.6 g.m^{-2} (KASYMOV *et al*., 1974). Biomass of this crab attains 12,4 g.m^{-2} near Sumgait, 12,4 g.m^{-2} near Neft Dashlari Island (KASYMOV & BAGIROV, 1974), 15,4 g.m^{-2} in the Turkmenbashi Gulf, 17,5 g.m^{-2} in the eastern section of the South Caspian (KASYMOV, l982).



Distribution of *Rhithropanopeus harrisi tridentatus* in the Caspian Sea

★ - Area of the first registration

Habitats. Euryhaline species. Planktonic larvae are distributed over the sea by currents. It is additional food for sturgeons. Occurs at the depths over to 150-200 m (KASYMOV & ROGERS, 1996). Lives mainly on muddy and sandy bottoms.

Impact on native species. As a predator, this crab feeds on bottom crustaceans, hydroids, small molluscs and is a competitor of benthophagous fish. Besides, the crab spoils fish in the nets (ZENKEVICH & ZEVINA, 1969). *Rhithropanopeus* is eaten by sturgeons. But itself feeds on amphipods, which are food of many benthic commercial fishes (TARIVERDIEVA, 1965). Its larvae consume large amount of phytoplankton and detritus which are suitable food for zooplankton and zoobenthos.

As a whole , this crab brings more damage than benefit to the Caspian Sea ecosystem. Its larvae consums large amount of phytoplankton and detritus, which are the food of zooplankton and zoobenthos species.

Compiled by A. Kasymov

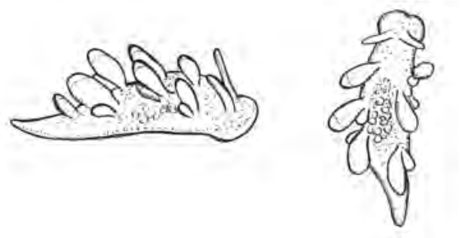
Tenellia adspersa (Nordmann,1845)

Synonyms: *Tergipes adspersus* Nordmann, 1845, *Eolis pallida* Alder et Hancock, 1855

Common names: No

Taxonomy: Class- Bivalvia
Order- Nudibranchia
Family- Tergipedidae

Distinctive characteristics. Body length from 1,5 to 3 mm. Dorsal appendages pin shaped, settled in longitudinal lines in 3-5 groups . Appendages unpaired on body ends. Mouth pulpi absent. According to morphology the Caspian species completely identical to the Azov-Black Sea ones (ANTSULEVICH & STAROBOGATOV, 1990), but the latters somewhat bigger, up to 5 mm (TURPAEVA, 1972). Body white-pine, appendages reddish, numerous black spots on the body.

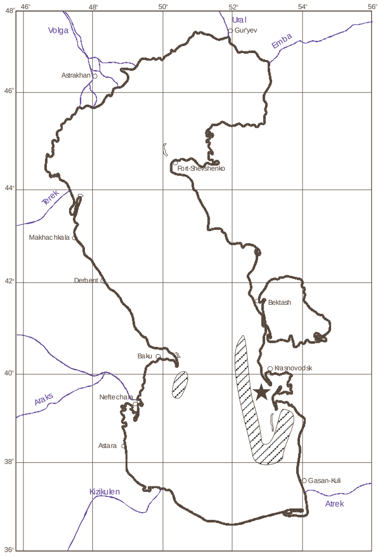


Tenellia adspersa

Probable origin. The Mediterranean Sea, Black Sea and the Sea of Azov.

Possible way of introduction. Accidentally introduced into the Caspian Sea from the Azov or Black Sea through the Volga-Don Canal on the ships' bottom. For the first time it was found in the eastern coast of the south Caspian Sea in 1989 (ANTSULEVICH & STAROBOGATOV, 1990). In 1998, was found near Baku in the area of Shahdeniz field.

Distribution. Cheleken and Apsheron coastal areas of the Caspian Sea. In Cheleken area, on a artificial reef, their density was 700 spec.m-^{2} and on the bottom in the Shahdeniz field up to 160 spec.m-2. The species was also found near Ogurchinski island in the easthern part of the southern Caspian.



Distribution of *Tenellia abspersa* in the Caspian Sea

★ - Area of the first registration

Habitats. Lives in the fouling of artificial reefs at salinities from 5,3 to 36‰ (in coastal lagoons). In the Caspian itself lives in the colonies of the hydroid *Cordylophora caspia* and feeds not only on hydroid's body but on its gastroplasm not damaging hydrants (ANTSULEVICH & STAROBOGATOV, 1990).

Impact on native species. Insufficiently known.

Compiled by A. Kasymov

<u>Fishes</u>

Liza aurata (Risso, 1810)

Synonym: *Mugil auratus* Kasancheev, 1981

Common names: Grey mullet (Eng), Singil' (Rus), Orsbalyk, Iylanbaş, Çontam (Turkmenian)

Taxonomy: Class- Osteichthyes
Order- Mugiliformes
Family- Mugilidae

Distinctive characteristics. Length up to 30 cm, mass to 1 kg. Head large, snout covered by scales as far as back pair of nostrils. Snout rather wide. Scale on the back and head has one by one canal in the middle.

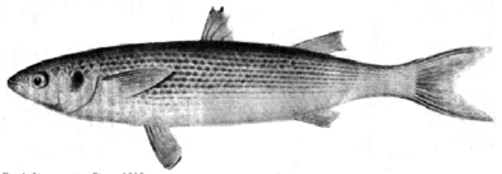
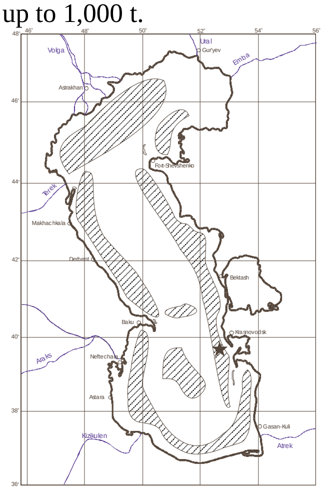


Fig.4. Liza auratus Risso, 1810

Liza aurata

Origin of species. The Atlantic Ocean, Mediterranean Sea, Black Sea and Sea of Azov.
Way of introduction. Fries and youngs of grey mullets *L. aurata* and *L. saliens* were released as commercial species into the Caspian Sea in 1930-1934 from the Black Sea (MARTI, 1940). For the first time, it was found to the north of Krasnovodsk Gulf in 1933.

Distribution. Lives in all the Caspian Sea except very low salinity areas of the river mouths. It winters in the Southern Caspian Sea. Migrates from the Southern Caspian to the North in the beginning of March (KAZANCHEEV, 1981). Commercial fishery of this species is carried out in Turkmenistan, Azerbaijan and Kazakhstan. Annual catch up to 1,000 t.



Distribution of *Liza aurata* in the Caspian Sea
★ - Area of the first registration

Habitats. Coastal waters. Adult specimens feed on mainly on micro- and meiobenthos, but youngs on zooplankton, including larvae of molluscs and other invertebrates.

Impact on native species. Insufficiently known.

Compiled by A. Kasymov and F. Shakirova

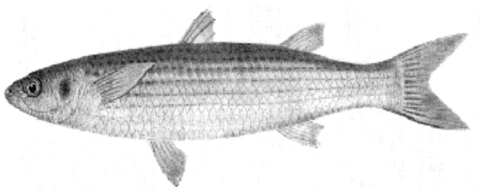
Liza saliens (Risso, 1810)

Synonyms: *Mugil saliens* Kazancheev, 1981

Common names: Grey mullet (Eng), Ostronos (Rus), Yitiburun, Gatykelle (Turkmenian).

Taxonomy: Class - Osteichthyes
Order- Mugiliformes
Family- Mugilidae

Description. Length up to 40 cm, average mass 300g. Head narrower than *L. auratus,* side view straight. Scales on the head yet finer toward to the end of snout. Scales on the head and the fore part of back has 2-3, sometimes 5 canals. Snout comparatively wide, rounded. Stomach fundus with unequal in length pyloric appendages.



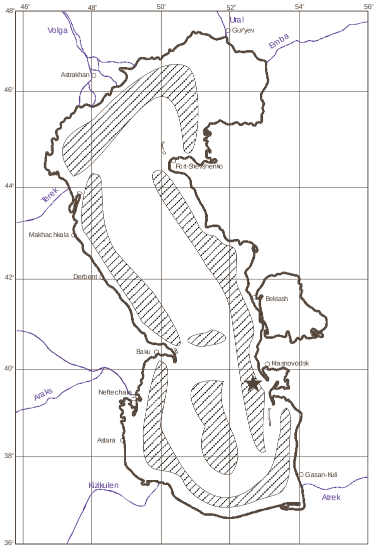
Liza saliens

Origin of species. The Atlantic Ocean, Mediterranean Sea, Black and Azov seas.

Way of introduction. Fry and young fish of grey mullets *L. aurata* and *L. saliens* were released into the Caspian Sea in 1930-1934 from the Black Sea (MARTI, 1940). This species was first found to the north of the Krasnovodsk Gulf in 1933.

Distribution. *L. saliens* lives in the same regions as the previous species. Predominates in the western and southern coasts of the Caspian Sea. It usually lives closer to seashore and does not go to the north. It was found in the

Mankishlack region of the Caspian sea , too. Larvae and youngs live close near to the Middle and Southern Caspian seashores (KAZANCHEEV, 1981).



Distribution of *Liza saliens* in the Caspian Sea

★ - Area of the first registration

Habitats. Spawning occurs in the South Caspian at the end of May at water temperature of 22°C. In the Middle Caspian spawning begins in the middle of June, but in the northern regions it happens in the beginning of July.

Impact on native species. Naturalization of this species into the Caspian Sea has not lead negative effects for indigenous fishes. It occupied vacant ecological niches and feeds on detritus, micro- and meiobenthos, which are not used much by native Caspian fishes.

Compiled by A. Kasymov and F. Shakirova

Additional Information to Chapter 5

The way of introduction into the Caspian Sea of red macroalgae *Ceramium diaphanum* (Lightf.) Roth and *C. tenuissimum* (Lyngb.) J. Ag., and brown alga *Ectocarpus confervoides* (Roth) Le Jolis, which are usually common in the Black Sea (ZINOVA, 1967), is not yet clear. It is possible that they have been introduced via anthropogenic activities, but it is rather difficult to discern where they are native or non-native. CARLTON (1996) refered to these taxa as cryptogenic species.

The bivalve *Abra ovata* Philippi, from the Sea of Azov was released into the Caspian Sea in 1939-1940 and in 1947 (KASYMOV, 1987a). It was first discovered in the Caspian in 1956. Now it is a mass mollusc species in the Middle and Southern Caspian, its biomass reaching up to 804 $g.m^{-2}$.

Recently, in the Caspian Sea were found the moon jelly *Aurelia aurita* (Scyphozoa), *Penilia avirostris* (Cladocera), and *Lithogliphus naticoides* (Gastropoda), which were introduced, probably, by ships from the Black Sea or the Sea of Azov.

Corophium volutator (Pallas, 1766) (Amphipoda). A native species in the Black and Azov Seas. According to BIRSHTEIN & ROMANOVA (1968), it was penetrated into the Caspian Sea from the Mediterranean Sea in ancient times. But, it is very likely that it was accidentally introduced by ships from the Black and Azov Seas (KASYMOV 1974). Distributed in the South and Middle Caspian Sea (BAGIROV 1968).

Mnemiopsis leidyi, Agassiz, 1865 (Ctenophora). It was accidentally introduced by ships from the Black and Azov Seas. In 1996 Turkmeni fishermen began reporting 'strange jellyfish' in their nets. In November 1999 the presence of *Mnemiopsis* in the Caspian Sea was confirmed by scientists from Fisheries Research Institute of Russian Federation in Astrakhan (P. IVANOV and A. KAMAKHIN) during an expedition along the east coast of the Caspian, in the Turkmen and Kazakh sectors at 40°58’, 52°45’ in coastal zone at 40 m depth (S. VOLOVIK, pers. comm.) By the summer of 2000 ,it was recorded at densities of up to 100 individuals per m^2. Less than one year after its initial siting, the comb jelly succesfully inhabits most of the Caspian Sea (SR, 2001).

Medaka *Oryzias latipes* (TEMMINK et SCHLEGEL) (See Chapter 3). Originated from the eastern Asia, this small fish was introduced in the Kazakhstan rivers as a non-target species with commercial fish. In the sea it can be observed in the river mouth areas (GVOZDEV & MITROFANOV, 1986).

Mosquitofish *Gambusia affinis halbrookii* (Girard.). Originated from the North American fresh waters. It was introduced in Kazakhstan rivers in 1934, probably from the Black Sea wetlands (GVOZDEV & MITROFANOV, 1986). It can be observed in river mouth areas of the Caspian Sea.

Snake-head *Ophiocephalus argus warpakhowskii* Berg (Class- Osteichthyes, Order- Ophiocephaliformis, Family- Ophiocephalidae). A large fish up to 1m in length, originated from the East Asian rivers. It was introduced in the Caspian Sea and inflowing rivers as a non-target species with commercial fish, silver carp *Hypophthalmichthys molitrix* and green carp *Ctenopharingodon idella* in the 1950s. It is caught in the Caspian Sea (SHAKIROVA & SUKHANOVA, 1993).

Flounder *Platichthys flesus luscus* (Pallas), (Class- Osteichthyes, Order- Pleuronectiformes, Family- Plueronectidae). It was released in the Caspian Sea in the 1910s and in 1930-1931 from the Black Sea and the Sea of Azov (ZENKEVICH, 1956), but is not a mass species in the Caspian Sea today.

Raccoon-dog *Nyctereutes procyonoides* (Gray), (See Chapter 4). It is a rather usual animal in the Caspian coastal wetlands. It feeds on terrestrial and aquatic animals.

Raccoon *Procyon lotor* L. (Class- Mammalia, Order- Carnivora, Family- Procyonidae). Originated from North America, it was settled into the URSS in 1936-1940, as a fur-bearer. Now it is a mass inhabitant of the Caspian Sea shores, especially in Azerbaijan. It is an omnivorous carnivore, harmful for poultry (Ramiz Taghiev, pers. comm.), sometimes feeds on aquatic molluscs, crayfish, crabs and fish.

DISCUSSION

During the 20th century, especially since the 1950s, the Aegean, Marmara, Black, Azov and Caspian Seas (AMBACS)were invaded by different allochthonous species of plants and animals, originated from outside and transported into the AMBACS by human activities. There are several natural and anthropogenic reasons for process. One of the natural reasons is the habitat diversity in these seas, which allows the colonization of different halophylic and halophobic, thermophylic and thermophobic, pelagic and benthic organisms. Another natural reason is the pronounced endemism of native flora and fauna in the Black, Azov and Caspian Seas and, as a result, a low specific diversity and relativly weak biological immunity of respective ecosystems. Introduced exotics do not encounter antagonistic species and corresponding inhibition from local biota. The result of this exposure to external factors is the practically unlimited development of invaders.

The anthropogenic reasons are the development of shipping and the increasing of other kind of man-made impacts on marine environment, including cultural eutrophication, construction of canals, harbors, and other hydrotechnical installations.

The lists of exotic species in each sea are becoming longer and this is not only because of penetration of new settlers, but also because of increasing attention of scientists, seamen, national and international organizations to this problem.

According to the editor's estimation, by the year 2000, the total number of exotic organisms, introduced into the considered system of seas and its coastal wetlands, was 18 species of plants and 126 species of animals. Their taxonomic structure is represented as follows.

Plants	18 species
Invertebrates	79 species
Fish	43 species
Mammals	6 species
Total	146 species

Phyletic diversity

From 22 divisions (phyla) of plants (FEDOROV, 1974), representatives of 8 divisions (36%) are in the list of exotic species in the AMBACS system, and from 35 animal marine phyla (RAY & GRASSLE, 1991), representatives of 9 phyla (26%) were introduced in the same seas (Figure 1).

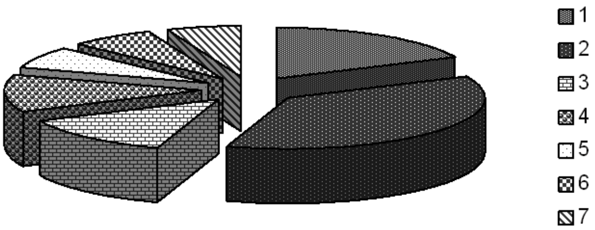


Figure1. Phyletic diversity of exotic species accidentally and intentionally introduced into the AMBACS system (in brackets are numbers of species).

1. Plants divisions (phyla): Pyrrophyta (2); Chrysophyta (1); Bacillariophyta (3); Euglenophyta (1); Phaeophyta (2); Rhodophyta (5); Chlorophyta (2); Polypodiophyta (2).

Animal phyla: 2. Chordata (49); 3. Arthropoda (25); 4. Mollusca (30); 5. Annelida (9); 6. Coelenterata (8); (7)Other Invertebrata, 4 phyla: Ctenophora (2); Entoprocta (2); Platyhelminthes (1); Bryozoa (2).

Among 18 species of plants, there are 2 species of Pyrrophyta (dinoflagellates), 1 of Chrysophyta (yellow-green algae), 3 of Bacillariophyta (diatoms), 1 of Euglenophyta (flagellate). All these species are planktonic. Benthic algae are represented by 2 species of Phaeophyta (brown algae), 5 species of Rhodophyta (red algae) and 2 species of Chlorophyta (green algae). At least, 2 species belongs to floating ferns, Polypodiophyta.

Probably, the main part of these non-native plants was introduced with ballast waters, but some of them, e.g. *Acantophora muscoides*, *Caulerpa racemosa* and *Ganonema farinosum*, could be transported in the form of floating spores by water currents from the Red Sea. Consequently, they can be considered as Lessepsian migrants.

The phylum Coelenterata is composed of 7 species of hydroids and two jellyfishes *Aurelia aurita* and *Rhopilema esculenta.* The last one was introduced from the Black Sea or the Sea of Azov into the Caspian Sea. All hydroid species have both benthic (polyps) and pelagic (hydromedusae) stages and probably have been transported by ships in ballast waters and in hull's fouling.

Two species of comb jellies (phylum Ctenophora) are pelagic and probably were transported in ballast waters.

The flat worm *Pentacoelum caspicum* (phylum Platyhelminthes) is a benthic invertebrate and probably it was introduced into the Caspian Sea from the Sea of Azov or the Black Sea as a component of hulls' fouling community. Representatives of Entoprocta Phylum, *Barentsia benedeni* and *Urnatella gracilis* are also benthic animals able to attach to ships' hulls.

Eight species of Annelida phylum are represented by Polychaeta worms. All of them have pelagic larvae and can be transported in ballast waters. Adult specimens of *Mercierella enigmatica* are living in calcareous tubes attached to solid substratum and are one components of fouling communities. *Nereis diversicolor*,bristle worm**,** was released into the Caspian Sea as a prey worm for sturgeons and other benthophagous fish.

The Arthropoda phylum is represented by different crustacean species of Cirripedia, Copepoda, Cladocera and Decapoda. Planktonic copepods (*Acartia tonsa* and *A. clausi*) and cladocerans (*Penilia avirostris* and *Pleopis polyphemoides*) were introduced in ballast waters. Barnacles *Balanus improvisus* and *B. eburneus* can survive in both ballast waters and in hulls' fouling. Probably the same way of introduction concerns shrimps and crabs. At least, zoea and megalops of crabs were repeatedly observed in ballast waters. The shrimp *Ma*rsup*enaeus japonicus* is most probably a Lessepsian migrant through the Suez Canal from the Red Sea and Indian Ocean.

The Mollusca phylum is composed of 5 species of Gastropoda and 7 species of Bivalvia. All of them has pelagic larvae , thus could be transported in ballast waters. Besides *Rapana* have egg capsules attached to hard substrate, *Mytilaster* has byssus, a bundle of silken anchorage files to attach to hard underwater surfaces. The oyster *Crassostrea gigas* was introduced in the Black Sea for maricultural purposes. The shipworm *Teredo navalis* is considered to be introduced by ancient ships, as a wood boring mollusc. The bivalve *Abra ovata* was intentionally introduced into the Caspian Sea to enrich its food resources for bottom fishes.

The Chordata phylum is the most numerous in the list of the AMBACS introduced exotic species. Among 35 fish species, 16 are considered as Lessepsian migrants, entering the Mediterranean and Aegean Seas via the Suez Canal. There are *Alepes djeddaba, Atherinamorus lacunosus, Hemiramphus far, Lagocephalus spadiceus,Leiognathus klunzingeri, Liza carinata, Parexocoetus mento, Pempheris vanicolensis, Sargocentron rubrum, Saurida undisquamis, Scomberomorus commerson, Siganus luridus, S. rivulatus, Sphyraena chrysotaenia, Stephanolepis diaspros*, and *Upeneus moluccensis*. All of them settled in the eastern Mediterranean and Aegean Sea but their further spreading to the Black Sea and the Sea of Azov is obviously stopped by the salinity and temperature barrier.

Other 14 species were intentionally introduced as economically important fish. There are *Aristichthys nobilis, Ictalurus punctatus, Ictiobus bubalus, I. niger, Morone saxatilis, Mugil soiuy, Hypophthalmihthys molitrix, Liza aurata, L. saliens, Platichtys flesus luscus, Polyodon spatula, Setiobus cyprinellus, Tilapia mossambica***,** and *Tribolodon brandti.* These species were introduced mainly in the Black, Azov and Caspian Seas and in the coastal wetlands of these seas. Some of them are now important commercial fish. Among them there are the haarder, *Mugil soiuy* in the Black and Azov Seas, the grey mullets *Liza aurata* and *L. saliens* in the Caspian Sea, and the silver carp *Hypophthalmichthys molitrix* in the rivers flowing into the Black, Azov and Caspian Seas and in freshened areas of these seas.

The Japanese medaka *Oryzias latipes* is a non- target species introduced during stocking of Far East origin commercial fish. The mosquito fish *Gambusia affinis* was introduced for mosquito eradication in some coastal wetlands. At last, the sunfish *Lepomis gibbosus* was accidentally released from freshwater aquaria.

Marine mammals, the white whale, *Delphinopterus leucas*, the northern fur seal, *Callorhinus ursinus* and the Steller sea lion, *Eumetopias jubatus* were kept in marine aquaria in the Black Sea. Accidentally escaped from the aquaria, these marine mammals, for a short periode of time (weeks, months or years), were free living animals in the Black Sea and the Sea of Azov.

Other three species of mammals are terrestrial semi-aquatic animals living in coastal wetlands and feeding, in addition to terrestrial food, on aquatic plants, invertebrates and fish, including marine ones. Therefore, these species are mentioned among other introduced exotic species in the AMBACS. The raccoon dog *Nictereutes procyonoides* and muskrat *Ondathra zibethica* were intentionally introduced in the Black Sea and Sea of Azov coastal wetlands, and the raccoon *Procyon lotor* in the Caspian Sea coastal wetlands.

Incomplete food chains and following behavioural changes

Analyses of feeding relations of recently introduced exotic species shows that many of them have short-cut food chains in comparison with original waters. It concerns especially the last links (secondary and tertiary consumers) which are lacking in new habitats.

For example, the gastropod *Rapana thomasiana*, originated from the Sea of Japan, in the Black Sea do not suffer from with its main predators; sea stars, octopus and large crabs, like in the Sea of Japan. Therefore, the growth of *Rapana*'s population in not restricted by biotic factors. As a result, the impact of *Rapana* on native bivalves in the Black Sea is much more severe than in the Sea of Japan.

The comb jelly *Mnemiopsis leidyi* in the North American Atlantic coastal waters is neither such a serious competitor for food of planktophagous fish or a predator of pelagic eggs and larvae as in the Black and Azov Seas. For instance, in Chesapeake Bay, the population of the mass pelagic fish menhaden, *Brevoortia tyrannus* (Clupeidae) is not threatened by *Mnemiopsis* (FIRTH, 1969). The reason of this is the fact that in the same waters there occurs commonly Beroe's comb jellies (*Beroe* species), which are the most effective consumers of *Mnemiopsis*, its antagonistic species. The jellyfish *Chrysaora quinquecirrha* also feeds on *Mnemiopsis* (FEGENBAUM & KELLY, 1984). Besides, in the same area is common the burrowing anemone, *Edwardsia leidyi*, which is parasitic in the gut of *Mnemiopsis* (GOSNER, 1978). All these natural biological counterbalances of *M. leidyi* lack in the Black Sea and the Sea of Azov, and the outburst of its population was a natural consequence as a result.

Similar examples are shown by The East European species, which were accidentally introduced in the North American waters.

The zebra mussel, bivalve *Dreissena polymorpha*, one of Pontian relic invertebrates (ZAITSEV & MAMAEV, 1997), proved to be a harmful species in the Great Lakes, clogging water systems of power plants and water treatment facilities, as well as irrigation systems. They have also severely reduced and eliminated native mussel species. It provoked changes in bottom habitats (GOLLASH *et al*., 1999). It has spread to infest more than 40% of US waterways, fouls the cooling-water intakes of industry and may have costed over US$ 5 billion in control measures since 1989 (see "Stopping the ballast water stowaways!", Global Ballast Water Management Programme, March, 2001).

In its original waters (the Black, Azov and Caspian Seas and respective coastal wetlands), this bivalve is not considered so harmful. The probable reason is the fact, that the growth of its populations is inhibited by local mollusc eating fish, such as the endemic species *Rutilus frisii, Rutilus rutilus heckeli* and *Abramis brama,* which are consumers of young specimens of *Dreissena,* and an introduced exotic cyprinid fish *Mylopharyngodon piceus*, is feeding on adult bivalve molluscs. All these species lack in the New World.

The round goby, or black spotted goby, *Neogobius melanostomus,* which is one of the Pontian relic fishes (ZAITSEV & MAMAEV, 1997), was accidentally introduced in the North American fresh and brackish waters recently (JUDE ;*et al;* 1991; GOLLASH *et al*., 1999) and proved to be a harmful species. According to local experts (see 1998 University of Minnesota Sea Grant Program "Round Goby WATCH"), this settler is an aggressive fish, which competes with native bottom-dwellers like sculpins (Cottidae) and logperch (*Percina* species). The round goby in the North American waters can displace native fish, eats their eggs and youngs, takes over optimal habitat, spawns multiple times a season, and survives in poor quality water- given them a competitive advantage.

In its original waters (the Black Sea and the Sea of Azov) this goby is not considered to be an outstandingly aggressive fish. Probably, the reason is the inhibitory effect of its predators. Among them there are bottom fish like the toad goby *Mesogobius batrachocephalus* and turbot *Psetta maeotica,* and in the Sea of Azov even a larger pelagic fish, the European pike-perch *Stizostedion lucioperca*, up to 35% of whose food is composed of round gobies (COMMERCIAL FISH, 1949). Activity of such predators greatly reduces the round goby population in its native area.

A general conclusion, which arises from the above examples, can be formulated as follows.

Each non- native opportunistic species, introduced in a new habitat without its natural antagonistic species (therefore, strong predation pressure is absent is free for a practically unlimited growth of population. In the absence of antagonists, the new settler finds freedom of reproduction with an adequate impact on native organisms. This is the main reason for the outburst of such species during first years of their life in new habitats (ZAITSEV, 2000).

Appearance of antagonistic species againist new settlers marks the beginning of decline in populations of such exotics and weakening of its influence on native organisms. Such is the case of *Mnemiopsis leidyi* in the Black Sea and the Sea of Azov after the accidental introduction in these seas in the late 1990s of *Beroe* ctenophores, which are highly specialized predators of *Mnemipsis* and other comb jellies.

An important condition for a successful acclimatization of an exotic species in a new habitat is the availability of suitable food, and the man-made eutrophication of marine waters is good prerequisite for this (ZAITSEV, 2000).

Therefore *a priori*, the impact of a potential settler on native species is unknown and unpredictable, because its behaviour in a new habitat can change. That is why to make a list of unwanted exotic species, for the prevention of their introduction , is impossible. On account of this, the call like "do not allow the penetration of exotic harmful species" is, in essence, scientifically not correct .With the exception of pathogenics, there are not harmful plants or animal species *a priori*. The only thing to do is to put a stop for the introduction of *all* non-native species whether harmful or not. It is clear that to realize completely this recommendation is beyond our power, but to minimize the inflow of exotics is quite a realistic policy.

Entry mechanisms

The entry mechanisms of non-native organisms, connected with human activities, are diverse.

For instance, the deliberate releases of commercial fish and invertebrates are, as a rule, accompanied by the introduction of non-target species. This was the case of parasitic Trematoda introduced with the grey mullet *Mugil soiuy* into the Black Sea and the Sea of Azov. The diatom *Rhizosolenia calcar avis* was probably introduced into the Caspian Sea with target fish species *Liza aurata* and *L. saliens*, or with the prey polychaete *Nereis diversicolor*.

Another very important entry mechanism of exotics is associated with shipping activities, namely with ballast waters, bottom sediments in ballast tanks, and fouling organisms on ships' hulls. In ballast waters are transported planktonic species and in sediments- spores, cysts, eggs and settled larvae of bottom animals. For example, it is known that more than 80 marine and 15 freshwater species of modern dinoflagellates are known to produce resting cysts (KAZUMI & YASUWO, 2000). Resting stages or quiescent phases allow survival of these species in the dark. Dormancy period in different species can last from two weeks to 6 months (GLIBERT & PITCHER, 2001). Fouling of ships' hulls is strongly reduced now by toxic antifouling paints, but in some cases the underwater parts of hulls are densely covered by algae, barnacles, molluscs and other sedentary (attached to the substratum) plants and animals.

A specific entry mechanism concerned with ships is the transport of wood damaging organisms in wooden decks. For example, marine fungi of *Chaetomium* genus (Family Chaetomiaceae), which are able to develop also in freshwater and wetland conditions, were discovered in the wooden deck of a ship, recently entered in Odessa Port (N. KOPYTINA, pers. comm.).

Opening of shipping canals, connecting neighbouring seas, bears, in some aspects, new possibilities for introduction of exotics via ships, with water currents and for active migration of nektonic organisms (fish, squids, marine mammals), which are able to move independently of water currents. In the AMBACS system there are two man-made canals: the Suez Canal between the Red Sea and the

Mediterranean, opened in 1869, and the Volga-Don Canal between the Sea of Azov and the Caspian Sea, opened in 1952. The Suez Canal was constructed with assistance of a French diplomat Ferdinand de Lesseps and the term "Lessepsian migration" was proposed by POR (1964) to characterize a new phenomenon of unidirectional and successful biotic advance from the Red Sea to the eastern Mediterranean. In another paper, POR (1969) named also the term "Lessepsian migrant" for Red Sea species that have passed through the Suez Canal and settled in the eastern Mediterranean (PAPACONSTANTINOU, 1987). Such migrants, which are attributed in this book to man-induced exotic species are found in the Aegean Sea and a few of them in the Sea of Marmara. The main part of the recent Caspian Sea exotics were transported by ships from the Sea of Azov through the Volga-Don Canal.

In some cases exotic species were accidentally introduced in the AMBACS after escaping from freshwater and marine aquaria. This is the case of the freshwater sunfish *Lepomis gibbosus*, which is common in the Danube Delta and in other coastal wetlands and in the Black Sea itself. Another example of this entry mechanism is shown by marine mammals escaping from the Black Sea aquaria. The mosquitofish *Gambusia affinis* was deliberately introduced in some wetlands to combat malaria. Now it is found in the low salinity areas of the AMBACS.

Chronology of invasions

Because of natural and human reasons, the time scale of introduction of exotic species in the area under consideration differs in each sea of the AMBACS system. This problem is better investigated in the Black Sea.

The earliest exotic species introduced into the Black Sea is considered to be the shipworm *Teredo navalis* (GOMOIU & SKOLKA, 1996), carried by ancient ships. Really, the ancient civilizations were well aware of the shipworm and its ravages. The ancient Phoenicians coated the hulls of their ships with pitch, later, copper sheating (FIRTH, 1969). An oil mixture of arsenic and sulfur was used by the 5th century B.C., and lead sheathing was used by the Greeks as early as the 3rd century B.C. Therefore, early maritime visitors of the Black Sea about 2500-3000 years ago, ancient navigators, Phoenicians and, later, Greeks were quite likely at the starting point of the introduction of shipworms from the Mediterranean, and/or from the Atlantic Ocean into the Black Sea.

The next settlers, in chronological order, seem to be barnacle species. The bay barnacle *Balanus improvisus* was introduced in the 1840s (GOMOIU & SKOLKA, 1996), and the ivory barnacle *B. eburneus* was firsty described in the late 19th century (OSTROUMOV, 1892).

The 20th century was the peak of the exotics' introduction and the main reason of this was the increase in shipping activities. According to our estimations, in the second half of the 20th century were accidentally introduced into the Black Sea and its coastal wetlands not less than 47 non-native species. This means that, a foreign marine and brackish water species was introduced almost every year.

Table 1. Chronology of invasions of exotic species in the AMBACS marine system

№	Taxa	Species	Seas				
			Aeg	Mar	Bl	Az	Cas
			Years of the first registration				
1	INVERTEBRATES	*Teredo navalis*	750-500 B.C.	750-500 B.C.	750-500 B.C.	1953	-
2	INVERTEBRATES	*Balanus improvisus*	?	?	1844	?	1954
3	INVERTEBRATES	*Hydroides dianthus*	1865	-	-	-	-
4	INVERTEBRATES	*Balanus eburneus*	?	?	1892	-	1956
5	INVERTEBRATES	*Crassostrea gigas*	1970s*	?	1900s	-	-
6	INVERTEBRATES	*Mytillaster lineatus*	+	+	+	+	1919
7	PLANTS	*Rhizosolenia calcar-avis*	-	?	1926	1924	1936
8	PISCES	*Gambusia affinis holbrooki*	?	?	1925	1980s	1934
9	INVERTEBRATES	*Blackfordia virginica*	-	-	1925	1925	1956
10	INVERTEBRATES	*Mercierella enigmatica*	1942	?	1929	1956	1960
11	INVERTEBRATES	*Penaeus semisulcatus*	1930*	-	-	-	-
12	INVERTEBRATES	*Palaemon elegans*	+	+	+	+	1930
13	INVERTEBRATES	*Palaemon adspersus*	+	+	+	+	1930
14	PISCES	*Platichthys flesus luscus*	-	-	+	+	1930
15	MAMMALS	*Ondathra zibethica*	-	-	1930s	1930s	-
16	MAMMALS	*Nyctereutes procyonoides*	-	-	1930s	1930s	1930s
17	PISCES	*Lepomis gibbosus*	-	-	1930s	-	-
18	PISCES	*Liza aurata*	-	-	+	+	1933
19	PISCES	*Liza saliens*	-	-	+	+	1933
20	INVERTEBRATES	*Perigonimus megas*	-	-	1933	1956	1960
21	PISCES	*Siganus rivulatus*	1934*	?	-	-	-
22	MAMMALS	*Procion lotor*	-	-	-	-	1936
23	PISCES	*Hemiramphus far*	1937*	-	-	-	-
24	PISCES	*Leiognathus klunzingeri*	1937*	-	-	-	-
25	INVERTEBRATES	*Rithropanopaeus harrisii tridentatus*	-	-	1937	1950s	1961
26	PISCES	*Parexocoetus mento*	1938*	-	-	-	-
27	INVERTEBRATES	*Nereis diversicolor*	+	+	+	+	1939
28	INVERTEBRATES	*Abra ovata*	+	+	+	+	1939
29	INVERTEBRATES	Pentacoelum caspicum	+	+	+	+	1941

30	PLANTS	*Codium fragile*	1941*	1941*	-	-	-
31	PISCES	*Stephanolepis diaspros*	1940s*	-	-	-	-
32	PISCES	*Sargocentron rubrum*	1940s*	-	-	-	-
33	INVERTEBRATES	*Rapana thomasiana*	1991*	?	1946	?	-
34	INVERTEBRATES	*Pseudochama corbieri*	1946*	-	-	-	-
35	PISCES	*Upeneus moluccensis*	1947*	-	-	-	-
36	PISCES	*Lagocephalus spadiceus*	1950*	-	-	-	-
37	INVERTEBRATES	*Urnatella gracilis*	-	-	1950	1962	-
38	PISCES	*Hypophthalmichthys molytrix*	-	-	1950s	-	?
39	PISCES	*Aristichthys nobilis*	-	-	-	1950s	-
40	PISCES	*Ophiocephalus argus warpakhowskii*	-	-	-	-	1950s
41	PISCES	*Ctenopharingodon idella*	-	-	-	-	1950s
42	INVERTEBRATES	*Aurelia aurita*	+	+	+	+	1950s
43	INVERTEBRATES	*Lithoglyphus naticoides*	-	-	+	-	1950s
44	INVERTEBRATES	*Penilia avirostris*	+	+	+	+	1950s
45	PISCES	*Atherinamorus lacunosus*	1950s*	-	-	-	-
46	INVERTEBRATES	*Hesionides arenarius*	-	-	1950s	-	-
47	INVERTEBRATES	*Potamopyrgus jenkinsi*	-	-	1952	?	-
48	INVERTEBRATES	*Ixa monodi*	1956*				
49	PISCES	*Saurida undosquamis*	1956*	-	-	-	-
50	PISCES	*Liza carinata*	1956*	-	-	-	-
51	INVERTEBRATES	*Pleopis polyphemoides*	+	+	+	+	1957
52	INVERTEBRATES	*Streblospio shrubsolii*	-	-	1957	-	-
53	INVERTEBRATES	*Conopeum seurati*	-	-	+	+	1958
54	INVERTEBRATES	*Membranipora crustulenta*	-	-	+	+	1950s
55	INVERTEBRATES	*Pandallus kessleri*	-	-	1959	-	-
56	INVERTEBRATES	*Hypanis colorata*	-	-	+	+	1959
57	INVERTEBRATES	*Moerizia maeotica*	-	-	+	+	1960
58	PISCES	*Alepes djeddaba*	1960*	-	-	-	-
59	INVERTEBRATES	*Charybdis (Goniohellenus) longicollis*	1961*	-	-	-	-

60	INVERTEBRATES	*Erugosquilla massavensis*	1961*	-	-	-	-
61	INVERTEBRATES	*Bursatella leachi*	1961*	-	-	-	-
62	PISCES	*Sphyraena chrysotaenia*	1960s*	-	-	-	-
63	PISCES	*Morone saxatilis*	-	-	1960s	1960s	-
64	PLANTS	*Ceramium diaphanum*	?	+	+	+	1960s
65	PLANTS	*Ceramium tenuissimum*	?	+	+	+	1960s
66	PLANTS	*Ectocarpus confervoides*	?	+	+	+	1960s
67	INVERTEBRATES	*Marsupenaeus japonicus*	1960s	?	1970s	-	-
68	INVERTEBRATES	*Barentsia benedeni*	-	-	+	+	1962
69	PISCES	*Plecoglossus altivellis*	-	-	1963	-	-
70	INVERTEBRATES	*Ancistrosyllis tentaculata*	-	-	1964	-	-
71	PISCES	*Roccus saxatilis*	-	-	1965	-	-
72	PISCES	Salmo gairdneri	-	-	1965	-	-
73	INVERTEBRATES	*Mya arenaria*	1990s*	?	1966	1970s	-
75	INVERTEBRATES	*Streptocyllis varians*	-	-	1966	-	-
76	INVERTEBRATES	*Corophium volutator*	+	+	+	+	1966
77	INVERTEBRATES	*Callinectes sapidus*	1959	?	1967	1975	-
78	INVERTEBRATES	*Trachysalambria curvirostris*	1968*	-	-	-	-
79	PLANTS	*Asterionella japonica*	-	-	1968	-	-
80	PISCES	*Mugil soiuy*	1989	?	1968	1968	-
81	INVERTEBRATES	*Alpheus lobidens*	1969*	-	-	-	-
82	INVERTEBRATES	*Pinctada radiata*	1969*	-	-	-	-
83	PISCES	*Siganus luridus*	1969*	-	-	-	-
84	PISCES	*Oryzias latipes*	-	-	-	1970s	1980s
85	INVERTEBRATES	*Scapharca inaequivalvis*	1970s	1970s	1982	1989	-
86	INVERTEBRATES	*Petricola pholadiformis*	1970s*	-	-	-	-
88	INVERTEBRATES	*Nephthys ciliata*	?	?	1972	-	-
89	INVERTEBRATES	*Capitellethus dispar*	?	?	1972	-	-
90	PISCES	*Onchorhynchus keta*	-	-	1972	-	-
91	INVERTEBRATES	*Nerita sanguinolenta*	1973*	-	-	-	-
92	PISCES	*Dicentrarchus labrax*	-	-	1977	-	-
93	INVERTEBRATES	*Anadara demiri*	1977*	-	-	-	-
94	PISCES	*Lateolabrax japonicus*	-	-	1978	-	-

95	INVERTEBRATES	*Brachidontes pharaonis*	1976*	-	-	-	-
96	INVERTEBRATES	*Doridella obscura*	-	-	1980	1991	-
97	INVERTEBRATES	*Metapenaeus stebbingi*	1980*	-	-	-	-
98	INVERTEBRATES	*Acartia clausi*	+	+	+	+	1981
99	INVERTEBRATES	*Metapenaeus stebbingi*	1980s *	-	-	-	-
100	PLANTS	*Mantoniella squamata*	-	-	1980 s	-	-
101	PISCES	*Pempheris vanicolensis*	1980s *	-	-	-	-
102	PISCES	*Scomberomorus commerson*	1980s *	-	-	-	-
103	INVERTEBRATES	*Pilumnopeus vauquelini*	1980*	-	-	-	-
104	INVERTEBRATES	*Acartia tonsa*	1980s	1980 s	1994	-	-
105	INVERTEBRATES	*Sirpus zariqieyi*	-	1982	1982	-	-
106	INVERTEBRATES	*Mnemiopsis leidyi*	1990	1991	1982	1988	1998
107	INVERTEBRATES	*Tenellia adspersa*	+	+	+	+	1989
108	PLANTS	*Thalassiosira nordenskjoldi*	+	+	1986	-	-
109	INVERTEBRATES	*Fulvia fragilis*	1988*	-	-	-	-
110	INVERTEBRATES	*Gastrochaena cymbium*	1989*	-	-	-	-
111	PLANTS	*Azolla caroliniana*	-	-	1989	-	-
112	PLANTS	*Azolla filiculoides*	-	-	1989	-	-
113	PISCES	*Pseudorasbora parva*	-	-	1989	-	-
114	PLANTS	*Phaeocystis pouchettii*	1989	1990	1990	-	-
115	PLANTS	*Caulerpa racemosa*	1989	-	-	-	-
116	MAMMALS	*Callophinus ursinus*	-	-	1990 s	1990 s	-
117	INVERTEBRATES	*Pyrunculus fourierii*	1990*	-	-	-	-
118	INVERTEBRATES	*Eudendrium annulatum*	-	-	1990 s	-	-
119	INVERTEBRATES	*Eudendrium capillare*	-	-	1990 s	-	-
120	INVERTEBRATES	*Tiaropsis multicirrata*	-	-	1990 s	-	-
121	MAMMALS	*Eumetopias jubatus*	-	-	1990 s	-	-
122	MAMMALS	*Delphinopterus leucas*	-	-	1991	-	-
123	PLANTS	*Alexandrium monilatum*	1980s	1985	1991	-	-
124	INVERTEBRATES	*Atergatis roseus*	1992*				
125	PLANTS	*Desmarestia viridis*	-	-	1992	-	-
126	INVERTEBRATES	*Smaragdia souverbiana*	1994*	-	-	-	-
127	PLANTS	*Gymnodinium uberrimum*	?	?	1994	-	-
128	INVERTEBRATES	*Thalamita poissonii*	1994*	-	-	-	-

129	INVERTEBRATES	*Cylichna girardi*	1996*	-	-	-	-
130	INVERTEBRATES	*Beroe ovata*	+	+	1997	1999	-
131	INVERTEBRATES	*Trochus erythreus*	1997*	-	-	-	-
132	INVERTEBRATES	*Cellana rota*	1998*	-	-	-	-
133	INVERTEBRATES	*Eriocheir sinensis*	-	-	1998	1998	-
134	INVERTEBRATES	*Rhopilema esculenta*	1998	-	-	-	-
135	PISCES	*Micromesistius poutassou*	-	-	1999	-	-
136	INVERTEBRATES	*Bulla ampulla*	1999*	-	-	-	-
137	PISCES	*Ictalurus punctatus*	-	-	-	?	-
138	PISCES	*Ictiobus bubalus*	-	-	-	?	-
139	PISCES	*Ictiobus niger*	-	-	-	?	-
140	PISCES	*Polyodon spatula*	-	-	-	?	-
141	PISCES	*Setiobus cyprinellus*	-	-	-	?	-
142	PISCES	*Tilapia mossambica*	-	-	-	?	-
143	PISCES	*Tribolodon brandti*	-	-	-	?	-
144	PLANTS	*Achanthophora muscoides*	?	-	-	-	-
145	PLANTS	*Ganonema farinosum*	?	-	-	-	-
146	PLANTS	*Laurencia intermedia*	?	-	-	-	-
Total number of exotic species			71	23	59	32	39

Notes:

Aeg. - Aegean Sea, Mar. - Sea of Marmara, Bl. - Black Sea, Az. -Sea of Azov, Cas. - Caspian Sea.
+ - Origin basin for the species
? - Data of the first registration is unknown
* - Data of registration was taken from CIESM Atlas of exotic species in the Mediterranean Sea (http://www.ciesm.org/atlas).

Sensitivity of different seas to exotics' invasions

The presented materials in this volume and published data display that the ecological capacity of a sea, regarding the ability to receive and to adopt new exotic organisms, is a function, *inter alia*, of its biological diversity.

Comparison of different marine areas concerning the relation of non-native and native species shows a certain general rule: a high biological diversity corresponds to a low share (percent) of introduced exotic species and, an area with low biological diversity, inhabited by many relic and endemic species, has a high percent of introduced species.

An example of an area with high specific diversity of marine life is the coastal zone of South Africa. This area is particularly rich in marine fauna and flora- over 10,000 species, or almost 15% of all the coastal marine species known world-wide (BRANCH et al., 1994). Here there are more than 5,000 of mollusc species, more than 2,000 species of fish, about 300 species of true crabs , etc.

According to the data for 1994, in the coastal waters of South Africa were noted two species of exotic molluscs. One of them is the Mediterranean mussel, *Mytilus galloprovincialis*, a recent introduction from Europe. Now it is a dominant intertidal mussel throughout the south and west coasts, often forming a dense band in the low intertidal (BRANCH, 1994). It is cultured at commercial scales.

Another exotic mollusc is the bisexual mussel, *Semimytilus algosus*, which possibly was introduced from South America.

As to crabs, only one species was introduced from outside. It is the European shore crab, *Carcinus maenas*, originated, probably, from the North Sea. First recorded in Table Bay docks in 1983, but by 1990 had spreaded 120 km to Saldanha Bay. It is a voracious predator, which poses a threat to many local molluscs, including some species in aquaculture (BRANCH, 1994).

The term "Exotic index" (**Ei**) is proposed for this quantitative characteristic. It is defined by the equation:

$$\mathbf{Ei} = E \cdot 100/N$$

where E is the number of exotic species of a taxon in an area, and N is the number of native species of the same taxon in the same area. In exceptional cases, when the number of native species is "0", one may use the denominator "N+1".

In the Aegean Sea **Ei** for molluscs will be 3.8 and for bottom crustaceans (shrimps and crabs) 2.44. In the Black Sea **Ei** are respectively, 3.22 and 33.30, in the Sea of Azov 7.01 and 150.00, in the Caspian Sea 4.24 and 300.00.

It is very likely that special investigations on this problem in the framework of the IMO GloBallast Programme may discover more non-native species.

A relatively high number of exotics in the Aegean Sea is a result of migrations through the Suez Canal. A well-known expert on Lessepsian migrants, B.S. GALIL, quite correctly considers the Mediterranean Sea as "a sea under siege" (GALIL, 2000), but only 3% of its exotic species were introduced via ships into the Aegean Sea, which is very rich in native species. On the other hand, the brackish Baltic Sea, which is one of the best investigated seas (LEPPAKOSKI & OLENIN, 2000) , is a real "sea of exotics".

There is no doubt that given figures will be defined more exactly by futur investigations, but the general trend is obvious: low biological diversity is an important condition for a successful acclimatization of exotic species in corresponding seas.

Distribution of settlers in new habitats

Geographical distribution of alien organisms depends both on species requirements and on habitat diversity in the sea.

For example, the main part of the Aegean Sea exotics are originated from the Indo-Pacific area. They are thermophilic and halophilic plants and animals. Therefore these exotics are settled in this sea, which is the most saline and warm in the AMBACS marine system. Their spreading to the north is stopped by the salinity and temperature. The majority of the Black Sea exotics are originated from the North Atlantic temperate zone and from its low salinity coastal waters.

Therefore they are distributed everywhere in this sea and especially in the low salinity north-western shelf area. Some of the Black Sea exotics, like *Rapana thomasiana* and *Mnemiopsis leidyi,* are most eurybiontic ones, and can spread to neighbouring seas.

In the Caspian Sea , almost all exotics are from the Black Sea and the Sea of Azov or originally foreign species but acclimatized in these seas. Correspondingly, they are distributed everywhere or predominantly in the Middle and South Caspian, which are more saline and warm in winter season.

Important ways of exchange of exotic species between the seas are the water currents through straits (Figure 2).

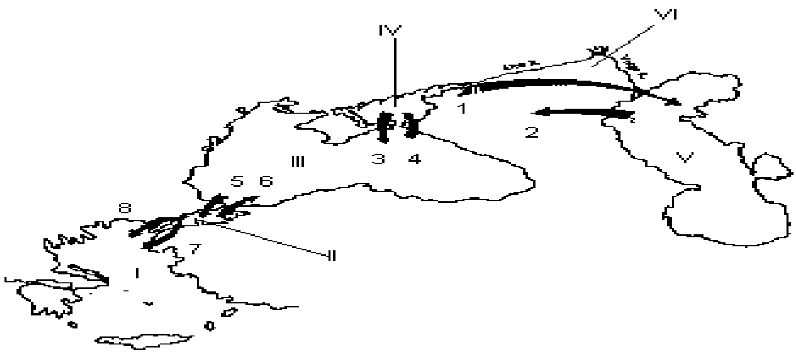


Figure 2. Interchange of exotic species among the seas of AMBACS system.
I-Aegean Sea; II- Sea of Marmara; III- Black Sea; IV- Sea of Azov;
V- Caspian Sea;VI- Volga-Don Canal.

1- From the Black Sea and the Sea of Azov to the Caspian Sea through the Volga-Don Canal;
2- From the Caspian Sea to the Sea of Azov and Black Sea through the Volga-Don Canal (this vector is not yet enough revealed);
3- From the Sea of Azov to the Black Sea through the Kerch Strait .
4- From the Black Sea to the Sea of Azov through the Kerch Strait .
5- From the Black Sea to the Sea of Marmara through the İstanbul Strait .
6- From the Sea of Marmara to the Black Sea through the İstanbul Strait .
7- From the Sea of Marmara to the Aegean Sea through the Çanakkale Strait .
8- From the Aegean Sea to the Sea of Marmara through the Çanakkale Strait.

The strong upper current of the Bosphorus (Istanbul Strait) from the Black Sea to the Sea of Marmara is carriyng from 338 to 612 km^3 of marine water per year (RESHETNIKOV, 1992; UNLUATA *et al*., 1990; ZAITSEV & MAMAEV, 1997).

This water mass transports from the Black Sea to the Sea of Marmara 109,800 to 183,600 t of phytoplankton and from 128,100 to 214,200 t of zooplankton per year. In such condition, representatives of practically all exotic planktonics organisms, introduced into the Black Sea, will be carried into the Sea of Marmara. Similar water and plankton exchange occurs in other straits (Table 2).

Table 2. Water and plankton (except *Mnemiopsis*) exchange through the straits between the Sea of Marmara, the Black Sea and the Sea of Azov.

Strait and flow direction	Water km^3/yr*	Phytoplankton 10^3 t/year	Zooplankton 10^3 t/year
Istanbul Strait			
From the Black Sea to the Sea of Marmara	348-612	109.8- 183.6	128.1-214.2
From the Sea of Marmara to the Black Sea	123-312	12.3-31.2	18.5-46.8
Kerch Strait			
From the Sea of Azov to the Black Sea	38-95	35-98	17-42.7
From the Black Sea to the Sea of Azov	29-70	14.5-35.2	8.7-21.1

* (From RESHETNIKOV, 1992; UNLUATA *et al.*, 1990; ZAITSEV & MAMAEV, 1997)

As to *Mnemiopsis leidyi*, its outflow from the Black Sea to the Sea of Marmara, according to authors' estimations, varies from 7,320,000 to 12,240,000 t per year. Into the Sea of Azov, it cannot spend winter and its population is restored each spring and early summer owing to the water current from the Black Sea.

Impact on native species

It is rather complicated to elucidate all biological consequences of introduction of a foreign species into an area where it does not naturally occur and to tell an integral estimation. Practically each settler can be, on one hand, positive for native species, and on the other hand, negative . Therefore, more often it remain to conclude that the considered species in its new habitat is "more positive, than negative" or vice versa.

However, in some cases, there are no doubt about its effect. For instance, *Mnemiopsis leidyi* is certainly a very harmful exotic species. With specification: in absence of *Beroe*. The snail *Rapana thomasiana* is a very harmful exotic species in the absence of sea stars.

The shipworm *Teredo navalis* is harmful as a wood-boring mollusc. In the Black Sea till the 1950s, it was the main destroyer of wooden piers and pillars of fixed nets. After the replacement of wood by concrete, metal and synthetic materials, the population of *Teredo* was greatly reduced and now it is rather difficult to find even a single mollusc for scientific purposes.

The large-size diatom *Rhizosolenia calcar avis* is more negative than positive because it is not eaten by zooplankton and fish schools avoid the areas of *Rhizosolenia* blooms. Its positive effect is the generation of oxygen. The dinoflagellates *Alexandrium monilatum* and *Phaeocystis pouchetii* are harmful blooming species. In other seas , *Alexandrium* spp. are responsible for paralytic shellfish poisoning and *Phaeocystis* spp for gill clogging and necrosis in fish (ZINGONE & ENEVOLDSEN, 2000).

The acridic cell sap of the brown alga *Desmarestia viridis* is destructive to other weeds, but this property has not yet been investigated in the Back Sea.

Hydrozoan *Perigonimus megas*, because of fouling, is worsening the carrying capacity of water pipes in the Caspian Sea (KASYMOV, this book). In the Sea of Azov, *P. megas* is the main food source for native nudibranch mollusc *Stiliger bellulus* and for the exotic crab *Rithropanopeus harrisii tridentatus*. There found about 7,000 specimens of molluscs on a hydroid colony with 100 g weight and about 1,500 of young crabs on one square meter of hard substrate with *Perigonimus* type of fouling (SIMKINA, 1963).

The polychaete *Mercierella enigmatica* is negative because of fouling of ships' hulls and water pipes and positive because of its filtering activity.

The barnacles *Balanus improvisus* and *B. eburneus* are harmful settlers because of fouling. Fouling is a term commonly used to mean the adhesion of various aquatic organisms to hulls and other underwater parts of ships as well as to waterways and equipment placed in the sea. This type of marine attachment and growth, which the Swedish botanist Carolus Linnaeus called "*calamitas navium*" (calamity of ships) is especially serious in the case of ships since it inhibits their efficient operation. Besides, barnacles' nauplii are voracious predators of pelagic fish larvae (DOLGOPOLSKAYA, 1946). Covering fish nets, *Balanus* reduces their catchability and buoyancy (KASYMOV, this book). On the other hand, these sedentary crustaceans are positive in coastal water ecosystems as filtering organisms.

The soft shell clam *Mya arenaria* is both negative and positive. Its negative influence can be seen in the competition for habitats with a small local bivalve *Lentidium mediterraneum*, which avoids sandy bottoms silted by *M. arenaria*. For example, in the Odessa Gulf, the area of the biocoenosis of *L. mediterraneum* was reduced in the 1980s fivefold as a result of the expansion of *M. arenaria* biocoenosis. *L. mediterraneum* , due to its small dimensions and thin shells, is a favourite food of young of all native bottom fishes. But young specimens of *Mya* are additional food source for adult bottom-living fish (gobies, flounder, turbot and sturgeons), gulls and other marine birds. Adult specimens are eaten by another exotic mollusc, *Rapana* (GOMOIU, 1972). Moreover, it became an additional biofilter in the coastal zone, and this is quite important in eutrophicated water bodies .

After the introduction of *Mytilaster lineatus* into the Caspian Sea, the number of zebra mussel *Dreissena polymorpha* was considerably decreased (KASYMOV, this book).

The crab *Rhithropanopeus harrisi tridentata* spoils fish in nets (ZENKEVICH & ZEVINA, 1969), and it feeds on amphipods, which are the main food of various commercial fishes in the Caspian Sea (TARIVERDIEVA, 1965). *Rhithropanopeus* itself is eaten by sturgeons. But, as a whole, this species brings more damage than benefits in the Caspian Sea ecosytem (KASYMOV, this book).

The shrimp *Palaemon adspersus*, accidentally introduced into the Caspian Sea in the 1930s, became an important food of local fish such as herrings, sturgeons, and Caspian seal *Phoca caspica*.

The impact of other exotics is not yet sufficiently known. Some of them are *a priori* biologically and ecologically neutral because of small numbers. Others, more numerous, become key species in new biocoenoses (communities). Such are the biocoenoses of *Anadara inaequivalvis*, *Mya arenaria*, *Balanus improvisus*, *Rhithropanopeus harrisi tridentata* in the Sea of Azov (STUDENIKINA *et al*., 1998).

Economic consequences of accidentally introduced exotic species

It is rather difficult to estimate costs and profits, ensuing from biological and environmental activity of a species, which was accidentally introduced. Like in the case of biological impact, more often it resorts to qualitative, rough evaluation: positive or negative, essential or inessential.

Only regarding the ctenophore *Mnemiopsis leidyi* in the Black Sea and the Sea of Azov, the economic consequences of its introduction seem to be clear. According to CADDY & GRIFFITHS (1990), the damage caused by *M. leidyi* in the late 1980s for the Black Sea fisheries reached up to $200,000,000 per year. Much worse, according to the same authors, is the damage concerned with the inactivity of fishing ships, fishing ports and corresponding factories. In the Sea of Azov, the yearly damage caused by the same exotic ctenophore (where only the reduction of annual catches of anchovy, *Engraulis encrasicholus maeoticus* , and tyulka, *Clupeonella cultriventris*, were considered) reached up to $ 40,000,000 (VOLOVIK; 2000).

Probably it is not complicated to estimate costs of the fish spoiled in the nets by the crab *Rhithropanopeus harrisi tridentata*, and of its competition for food with local species in the Caspian Sea.

Certainly, there can be an economic expression of the fouling activity of hydroids, polychaetes, and barnacles, that attach to the submerged surfaces of boats, piling, pipes and other underwater hard substrates.

Of a special technological and economic interest is the impact of barnacles on iron and steel in marine water. Settlements of *Balanus improvisus* and even single specimens, attached to ships' hulls or to other underwater metallic construction, are severely increasing the speed of thecorrosion (ULANOVSKY*et al.,* 1961;STEPANOK, 1983).

Seldom we can reveal cases of positive effect of and benefit from accidentally introduced exotics. Export of *Rapana* meat (e.g. Turkey yearly export of this product in the 1990s exceeded 1,000 t) is the only example of this kind.

As for important commercial fish,there are Lessepsian migrants into the Aegean Sea: *Alepes djeddaba* (Carangidae), *Liza carinata* (Mugilidae), *Saurida undosquamis* (Synodontidae), *Siganus luridus, S. rivulatus* (Siganidae), and *Sphyraena chrysotaenia* (Sphyraenidae). Of less commercial importance are *Atherinamorus lacunosus* (Atherinidae), *Hemiramphus far* (Hemiramphidae), *Lagocephalus spadiceus* (Tetraodontidae), *Parexocoetus mento* (Exocoetidae), *Sargocentron rubrum* (Holocentridae), and *Stephanolepis diaspros* (Monacanthidae) (BAŞUSTA, this book). Besides *C.sapidus* is also one of the commercial crabs in the Aegean Sea .

Geographical origin of introduced species

This question is a very important one both theoretically and practically, in particular, because it allows to advise shipping of areas and times to be avoided in taking on ballast, so as to minimize the potential uptake and transfer of exotic species.

Practically all accidentally introduced species are originated from the coastal zones and not from the open ocean. Thus , the ballasting in shallow waters, in terms of uptaking of organisms, is much more unwanted, than in deep-water areas.

The process of man-made transfer of exotic species to the AMBACS marine system occurs, practically, in all the world oceans (Figure 3).

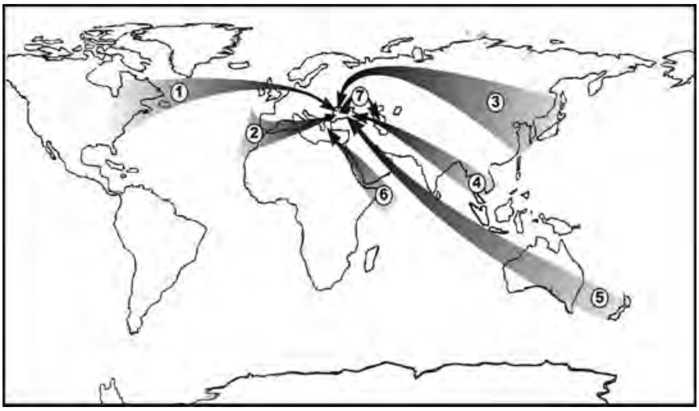


Figure 3. Man-made transfer of exotic species to the AMBACS system. Vectors: 1. North Atlantic; 2. East Atlantic-Mediterranean; 3. West Pacific; 4. South Eastern Asia; 5. South-West Pacific; 6. Indo-Pacific; 7. Ponto-Azovian.

It is interesting to analyse the contribution of different donor geographic areas to the specific diversity of accidentally introduced plants, invertebrates and fish in each sea of the AMBACS system (Figure 4).

The main source of exotic species introduced in the Aegean Sea (81%) is the Indo-Pacific region and directly, the Red Sea, whereas the North Atlantic area is represented only by 11% of accidentally introduced species. Thermophylic and halophylic organisms originated from the Indo-Pacific region are able to develop in the Mediterranean Sea, including the southern Aegean Sea. These species have been introduced both by ships and by water current through the Suez Canal, or by means of active migrations, which is probably the case of some fish.

The Sea of Marmara is populated by species from the North Atlantic (34%), East Atlantic (11.3%), West Pacific (33%), and Indo-Pacific (11.4%). Probably, most of them have been transported by ships, but some species, e.g. *Rhizosolenia calcar avis, Mnemiopsis leidyi, Rapana thomasiana, Scapharca inaequivalvis,* were introduced with the water current from the Black Sea. At last, such species as *Marsupenaeus japonicus* and *Sirpus zariquieyi* were introduced from the Aegean and Mediterranean Seas.

Among the Black Sea exotics, more than two thirds (68%) are originated from the North Atlantic, 13 % are from the Indo-Pacific region, and 8% from the Western Pacific. It is possible to suppose, that the main entry mechanism for this sea is by ships' ballast waters.

Similar situations are observed in the Sea of Azov, where 67% of accidentally introduced species are originated from the North and East Atlantic.

Geographical position and isolation of the Caspian Sea is the reason of peculiar specific composition of its exotics: 88% are originated from the Black and Azov Seas, or from the Atlantic Ocean, but introduced via the Black and Azov Seas.

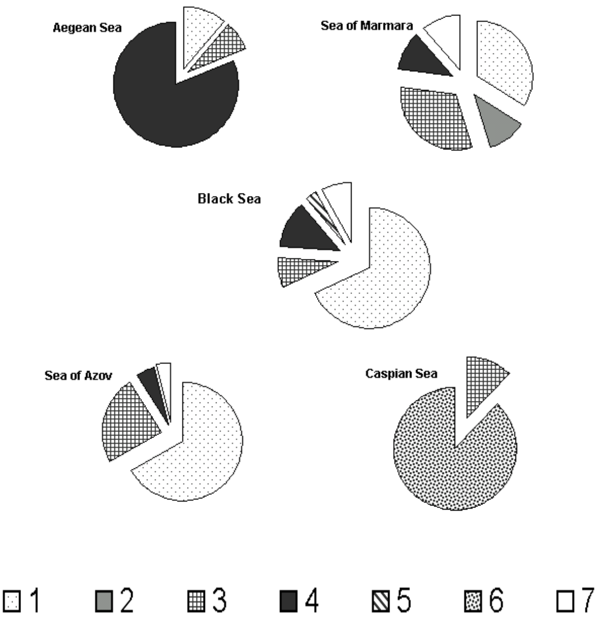


Figure 4. Geographical origin of exotic species, introduced in different seas of the AMBACS system. 1- North Atlantic, 2- EastAtlantic - Mediterranean, 3- West Pacific, 4- Indo-Pacific, 5- South-West Pacific, 6- Ponto-Azovian, 7- Cryptogenic.

Proceeding from these data, it is possible to tell the most dangerous, with respect to the transport of exotic organisms, sea routes (vectors) for each sea. For the Aegean Sea it is the Indo-Pacific vector, for the Sea of Marmara and especially for the Black Sea and the Sea of Azov, the North Atlantic vector. For the Caspian Sea, the only danger is the Ponto-Azovian vector through the Volga-Don Canal.

<u>Information gaps</u>

There are more than enough reasons to consider that the lists of species, presented in this book for each of examined seas, define only the visible part of exotics' "iceberg". Indeed, first of all, were considered large plants and animals, namely, macrophytobenthos, macrozoobenthos, and fishes. As to meiobenthos and microbenthos, phytoplankton, zooplankton and all the more, bacteria, our knowledge are very incomplete or lacking. However, the smallest organisms constitute the main part of the man-induced species, because these organisms are the most numerous in ballast water from coastal zones.

There are several reasons for this lack of consideration for all introduced species, including the smallest ones. One is the misunderstanding at governmental and local levels of biological, ecological, economic and social importance of marine organisms introduced with ballast water and associated sediments. Therefore the biological monitoring of marine areas, ports, ballast waters and sediments has not yet become customary in a majority of port states.

Another reason is the limited number of experts in systematics and taxonomy, which is far fewer than needed worldwide, and especially in developing countries (NORSE, 1993). The situation is especially disturbing in the exotics' "hot spots" (areas rich in introduced species), e. g. ports and areas of heavy sea transport.

A serious gap in knowledge concerns prompt identification of harmful (pest) species. It is practically impossible to determine, immediately after discovering, the ecological status of a recently introduced species: is it harmful one, neutral or helpful for native species and local ecosystem? These characteristics become apparent later and depends on biotic relations and behavioural changes in new habitat. Usually, there are no *a priori* harmful species, they become subsequently as such in new environmental conditions. Finally, we give only as additional information for some species, exotic molluscs and others species in this book due to the lack of sufficient information.

Means to minimize the risk of transfer of aquatic species in ballast water

There are two main fields where every effort should be made to minimize transfers of alien species in ships' ballast water (GUIDELINES,1998).

One of them is ballast water exchange. It is widely recognized that ballast water exchange has many limitations, including threatening the stability and/or the structural integrity of the ship. It is of great importance also the fact that translocation of species can still occur even a vessel has undertaken full ballast exchange (BALLAST WATER NEWS, 2001). The reason is that the bottom sediments in ballast containers are not washed out during the ballast water exchange. These sediments are, as a rule, even more contaminated by aquatic organisms, than the water from the same container.

An alternative is to develop effective ballast water treatment methods, which need to be destructive or mortal for transported aquatic organisms, safe for ships' materials and constructions, and inexpensive. There is a need to develop and implement international standards and procedures for the evaluation and approval of new ballast water treatment systems (BALLAST WATER NEWS, 2001).

Another field of activities in the same direction is to achieve decline in populations of harmful species in their new habitats. Once introduced in a sea and acclimatized, a non-native species cannot be exterminated. It is possible only to reduce its population. One of the possibilities in this area is to catch introduced species. Such is the case of the mollusc *Rapana thomasiana* in the Black Sea. As a result of this, the population of this voracious snail was greatly (about tenfold) reduced and its impact on native bivalves was weakened correspondingly.

Other means to decline in populations of alien species is the introduction of their antagonists. This method was proposed by GESAMP (1997) with reference to the outbreak of *Mnemiopsis leidyi* in the Black Sea, proceeding from the data of experts (HARBISON&VOLOVIK, 1993).

This is a realistic way to achieve good results. The only indispensable condition is the substantiation of the proposal taking into consideration, in particular, the behavioural peculiarities of alien species in new habitats ("precautionary principle"). Confirmation of the validity of antagonistics' method is the *Mnemipsis* population decline in the Black Sea and the Sea of Azov after the introduction (also accidental one) of *Beroe* comb jellies.

One may suppose that *Beroe* species were repeatedly introduced into the Black Sea with ballast waters, but without suitable food their acclimatization was impossible. Only after preliminary acclimatization of *Mnemiopsis*, this possibility appeared. As to *Mnemiopsis*, this species was, from the very outset, provided with a rich food, composed from zooplankton and pelagic eggs and larvae of fish, and its entering in the Black Sea ecosystem took place, obviously, in a short time.

Because it is impossible to stop once and for all the introduction of exotics via ships, it is very important to undertake biological surveys and monitoring in ports. This is one of recommendations under the current IMO ballast water management guidelines (PUGHIUC, 2001).

As to freshwater and brackish water exotics, an interesting paper "History of nonindigenous aquatic invertebrate introductions in the Ponto-Caspian region" was prepared by GRIGOROVICH *et al*., (in press). The paper concerns drainage basins of the Black, Azov and Caspian Seas,including rivers, lakes ponds and reservoirs, and provides information to develop effective control programmes to prevent the further human-mediated invasions. Some of the freshwater organisms mentioned in that paper can be found in low salinity areas and were also mentioned in this book.

A very detailed monograph “Invasive Aquatic Species of Europe: Distributions, Impacts and Management” (Editors: LEPPAKOSKI, OLENIN and GOLLASH) has been prepared by a group of experts and it will be published in the near future by Kluwer Scientific Publishers.

Glossary

(From ALLABY, 1983; DEDIU, 1989; LINCOLN *et al.*, 1985; ZAITSEV, 1971; ZAITSEV & MAMAEV, 1997)

Abiotic environment - The non-living component of an ecosystem; the physical and chemical factors of the ecosystem. Cf. biotic environment.

Adventive - Not native; an organism transported into a new habitat whether by natural means or by the agency of man.

Allochthonous - Exogenous; originating outside and transported into a given area; non-native.

Anoxic - Pertaining to a habitat devoid of molecular oxygen; anoxia.

Antagonism - The inhibition of one species by the action of another.

Anthropogenic - Caused or produced by man, man-made, man-induced, human-mediated.

Area - 1. The overall geographical distribution of a taxon. 2. The range occupied by a community or species.

Autochthonous - Produced within a given habitat, community or system.

Ballast water - Water carried by a vessel to improve stability, or the act of adding such weight.

Behaviour - The response of an organism, group or species to environmental factors.

Benthos - Those aquatic organisms attached to, living on, in or near bottom.

Biocoenosis (Biocenosis) - A community or natural assemblage of organisms inhabiting a biotope.

Bioerosion - Erosion resulting from the direct action of living organisms.

Biological diversity (Biodiversity) - The diversity of life often divided into three hierarchical levels: genetic (diversity within species), species (diversity among species), and ecosystems (diversity among ecosystems).

Biological indicator - An organism which is used as an indicator of chemical activity in, or the chemical composition of, a natural system.

Biomass - Any quantitative estimate of the total mass of organisms comprising all or part of a population or any other specific unit, or within a given area; measured as volume, mass (live, dead, dry or ash-free weight) or energy (calories); standing crop; standing stock.

Biota - The total flora and fauna of a given area; bios.

Biotic environment - The living component of an ecosystem.

Biotic factors - Environmental factors resulting from the activities of living organisms.

Biotope - The smallest geographical unit of the biosphere or of a habitat that can be delimited by convenient boundaries and is characterised by its biota.

Bloom - An explosive increase in numbers and biomass of an organism.

Carnivore - Flesh eating.

Coastal waters - Marine benthic and pelagic ecosystems which are substantially influenced by the land.

Continental shelf - The shallow gradually sloping seabed around a continental margin, not usually deeper than 200 m and formed by submergence of part of the continent. Generally, the most productive part of seas and oceans.

Cosmopolitan (cosmopolite) - Heaving a worldwide distribution, effect or influence; cf. ecumenical, pandemic, ubiquitous.

Cryptogenic species - Possible exotic species, for which it is difficult or impossible at present to discern whether they are native or introduced.

Cyclonic water circulation - An anticlockwise water rotation.

Detritus - Fragmented particulate organic matter derived from the decomposition of plant and animal remains; organic debris. Colonised by bacteria, detritus is a major food source in aquatic ecosystems.

Dominant - An organism exerting considerable influence upon a community by its size, abundance or coverage.

Ecology - The study of the interrelationships between living organisms and their environment.

Ecosystem - A community of organisms and their abiotic environment interacting as an ecological unit; the entire biological and physical content of a biotope or habitat.

Ecotone - The boundary or transitional zone between adjacent communities; tension zone.

Endemic - Native to, and restricted to, a particular geographical region.

Ecumenical (cosmopolitan) - World wide in extent or influence; pandemic.

Endemic - Native to, and restricted to, a particular geographical region.

Estuary - Any semi-enclosed coastal water, open to the sea, having a high fresh water drainage and with marked cyclical fluctuations in salinity. As tideless seas, the Black, Azov and Caspian Seas does not have estuaries, but their open limans are sometimes referred to as estuaries or estuary-type limans.

Ethology - The study of behaviour of animals in their natural environment.

Eurybiontic - Used of an organism tolerating a wide range of a particular environmental factor; cf. stenobiontic.

Euryhaline - Tolerant to a wide range of salinity.

Eurythermic - Tolerant to a wide range of ambient temperatures.

Eutrophication - Enrichment of a water body with nutrients, resulting in excessive growth of phytoplankton, seaweeds and some animals. This may happen naturally but is often a form of pollution. The algal growth can smother bottom plants reducing light intensity, and/or cause deoxygenation of bottom layers of water.

Exotic species - (also called alien, introduced, nonindigenous, non-native, settlers). A species that has been transported by human activity, intentional or accidental, into a region where it does not naturally occur.

Factor - Any causal agent.

Fauna - The entire animal life of a given region, habitat or geological stratum.

Flora - The entire plant life of a given region, habitat or geological stratum.

Food chain - A sequence of organisms on successive trophic levels within a community; energy enters the food chain during fixation by primary producers (mainly green plants) and passes to the herbivores (primary consumers) and then to the carnivores (secondary and tertiary consumers).

Food web - The network of interconnected food chains of a community or ecosystem.

Fouling - An assemblage of organisms growing on the surface of floating or submerged man-made objects (such as pilings or ship's hulls) that increases resistance to water flow or otherwise interferes with the desired operation of the structure. Fouling is an important way of transport of attached aquatic organisms from one sea or river to another.

GESAMP - Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection.

Habitat - The locality, site and particular type of local environment occupied by an organism.

Halophilic (halophilous) - Thriving in saline habitats.

Halophobic - Intolerant of saline habitats.

Herbivore (Herbivorous) - Feeding on plants; phytophagous.

Heterotrophic- Obtaining nourishment from exogenous organic materials (all animals).

Hot spot (in Ecology) - 1. An area rich in total number of species, or an area of especially high pollutant concentrations; 2. An area rich in total number of exotic species.

Hypoxia - A state of low oxygen concentration relative to the needs of most aerobic species.

Indigenous - Local, native.

Interstitial - Pertaining to, or occurring within, the pore spaces (interstices) between sand (sediment) particles.

Invasion - The mass movement or encroachment of organisms from one area into another. Invader.

Invertebrate - Any animal without a backbone or spinal column.

Keystone species (Key species) - A species that influences the ecological composition, structure, or functioning of its community far more than its abundance would suggest.

Liman - Local name of former mouth of a river now covered with sea water. Open limans are connected to the sea, closed limans are isolated from the sea by a sand bar. The formation of limans is a result of the geological dipping of the earth in the area. The Black Sea and Sea of Azov limans are ihhabited mostly by Pontian relics and many brackish water origin exotics take first refuge in limans.

Littoral - Pertaining to the shore; the intertidal zone of the seashore.

Macrobenthos - The larger organisms of the benthos, exceeding 1 mm in size.

Meiobenthos - Small benthic organisms that pass through a 1 mm mesh sieve but are retained by 0.1 mm mesh (e.g. foraminiferans, nematods, harpacticoids, ostracods, halacarids, newly sedimentated larvae of molluscs, etc.).

Naturalized species - An exotic species that has become successfully established in a new habitat.

Nekton - Aquatic organisms, such as fish, squids and dolphins, that are powerful enough to swim against currents.

Neritic - Pertaining to the shallow waters overlying the continental shelf.

Neuston - Organisms that occur at or just below the air-sea interface and are adapted to its specific environmental conditions.

Oceanic - Pertaining to the open sea (ocean) waters beyond the edge of the continental shelf.

Opportunistic species - A species adapted for utilizing variable, unpredictable or transient environments, typically with a high dispersal ability and a rapid rate of population growth.

Pandemic – 1. Very widely distributed, ubiquitous, cosmopolitan; 2. A disease reaching epidemic proportions simultaneously in many parts of the world.

Phytobenthos - Bottom-living plants; Macrophytobenthos - large bottom-living plants; Microphytobenthos - unicellular bottom-living algae.

Plankton - Those aquatic organisms that are unable to maintain their position or distribution indepependent of water currents.

Pontian relics - Type of fauna and flora that first appeared in the brackish to freshwater environments of the Pontian Age (Early Pliocene) in South-Eastern Europe. The survivors thus are called Pontian relics by some; others refer to them as "Caspian fauna" or "Caspian relics" because they now occupy the nortehern part of the Caspian Sea (e.g. molluscs pertaining to genus *Hypanis*, crustaceans - to genus *Paramysis*, fish - to genus *Neogobius* and others).

Population - 1. All individuals of one or more species within a prescribed area. 2. A group of organisms of one species, occupying a defined area and usually isolated to some degree from other similar groups.

Productivity - 1. The potential rate of incorporation or generation of energy or organic matter by an individual, population or trophic unit per unit area or volume; 2. Often used loosely for the organic fertility or capacity of a given area or habitat.

Range - The limits of the geographical distribution of a species or a group.

Red tide - Reddish, brownish or greenish discolouring of surface water coloration of sea water caused by a bloom of dinoflagellates or other phytoplankton species, and by some minute animals of the zooplankton.

Relic species (relict species) - Persistent remnants of formerly widespread fauna or flora existing in certain isolated areas or habitats.

Seston - The total particulate matter suspended in water, comprising bioseston and abioseston.

Shelf - (Continental shelf) - The edges of continental land masses, now covered with sea water; generally the most productive part of the sea.

Species diversity - The diversity of species in a higher taxon or a particular place; the middle, most familiar level of biological diversity.

Stenobiontic - Used of an organism requring a stable uniform habitat; cf. eurybiontic.

Systematics - The classification of living organisms into hierarchical series of groups emphasizing their phylogenetic interrelationships; often used as an equivalent to taxonomy.

Taxon - (Taxa) - A taxonomic group of any rank, including all the subordinate groups; taxonomic unit.

Taxonomy - The theory and practice of describing, naming and classifying organisms.

Thermophilic (thermophilous) - Thriving in warm environmental conditions.

Thermophobic - Intolerant of high temperatures.

Trophic level - Feeding level in a food chain or pyramid; for example, herbivores constitue one trophic level.

Ubiquitous (ubiquist) - Having a world-wide distribution, effect or influence; widespread; cosmopolitan, ecumenical; pandemic.

Wetland - An area covered permanently, occasionally, or periodically by fresh or marine water up to depth of 5 metres.

Zoobenthos - Those animals living in or on sea bed or lake floor.

Zooplankton - The animals of the plankton.

References

Abrikosov G.G. New settler of the Caspian Sea // Zool. journ., 1959, 38, 11, P. 1745-1746 (in Russian).

Aladin N.V. & Plotnikov I.S. Settlers in the Caspian Sea // Vestnik Caspia, 2000, 4, (in Russian).

Alexandrov B.G. Ecological aspects of spatial distribution and development of fouling invertebrates larvae in northwestern part of the Black Sea // Ph:D. thesis (Autoreferat).- Sevastopol, 1988, 22 pp. (in Russian).

Alexandrov B.G. Biotic balance of the ecosystem of the coastal zone of the Black Sea in conditions of intensive antropogenic influence / In: Black Sea Symposium: “Ecological Problems and Economical Prospects” (16-18 September, 1991, Istanbul, Turkey).- Istanbul: Acar Matbacılık A.S., 1994, P. 77-84.

Alexandrov B.G. & Zaitsev Yu.P. Black Sea biodiversity in eutrophication conditions // Conservation of the Biological Diversity as a Prerequisite for Sustainable Development in the Black Sea Region. Dordrecht: Kluver Academic Publ., 1998, P. 221-234.

Alexandrov B.G. & Khodakov I.V. Changes of the fouling structure and self-purification activity in coastal zone of the Black Sea in conditions of antropogenic influence / Ecological problems of the Black Sea: collected papers.- Odessa: OCSTEI Publ., 1999, P. 192-197 (in Russian).

Allaby M. A Dictionary of the Environment. New York: New York University Press, 1983, 529 pp.

Altug G.& Erk H. Level of *Coliform*, *Esherichia coli*, *Salmonella* spp *and* Cu, Pb, Cd, Zn, Hg on the coastline of Gökçeada in water body and some organism. National Aegean Islands meeting 2001. P.142-150 Gökçeada. Tudav Publications Number 7. (in Turkish).

Annenkova N.P. Polychaete from relic Paleostomi Lake (the Caucasus) and the rivers connected with it // Doklady AN SSSR, 1929, T. 6, P. 138-140 (in Russian).

Antsulevich A.Y. & Starobogatov Y.I. The first revealing of molluscs from the Order Nudibranchia (Tritoniiformes) in the Caspian Sea // Zool. journ. 1990, 69, 11, P. 138-140 (in Russian).

Artüz M. I. Ctenophora invasion in the Marmara Sea. Cumhuriyet Bilim Teknik Dergisi, 1991, 9, 571 P. 9-11. (in Turkish).

Aysel V.Aegean Sea Flora of Turkey .(Rhodophyta). Doğa. Türk. Bot. Der. 1987. 11. (1): P.1-21 (in Turkish).

Aysel V .Marine Flora of Turkish Mediterranean coast 1. Red Algae (Rhodophyta) Tr.J. of Botany. 1997. 21. (3) P. 155-163.

Bagirov R.M. Fouling of buoys and hydrotechnical constructions in the Krasnovodsk gulf // Pr. Inst. oceanology AS USSR, 1967, 85, P. 58-42 (in Russian).

Bagirov R.M. Fouling formation in the Middle and Southern Caspian / In: Biol. Mid. and Soth. Casp. Moskow: Nauka Publ., 1968, P.105-112 (in Russian).

Bagirov R.M. Azov-Black sea tenants in the benthos and foulings of the Caspian Sea // Abst. Thes. doct. dis., Baku, 1989, 44 pp. (in Russian).

Balık S., Mater S., Ustaoğlu M.R., Bilecik N. Grey mullets and its culture techniques // Turkish Ministry of Agriculture, Forest and Rural Affairs. Fisheries Research Enst., Bodrum 1992, Seri A, No.6, P. 3-25 (in Turkish).

Balık S. Taxonomic Status of West Anatolia Freshwater Fishes and Geographical Distribution of This Species in the Area // T.B.T.A.K.V. Science Congress, Izmir, 1975, P.299-313 (in Turkish).

Ballast Water News. Global Ballast Water Management Programme. Issue 4, January-March 2001, 8 pp.

Belmonte G., Mazzocchi M.G., Prusova I.Yu., Shadrin N.V. *Acartia tonsa*: a species new for the Black Sea fauna // Hydrobiologia, 1994, T. 292/293, P. 9-15.

Basusta N. Pelagic and Demersal Fishes of Iskenderun Bay / Çukurova Univ. Enst.of Science, Ph:D .thesis, Adana, 1997, 202 pp. (in Turkish).

Basusta N., Erdem Ü., Sarıhan E. Lessepsian ımmigrant fish species in Iskenderun Bay // IX. Symposium on Fisheries, Süleyman Demirel University, Eğirdir, 1997, P.140-151 (in Turkish).

Basusta N. & Erdem Ü. A Study on the Fishes of Iskenderun Bay // Turk. J.Zool.Supp., 2000, P. 1-19 (in Turkish).

Ben-Tuvia A. Red Sea Fishes recently found in the Mediterranean // Copeia, 1966, 2, P. 254-275.

Ben-Tuvia A. Revised list of the Mediterranean fishes of Israel // Israel J. Zool., 1971, 20, P.1-30.

Ben-Tuvia A. Immigration of Fishes through the Suez Canal // Bull. Fish., 1978, 76, P. 249-255.

Beshevly L.E. & Kalyagin V.A. On finding of the mollusc *Mya arenaria* L. (Bivalvia) in the north-western Black Sea // Vestnik zoologyi, Kiev 1967, No 3, P. 82-84 (in Russian).

Besiktepe Ş. T., Özsoy E., Latıf M. A., Oğuz T. Hydrography and circulation of the Marmara Sea / Marmara Denizi 2000 Sempozyumu Bildiriler Kitabı, Turkish Marine Research Foundation, İstanbul, 2000. P. 314-326.(in Turkish).

Bilecik N. Distribution of Sea Snail *Rapana venosa* (V.)in the Turkish Coast of Black Sea and its impact on Black Sea fisheries . Bodrum Su Ürünleri Araştırma Enstitüsü yayınları. 1990 .No.1.Seri B. Bodrum Turkey .(in Turkish).

Bini G. Catalogue of the names of fishes of commercial importance in the Mediterranean. 1960. FAO, Rome .250 p.

Birkun A. Jr. & Krivokhizhin S. Mammals of the Black Sea.- Simferopol: Tavria, 1996, 94 pp. (in Russian).

Birshtain Ya.A. & Romanova N.N. Order Side Amphipoda / In.: Atlas of invertebrate animals of the Caspian Sea. Moscow: Pischevaya Promyshlenost, 1968, P. 241-288 (in Russian).

Birshtain Y.A. & Spasski N.P. Bottom dwelling fauna of the Caspian Sea before and after *Nereis succinea* / In.: Materials to knowledge on fauna and flora. New. ser., zoology, 1952, 33 (48), P. 36-114 (in Russian).

Bobat A. Wood boring organism activity as a indicator of Pollution of the Black Sea .Kırsal çevre ve ormancılıksorunları Araştırma Dernegi .1995 . Yayın No :9 , P 72-79 .(in Turkish)

Bogachev V.V. New finding of elements of Mediterranean fauna in the Caspian Sea // DAN USSR, 1928, 14-15, P.187-188 (in Russian).

Bogoroditsky P.V. Mass development of polychaete *Mercierella enigmatica* Fauvel in Krasnovodsky Bay // Trudy Inst. Oceanog. SSSR, 1963, T. 70, P. 26-28 (in Russian).

Boguslavsky C.G., Mitin L.I., Tokovenko V.S. The Sea of Azov / Kiev: Ukr. Rad. Entsiclopedia, 1989, P. 26-28 (in Ukrainian).

Boltachev A.R., Gaevskaya A.V., Zuev G.V. Yurakhno V.,M. The blue whiting, *Micromesistius poutassou* (Risso, 1826), (Pisces: Gadidae) is the new species for the Black Sea fauna // Ecologya morya, 1999, 48, P. 79-82 (in Russian).

Bougis P., Arrecgros &J. D. Guide Nature Mer Mediterranee . 1991. P. 180. Editions Edimo .Monaco

Branch G.M., Griffiths C.L., Branch M.L., Beckley L.E. Two Oceans. A Guide to the Marine Life of Southern Africa.- Cape Town & Johannesburg: David Philip, 1994, 360 pp.

Bronfman A.M. The Sea of Azov / In: Enclosed Seas and Large Lakes of Eastern Europe and Middle Asia. Amsterdam: SPB Academic Publishing bv., 1995, P. 1-32.

Bronfman A.M. & Khlebnikov E.P. The Sea of Azov: Basis for Reconstruction.- Leningrad: Gidrometeoizdat, 1985, 271 pp. (in Russian).

Brotskaya V.A. & Netsengevich M.P. Distribution of the *Mytilaster lineatus* in the Caspian Sea // Zool. jurn. 1941, 20, 1, P.79-99 (in Russian).

Brylinski J.M. Report on the presence of *Acartia tonsa* Dana (Copepoda) in the harbor of Dunkirk (France) and its geographical distribution in Europe // J. Plankton Res., 1981, T. 3, P. 255-260.

Buhan E., Yılmaz H., Morkan Y., Büke E.,Yüksek A. A new potential fishing for the Güllük and Gökova Bays: *Scomberomorus commerson* (Lacepede, 1800) (Pisces-Teleostei) // Mediterranean Fisheries Congress, Ege Univ.Izmir, 1997, P. 937-944 (in Turkish).

Bulgurkov K.I. *Callinectes sapidus* Rathbun in the Black Sea // Izvest. NIORS, 1968, 9, P. 97-99 (in Bulgarian).

Buzzurro, G. & Greppi, E. The lessepsian molluscs of Tasuçu (South East Turkey). *La Conchiglia*, 1996. supplement to 279: 3-22.

Caddy J.F. & Griffiths R.C. A perspective on recent fishery-related events in the Black Sea // General Fisheries Council for the Mediterranean. Studies and Reviews, 1990, 63, P. 43-71.

Carlton J.T. Biological invasions and cryptogenic species // Ecology, 1996, 77, P. 1653-1655.

Caspian Sea: Its Hydrology and Hydrochemistry.- Moscow: Nauka Publ., 1986, 242 pp. (in Russian).

Chepalyga A.L. & Tarasov A.G. Invasion of Atlantic Ocean species in the Caspian Sea: the Fate of Endemic Taxa and Biosystems. Oceanology, 1997, Vol. 37, 2,

Chukhchin V.D. Ecology of Gastropods of the Black Sea.- Kiev: Naukova dumka, 1984, 176 pp. (in Russian). P. 261-268 (in Russian, Engish summary).

Ciesm.org. Atlas of Exotic Species in the Mediterranean Sea covering fishes, molluscs and crustaceans. 22.11.2001.

Cirik Ş. & Ozturk B. Notes sur la présence d'une forme rare du *Caulerpa racemosa*, en Méditerranée orientale. Flora Mediterranea // 1, 1991. P. 217-219.

Collette B.B. & Russo J.L. Morphology, systematic and biology of the Spanish Mackerel (*Scomberomorus,* Scombridae) // Bull. of Sea Fisheries Research Station. Nos., 1984, T. 29-30, No76, P. 68-74.

Commercial fish of the USSR, Moscow: Pischepromizdat, 1949, 787 pp. (in Russian).

Conover R.J. Oceanography of Long Island South, 1952-1954. IV. Biology of *Acartia clausi* and *A. tonsa* // Bull. Bingham. Oceanogr. Coll., 1956, T. 15, P. 156-233.

Cosenza G.& Fasulo G. The littoral shelled mollusks of the Island of Crete. *La Conchiglia*, 1997 284: 51-58.

Crucitti P. &Rotella G. Una popolazione di *Strombus (Conomurex) decorus* del Golfo di Iskenderun (Turchia sud-orientale): Biometria e osservazioni ecologiche. *Bollettino Malacologico,* 1991. 26: 211-218.

Çağatay N. Görür, N.Algan. O, Eastoe, C. Tchapalgyga, A. Ongan, D.Kuhn,T.Kuşçu.İ.Late Glacial –Holocene Palaeocenonography of the Sea of Marmara: Timing of Connections with the Mediterranean and The Black Sea. 2000. P. 264-273. Tudav Yayınları. İstanbul. (in Turkish).

Çelikkale M. S, Düzgüneş E.,Okumuş., I. Fisheries Sector of Turkey : Potential, Present structure, Problems and Solutions Projects / İstanbul Ticaret Odası, 1999. No: 2. (in Turkish).

Dediu I.I. Ecological encyclopedic dictionary.-Kishinev: Glav. Red. Mold. Sov Encyclop., 1989, 406 pp. (in Russian).

Demir M. Boğaz ve Adalar sahillerinin omurgasız dip hayvanları. İst. Üniv.Fen Fakültesi Hidrobiologi Araş. Enst. Yayın.İstanbul 1954. (in Turkish)

Demir M. On the presence of *Arca (Scapharca) amygdalum* Philippi, 1847 in the harbour of Izmir, Turkey. *Istanbul Universitesi* Fen Fakultesi Mecmuasi *1977.* Sér. B, 42: 197-202.

Dimov I., Marinov T., Konsulov A. Some hydrological and hydrobiological particularities of the northwestern section of the Varna Lake and the cooling system of the Varna thermoelectric power station during 1968 // Proceedings of the Institute of oceanography and fisheries-Varna, Sofia, 1970a, v. 10, P. 27-47 (in Bulgarian).

Dimov I., Marinov T., Konsulov A. Attachment rate of *Balanus improvisus* and *Mercierella enigmatica* depending on the temperature of the water // Proceedings of Institute of Oceanography and fisheries-Varna, Sofia, 1970b, v. 10, P. 49-53 (in Bulgarian).

Dolgopolskaya M.A. Barnacles as a pest in fisheries // Priroda, 1946, 3, P. 72 (in Russian).

Dolgopolskaya M.A. Cirripedia / In: Key Book of the Black Sea and the Sea of Azov Fauna.- Kiev: Naukova dumka Publ., 1969, T. 2, P. 260-267 (in Russian).

Doumenge F. Quelques reflections sur les Alges Caulerpes .Biologia Marina Mediterranea , 1995. 2 (2):613-633.

Drapkin E.I. A new mollusc in the Black Sea // Priroda, 1953, 9, P. 92-95 (in Russian).

Düzgüneş E&Feyzioglu, M. Trabzon sahillerinde Deniz Salyangozunun *Rapana thomasiana* Gross.1861 Populasyon ve büyüme özelliklerinin belirlenmesi (Determination of growt and population parameters on the Sea Shell , *Rapana Thomasina*, Gross .1961.I. Ulusal Ekoloji ve Çevre Kongresi . 1993. İzmir. (in Turkish).

Düzgüneş E. Ecological characteristic of *Anadora cornea* in the eastern Black Sea. Proceedings of the Second International Conference on the Mediterranean Coastal Environment, 1995 P- 75-85., Tarragona, Spain. E. Özhan. (Editor) (in Turkish).

Dyunina K.A. Some data on *Nereis succinea* from Minor and Greater Gulfs named after Kirov (Gizilagach) // Rybnoe khozyaistvo, 1949, 8, P. 36-38 (in Russian).

EEA State and pressures of the marine and coastal Mediterranean environment Office for Official Publications of the European Communites 1999, p.137

Eng W. Specie prevalentemente lessepsiane attestate lungo le costa Turche. Boll. Malacologico. 1995. 31 (1-4) 43-50.

Enzenross L &Enzenross R. Niederhöfer H.J. Wissenschafftlich interessante Funde aus der Sammlung Enzenross (Marine Invertebraten) Jh.Ges. Naturkde. 1990. Wüttemberg. 145.Jahre. P.284- 294.

Enzenrob R. Enzenrob.L.Bingel F. Occurrence of Blue crab *Callinectes sapidus* (Rathburn, 1896) (Crustacea, Brachyura) on the Turkish Mediterranean and the Adjacent Agean Coast and its size Distribution in the Bay of İskenderun .1997.Tr.J.Zoology. 21. 113-122 .

Erazi R.A.R. Marine Fishes found in the Sea of Marmara and in the Bosphorus. Rev.Fac.Sci.Univ..Istanbul. 1942. B. 7: 103-15

Farabegoli A., Ferrari I., Manzoni C., Pugnetti A. Prima segnalazione nel Mare Adriatico del copepode calanoide *Acartia tonsa* // Nova Thalassia, 1989, 10, Suppl. 1, P. 207-208.

Fauvel P. Un nouveau serpulien d'eau saumatre, *Mercierella* n.g. *enigmatica* n.sp.// Bull. Soc. Zool. De France, 1923, v. 47, P. 185-193.

Fedorov A.A. (Ed.). The Life of Plants.- Moscow: Prosveshchenye Publ., 1974, v. 4, 487 pp. (in Russian).

Fedosov M.V. Reasons for the origin of oxygen deficit in the Sea of Azov // Trudy Vsesoyuznogo Instituta morskogo rybnogo khozyaistva i okeanografiy, 1955, 1, P. 9-34 (in Russian).

Fegenbaum D. & Kelly M. Changes in the lower Chesapeake Bay food chain in presence of the sea nettle *Chrysaora quinquecirrha* (Scyphomedusa) // Mar. Ecol. Progr. Ser., 1984, 19 (1-2), P. 39-47.

Firth F.E. (Ed.) The Encyclopedia of Marine Resources.- New York: Van Nostrand Reinhold Comp., 1969, 740 pp.

Fischer W., Bauchot M.-L., Schneider M.(Eds) Fiches FAO d'identification des especes pour les besoins de la peche.(Revision 1). Mediterranee et mer Noire. Vertebres. FAO and EEC, Rome, 1987, Zone de peche 37, v.2.

Friedrich H. Polychaeten-Studien. I-III. // Kiel. Meeresf., I, 2, P. 243-351.

Froglia C., Galil B., Noel P., Turkay .M. Alien Species in the Mediterranean Sea . Crustacea: Decapoda & Stomopoda 1998. " (Working Document) . 35. Congress CIESM.

Fyodorov P.V. The Stratigraphy of Quaternary Sediments and the History of the Evolution of the Caspian Sea / In: Transactions of the Geoligy Instityte of the USSR Academy of Sciences, Moscow, 1957, P. 10 (in Russian).

Galil B.S. A sea under siege - alien species in the Mediterranean. Biological Invasions, 2000, **2**, P. 177-186.

Gaudy R., Viñas M.D. Premieresignalization en Mediterranee du copepode pelagique *Acartia tonsa* // Rapp. Comm. Int. Mer. Médit., 1985, T. 29, P. 227-229.

Geldiay R.Izmir Körfezinin başlıca balıkları ve ve Muhtemel invansiyonları. Bornova.EgeUniv.Fen Fak.Monog.1969.P.135.(in Turkish).

Geldiay R. & Balık S. Turkish Freshwater Fishes // Ege University, Science Faculty Books Series, Ege Univ. Publication-house, 1988, No 97. (in Turkish) .

GESAMP (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, 1997, T. 58, 84 pp.

Ghisotti F. & Rinaldi E. Osservazioni sulla popolasione di *Scapharca*, insediatasi in questi ultimi anni su un tratto del litorale romagnolo // Conchiglie, 1976, 12, P. 183-195.

Glibert P. & Pitcher G. (Eds). Global Ecology and Oceanography of Harmful Algal Blooms // Science Plan. SCOR and IOC, Baltimore and Paris, 2001, 86 pp.

Golani D. Trofic adaptation of Red Sea fishes to the Eastern Mediterranean environment review and new data // Israel J. Zool., 1993, 39, P. 391-402.

Golani D. The marine ichthyofauna of the Eastern Levant history, inventory and characterization // Israel J. Zool., 1996, 42, P. 15-55.

Golani D. & Ben-Tuvia A. The Biology of the Indo-Pacific squirrel fish *Sargocentron rubrum* (Forsskal), a Suez Canal Migrant to the Eastern Mediterranean // J.Fish Biol., 1985, 27, P. 249-258.

Golani D. & Diamant A. Biology of the sweper *Pempheris vanicolencis* Cuvier & Valenciennes, a Lessepsian migrant in the Eastern Mediterranean with a comparison original Red Sea population // J. Fish Biol., 1991, 38, P. 819-820.

Golitsyn G.S. & Panin G.N. On the Water Balance and Present Day Changes of the Caspian Level // In: Meteorology and Hydrology, 1985, 1, P. 57-64 (in Russian).

Gollash S. & Leppakoski E. Initial Risk Assessment of Alien Species in Nordic Coastal Waters, Nord. 1999, P. 13-122.

Gollash S., Minchin D., Rosenthal H., Voigt M. (Eds.) Case histories on introduced species: their general biology, distribution, range expansion and impact // Dept. of Fishery Biology, Institute for Marine Science, University of Kiel, Germany , 1999, 73 pp.

Gomoiu M.T. Some ecological data on the gastropod *Rapana thomassiana* Crosse along the Romanian Black Sea shore // Cercetari marine, IRCM, 1972, 4, P. 169-180.

Gomoiu M.-T. *Scapharca inaequivalvis* (Bruguiére) - a new species in the Black Sea // Cercet. Marine IRCM, 1984, 17, P. 131-141.

Gomoiu M.-T. & Skolka M. Changements recents dans la biodiversité de la Mer Noire dûs aux immigrants / GEO-ECO-MARINA, RCGGM, 1996.- v. 1.- “Danube Delta – Black Sea System under Global Changes Impact”, Bucuresti- Constanta, 1996, P. 49-65.

Gomoiu M.-T. & Skolka M. Increasing of biodiversity by immigration of new species for the Romanian Fauna // An. Univ. “Ovidius” Constanta, Seria Biologie-Ecologie, 1998, v. 2, P. 181-202 (in Romanian).

Gosner K.L. A Field Guide to the Atlantic Seashore.- Boston: Houghton Mifflin Comp., 1978, 329 pp.

Gotsis-Skretas O. & Friligos N. Contribution to eutrophication and phytoplankton ecology in the Thermaikos Gulf // Thalassographica, 1990, T. 13, v. 1, P. 1-12.

Green J. The biology of estuarine animals. Biology series.- London, 1968, 379 pp.

Grishicheva N.P. & Shadrin N.V. Hydroids as epibionts of mussel and *Cystoseira* / In: Sebastopol coastal waters: ecosystem processes and facilities to society, Sebastopol, 1999, P. 294.

Grishin A.N. & Zolotarev P.N. Biological characteristics and stocks of *Rapana thomasiana* in the Black Sea / In: Resources and biological basis of the rational use of commercial invertebrates. Abstracts of Papers of All-Union Conference. Vladivistok, 1988, P. 56-57 (in Russian)

Grishin A.N., Shliakhov V.A., Arutiunian S.V. Unknown comb jelly in the Sea of Azov // “Ribne gospodarstvo Ukrainy”, 1999, T. 4, No 7, P. 30 (in Russian).

Gubanova A.D. To a question on occurrence of *Acartia tonsa* Dana in the Black Sea // Second Congr. Ukr. Hydroecolog. Soc. (27-31 Oct., Kijv, Ukraine), Kiev, 1997, P. 24-25 (in Russian).

Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens. Resolution A. 868(20). International Maritime Organization, London, 1998, 16 pp.

Gücü A.C., Bingel F., Avsar D., Uysal N. Distribution and occurrence of Red Sea fishes at the Turkish coast-Northern Cilian basin // Acta Adriatica, 1994, T. 34, v. 1-2, P. 103-113.

Gücü A.C. & Bingel F. Trawlable species assemblages on the Norheastern Levant Sea (Mediterranean) with an emphasis on Lessepsian migration // Acta Adriatica, 1994, T. 35, v. 1-2, P. 83-100.

Güven K. C., Özsoy Y., Öztürk B., Topaloglu.B. Raparin, a new heparinoid from *Rapana venosa* (Valenciennes) Pharmazie, 1991 (46), H. 7, P.547-548.

Gvozdev E.V. & Mitrofanov V.P. (Eds.) The Fishes of Kazakhstan.- Almaty: Nauka, 1986, 272 pp. (in Russian).

Harbison G.R. & Volovik S.P. Methods for the Control of the Ctenophore *Mnemiopsis leidyi* in the Black and Azov Seas // FAO Fisheries Reports, 1993, P. 32-44.

Harbison G.R. & Volovik S.P. The ctenophore, *Mnemiopsis leidyi*, in the Black Sea: a holoplanktonic organism transported in the ballast water of ships / In: Nonindigenous Estuarine and Marine Organisms (NEMO), Proceedings of the Conference and Workshop, Seattle, Washington, April 1993., 1994, P. 25-36.

Henry D.P. & McLaughlin P.A. The barnacle of the *Balanus amphitrite* complex (Cirripedia, Thoracica) // Zool. Verh., 1975, v. 141, P. 1-254.

Holthuis L.B.& Gottlieb.E Two interesting crabs (Crustacea Decapoda, Brachyura) from Mersin Bay, SE Turkey Zoologische Mededelingen,*1956.* 34:287-299.

Holthuis L.B., Report on a collection of Crustacea Decapoda and Stomatopoda from Turkey and the Balkans. *Zoologische Verhandelingen, 1961.* 47:1-67.

ICES Report of the working group on introduction of non-indigenous marine organisms. Cooperative Research Reports, No 32, 1992, 59 p.

Isayev A.A. Methodological Aspects of Research into Variation in Accretion of Hydrometeorological Elements for Dagnostic and Prognostic Purposes / In: Transactions of the VNIIGMI-MTsD, 1987, P. 104-143 (in Russian).

Ivanov A.I. Characteristics of the qualitative composition of the Black Sea phytoplankton / In: Issledovanie planktona Chernogo i Azovskogo morey.- Kiev: Nauk. dumka, 1965. P. 17-34 (in Russian).

Ivanov A.I. The expansion and population dynamics of the new mollusc *Mya arenaria* introduced into the Black Sea / In: Abstr. of the 4th All-Union conference on commercial invertebrates. Part 2. Moscow, 1986, P. 225-226 (in Russian).

Jeffries H.P. Succession of two *Acartia* species in estuaries // Limnol. Oceanogr., 1962, 7, P. 354-364.

Jude D.I., Reider R.H., Smith G.R. First evidence of Gobiidae in the Great Lakes basin // 34th Conf. of the int. Assoc. for Great Lakes Research, Buffalo, N.Y. (USA), 1991. Programme and Abstracts-: IAGLR , Univ. Michigan., P. 124.

Kalugina-Gutnik A.A. Phytobenthos of the Black Sea.- Kiev: Naukova Dumka, 1975, 247 pp. (in Russian).

Kamburska L., Moncheva S., Konsulov A., Krastev A., Prodanov K. The invasion of *Beroe ovata* in the Black Sea – Why a warning for ecosystem concern? / In: Mediterranean Marine Science, v. 2.- Internat. Conf. "Oceanography of the Eastern Mediterranean and Black Sea. Similarities and Differences of two Interconnected Basins", Athens, 23-26 February, 1999, 15pp.(in press).

Kamshilov M.M. Nutrition of the comb jelly *Beroe cucumis* Fabr // Doklady AN SSSR, 1955, T. 102, No 2, P. 399-402 (in Russian).

Kamshilov M.M. Dependance comb jelly *Beroe cucumis* Fabr measurement from its nutrition // Doklady AN SSSR, 1960, T. 131, No 4, P. 957-960 (in Russian).

Kaplin P. The Caspian: Its past, present and future / In: Enclosed Seas and Large Lakes of Eastern Europe and Middle Asia (A. Mandych). Amsterdam: SPS Academic Publ. bv, 1995, P. 71-117.

Karpevich A.F. Influence of the hydrogen sulphide on survival of *Mytilaster lineatus* and *Pontogammarus maeoticus* in the Caspian Sea // Zool. jurn. 1940, 19, 6, P. 860-864 (in Russian).

Karpevich A.F. Influence of environment on change of fauna of the Northern Caspian // Reports on Biology VNIRO, 1952, 1, P.111-114 (in Russian).

Karpevich A.F. Bioecological characteristic of mollusc *Monodacna colorata* (Eichwald) Taganrogsky Gulf // Trudy VNIRO, 1960, 43, P. 244-256 (in Russian).

Karpevich A.F. Theory and practice on acclimatization of aquatic organisms - Moscow: Pischevaya Promyshlenost, 1975, 431 pp. (in Russian).

Kasymov A.G. Industry and the productivity of the Caspian Sea Marine Pollution Bulletin, 1970, 1, 7, P.100-103.

Kasymov A.G. Species composition and quantitative distribution of the zoobenthos in the Turkmenski gulf of the Caspian Sea // Oceanology, 1974, 14, 4, P.709-712 (in Russian).

Kasymov A.G. The role of Azov-Black Sea invaders in the productivity of the Caspian Sea benthos // Int. Revue ges. Hydrobiol., 1982, 67, 4, P.533-541.

Kasymov A.G. Animal World of the Caspian Sea.- Baku: Elm, 1987a, 156 pp. (in Russian).

Kasymov A.G. The Caspian Sea. – Leningrad: Gidrometeoizdat Publ., 1987b, 152 pp. (in Russian)

Kasymov A.G. Quantitative development of zooplankton and zoobenthos in the Baku Bay of the Caspian Sea // Oceanology, 1988, 28, 4, P. 670-675 (in Russian).
Kasymov A.G. & Bagirov R.M. Zoobenthos in the Western section of the Caspian Sea // Biol. Sea, 1977, 2, P. 77-85 (in Russian).
Kasymov A.G. Bagirov R.M., Filippov G.M. Benthos near the South-Western coast of the Caspian Sea // Zool. jurn., 1974, 53, 3, P. 454-456 (in Russian).
Kasymov A.G. & Rogers L. Biological description of the southern Caspian Sea in the oil-field region of "Guneshly" // Polish. ecol, studies, 1996, 22, 3-4, P. 83-93.
Kaya M., Mater S., Korkut A.Y. A new grey mullet species *Mugil so-iuy* Basilewsky (Teleostei: Mugilidae) from the Aegean Coast of Turkey // Turk. J. Zool., 1998, 22, P. 303-306.
Kazancheev Y.N. Fishes of the Caspian Sea.- Moscow: Legkaya i pischevaya promishlenost Publ., 1981, 67 pp. (in Russian).
Kazumi M. & Yasuwo F. Technical Giude for Modern Dinoflagellate Cyst Study. WESTPAC-HAB/WESTPAC/IOC, 2000, 29 pp.
Khlebovich V.V. Class Polychaeta / In: Atlas of invertebrate animals.- Moscow: Pischevaya promyshlenost Publ., 1968, P. 96-104 (in Russian).
Kıdeys A.&Niermann U.,Intrusion of *Mnemiopsis* (Ctenophora : Lobata) into the Mediterranean Sea // Senckenbergia Maritima , 1993. 23, P. 43-47.
Kıdeys A. The Devastated Ecosytem of the Black Sea and Its Impact on Anchovy Fisheries //Aegean Univ. J . of Science Fac., 1994,Seri B., 16/1.(in Turkish).
Kırkım F., Kocataş A., Katagan T., Lessepsian Göçmen *Sphaeroma walkeri* (Stebbing,1905)(Isopoda:Crustacea) Türkiye kıyılarındaki dağılımı.2001. Ulusal Su Ürünleri Sempozyumu . M. K .Üniversitesi . Bildiri ve Poster özetleri 2001 P. 60. (in Turkish).
Kiseleva M.I. On the finding of the polychaete *Ancistrosyllis tentaculata* Tradwell in the Black and Red seas // Zoolog. zhurn., 1964, XLIII, v. 10, P. 11557-1558 (in Russian).
Knipovich N.M. Hydrological investigations in the Sea of Azov // Trudy Azovo-Chernomorskoy nauchno-promyslovoi ekspeditsiy, 1932, 5, 496 pp. (in Russian).
Koçak F., Ergen A., Cinar M.E. Fouling organisms and their development in a polluted and an unpolluted marina in the Aegean Sea (Turkey)// Ophelia, 1999, 50 (1), P. 1-20.
Kocatas A. Liste Preliminaire et repartition des Crustaces Decapodes des eaux Turques // Rapp. Comm. Mer Medit., 1981,27, 2, P.16-17.
Kocatas A., On the occurrence of *Sirpus zariquieyi* Gordon (Decapoda Brachyura) in the Black Sea and Sea of Marmara // Crustaceana, 1982, 43, 2, P. 177-180.
Kocatas A&Bilecik N., Aegean Sea and Its Living Resources Su Ürünleri Araştırma Enstitüsü, Bodrum 1992., Seri A., yayın No: 7,P 1-88 (in Turkish) .

Kocatas A., Koray, T., Kaya M., Kara.O.F. A review of the fishery resources and their environment in the Sea of Marmara// GFCM. Studies and Reviews . 1993. No: 64 . FAO . P.87-143.

Kocataş A., KatağanT., Uçal O., Benli H. A. Shrimps culture and Turkey's shrimps. Su ürünleri araştırma enstitüsü müdürlüğü, Bodrum 1991, Seri A, yayın no:4. P.143 (in Turkish).

Kochina E.M. The first mass record of *Beroe ovata* in Calamytsky Bay of the Black Sea // Vestnik zoologii, 1999, T. 33, v. 6, P. 26 (in Russian).

Konovalova G.V., Orlova T.Yu., Pautova L.A. Atlas of the Sea of Japan phytoplankton.- Leningrad: Nauka Publ., 1989, 160 pp. (in Russian).

Konsulov A. Trophic determination of ctenophora's new species invasion into the Black Sea // Comptes rendus de l'Academie bulgaire des Sciences, 1999, T. 52, No 1-2, P. 119-122.

Konsulov A.S. & Kamburska L.T. Ecological determination of the new Ctenophora – *Beroe ovata* invasion in the Black Sea // Trudove na Instituta po okeanologiya, Varna, 1998, T. 2, P. 195-198.

Kosova A.A. Bivalve *Monodacna colorata* Eichw. in the Lower Volga / Proceed. All Un. Hydrobiol. Society., 1963, 13, P. 84-89 (in Russian).

Koray T&Kesici.U.Phytoplancton and protozooplancton species composition of the bay of Bodrum (Aegean Sea)// E.Ü. Fen Fakültesi Dergisi.1994. Seri B. 16/1. P.972-980. (in Turkish).

Koutsoubas D. and Voultsiadou-Koukoura E., 1991. The occurrence of *Rapana venosa* (Valenciennes, 1846) (Gastropoda, Thaididae) in the Aegean Sea // Bollettino Malacologico,1991, 26, 201-204.

Kovalev A.V. & Shmeleva A.A. Fauna of Copepoda in the Mediterranean Seas // Ecologia moria, 1982, 8, P. 82-87 (in Russian).

Kudelina Y.N. Observations on biology of the Caspian srimp // Trans. Caspian basin Branch VNIRO, 1950, 11, P. 235-264 (in Russian).

Kuhlmann D., Quantz G., Witt U. Rearing of turbot larvae (*Scophthalmus maximus* L.) on cultured food organisms and postmetamorphosis growth on natural and artificial food // Aquaculture, 1981, T. 23, v. 1-4, P. 183-196.

Kurashova Y.K. & Abdullaeva N.M. *Acartia clausi* Giesbrecht (Calanoida, Acartiidae) in the Caspian Sea // Zool. J., 1984, 63, 6, P. 931-933.

Kurashova Y.K. & Tinenkova D.Kh. Number, biomass and. distribution of the tenant *Acartia clausi* Giesbrecht (Calanoida, Acartiidae) in the Northern and Middle Caspy // Hydrob. J., 1988, 24, 2, P. 23-27 (in Russian).

Lang W.H. Larval development of shallow water barnacles of the Carolinas (Cirripedia: Thoracica) with keys to naupliar stages // NOAA Technica Report NMFS Circular 421.- US Department of Commerce 1979, - 39 pp.

Lavrov-Navozov N.P. Black Sea shrimp in the Caspian Sea // Zool. J., 1939, 18, 3, P. 443 (in Russian).

Lebedev E.M. Fouling of the ships floating in the Sea of Azov and Kerch Strait // Trudy Inst. Oceanol. AN SSR, 1961.- T. 49.- P. 118-135 (in Russian).

Lebedeva L.P. Variability of the number and biomass of ctenophora *Mnemiopsis* in the Black Sea (a model research) // Okeanologia, 1998, 38, No 5, P. 727-

733 (in Russian).
Leonov A.K. Regional Oceanography.- Leningrad: Gidrometizdat, 1960, 765 pp. (in Russian).
Leppäkoski E. & Olenin S. Non-native species and rates of spread: lessons from the brackish Baltic Sea// Biological Invasion, 2000, 2, 2, P. 165-176.
Lincoln R.J., Boxhall G.A., Clark P.F. A dictionary of ecology, evolution and systematic Cambridge: Cambridge University Press, 1985, 298 pp.
Logvinenko B.M. On finding of medusa *Blackfordia virginica //* Zool. J., 1959, 38, 8, P.1257-1258 (in Russian).
Logvinenko B.M. On changes in the fauna of the Caspian molluscs from genus *Dreissena* after installation of *Mytilaster lineatus* (Gmel.) // Biol. Sci., 1965, 4, P.14-19.
Lonsdale D.J., Heinle D.R., Siegfried C. Carnivorous feeding behavior of the adult calanoid copepod *Acartia tonsa* Dana // J.Exp.Mar.Biol.Ecol., 1979, T. 36, v. 3, P. 235-248.
Makarov A.K. About some new elements in the fauna of Black Sea estuaries in connection with shipping // DAN URSS, 1939, T. 23, v. 8, P. 818-821 (in Russian).
Marcus Er. & Marcus Ev. Some opisthobranchs from the Northwestern Gulf of Mexico // Publs. Inst. Mar. Sci. Univ. Texas., 1960, v. 6, P. 251-264.
Marcus Ev. Notes on some opisthobranch gastropods from the Chesapeake Bay // Chesapeake Sci., 1972, v. 13, P. 300-317.
Marinov T. Contribution to the knowledge of our Polychaeta fauna in the Western Black Sea coast// Trudy morsk. Biol. St., 1957, 19, P. 121-126 (in Bulgarian).
Marinov T. Polychaeta fauna of brackish waters along Bulgarian Black Sea coasts // Izv. Zool. Inst. BAN, 1966, 21, P. 1139-152 (in Bulgarian).
Marinov T.M. Fauna of Bulgaria. T. 6. Polychaeta.- Sofia: BAN, 1977. 257 pp. (in Bulgarian).
Marinov T.M. The Zoobenthos from the Bulgarian sector of the Black Sea - Sofia: Bulg. Academy of Sci. Publ., 1990, 195 pp. (in Bulgarian). Marina Mediterranea, Peridico edito dalla Societa Italiana di Biologia Marina Vol. 7.Fasc.3 . 1-66.
Marti Yu. New information on acclimatization of gray mullets in the Caspian Sea // Priroda, 1940, 1, P. 88-90 (in Russian).
Mater S., Toğulga M., Kaya M. The Distribution and Economical Importance of Lessepsian Fish Species in the Turkish Seas // II. National Ecology and Environmental Congress, Ankara, 1995, P. 453-462 (in Turkish).
Mater S. & Torcu H. An Investigation on Biology of *Saurida undosquamis* (Richardson,1848) of Fethiye and Mersin Bays // XIII National Biology Congress, Istanbul,1996, P.178-189 (in Turkish).
Matsumato G.&Harbison G.R. In situ observations of foraging , feeding and escape behaivor in three orders of oceanic ctenophores: Lobata, Cestida and Beroida // Mar.Biol., 1993., 117, (2), P. 279-287.

Matvienko O.M. & Litvinenko R.M. The guide of fresh water algae of Ukrainian SSR.- Part 2. Pyrrophyta.- Kiev: Naukova dumka Publ., 1977, 386 pp. (in Ukrainian).

Mayer A.G. Ctenophores of the Atlantic coast of North America-Washington: The Carnegie Inst. of Washington, 1912, 58 pp.

Mihnea P. E. Major shifts in the phytoplankton community (1980-1994) in the Romanian Black Sea // Oceanologica acta, 1997, T. 20, v. 1, P. 119-129.

Mihnea P.E., Dragos N. *Mantoniella squamata* a new species for the Black Sea // Cercetari marine, I.R.C.M.- 1996-1997.- T. 29-30.- P. 95-114.

Milovidova N.Yu. Quantity characteristic of *Cystoseira* biocenosis in northeastern part of the Black Sea (on the base of underwater investigations) / In: Marine underwater investigations.- Moscow: Nauka Publ., 1969, P. 78-88 (in Russian).

Minicheva G.G. & Eremenko T.I. Algological discoveries in the north-western Black Sea // Algologya, 1993, 3, No 4, P. 83-86 (in Russian).

Moncheva, S. Eutrophication, plankton blooms and hypoxia // Rep. Int. Workshop on the Black Sea: Focus on the Western Black Sea Shelf. (Varna, 30 Sept. - 4 Oct. 1991), Varna, 1991.

Moncheva S., Doncheva V., Kamburska L. On the long-term response of harmful algal blooms to the evolution of eutrophication off the Bulgarian Black Sea coast: are the recent changes a sign of recovery of the ecosystem- the uncertainties / In: Rep. On IX Internation. Conf. “Harmful algal blooms” (5-11 February, Hobart, Tasmania, 2000), 2000 (in press), 7 pp.

Moncheva S., Gotsis-Skretas O., Pagou K., Krastev A. Phytoplankton blooms in Black Sea and Mediterranean coastal ecosystems: similarities and differences // Intern. Conf. “Oceanography of the Eastern Mediterranean and Black Sea. Similarities and Differences of Two Interconnected Basins” (Athens, 23-26 February 1999), (in press).

Moncheva S. & Krastev A. Some aspect of phytoplankton long-term alterations of Bulgarian Black Sea shelf // In: Sensitivity to Change: Black Sea, Baltic Sea and North Sea / E. Oszoy, A. Mikhaelian [ed.].- NATO ASI Series, 2.Environment.- Kluwer Academic Publ.,1997, v. 27, P. 79-94.

Moncheva S., Petrova-Karadjova V., Palasov A. Harmful algae blooms along the Bulgarian Black Sea coast and possible patterns of fish and zoobenthic mortalities // In: Harmful Marine Algal Blooms / P Lassus, G.Arzul, E.Denn, P. Gentien [eds], Lavoisier Publ. Inc., 1995, P. 193-198.

Moolenbeek R.G. & Dekker H. 1993. On the identity of *Strombus decorus* and *Strombus persicus*, with the description of *Strombus decorus masirensis* n. ssp. and a note on *Strombus fasciatus*. Vita Marina, 1993, 42(1),P. 3-10.

Moraitou-Apostolopoulou M. The zooplankton communities of the Eastern Mediterranean (Levantine Basin, Aegean Sea); influence of man-made factors / NATO Confer. Ser., Ecol., 1985, T. 8, P. 303-329.

Mordukhay-Boltovksoy F.D. Order Copepoda / In: Atlas of Invertebrate Animals of the Caspian Sea. Moscow: Pischevaya promyshlenost Publ., 1968, P.160-182 (in Russian).

Mordukhay-Boltovskoy F.D. (Ed.) Guide of the Black Sea and the Sea of Azov Fauna.- Kiev: Naukova Dumka Publ., 1968, T. 1, 423 pp. (in Russian).
Mordukhay-Boltovskoy F.D. (Ed.) Guide of the Black Sea and the Sea of Azov Fauna.- Kiev: Naukova Dumka Publ., 1969, T. 2, 536 pp. (in Russian).
Mordukhay-Boltovskoy F.D. (Ed.) Guide of the Black Sea and the Sea of Azov Fauna.- Kiev: Naukova Dumka Publ., 1972, T. 3, 340 pp. (in Russian).
Morozova-Vodianitskaya N.V. Phytoplankton of the Black Sea.- Part 1.- M.-L.: Tr. Sevast. biol. st. AN SSSR, 1948, T. 6, P. 39-172 (in Russian).
Muller, G.F. Review of the hıtherto recorded species og Crustacea Decapoda from the Bosphorus, the Sea of Marmasra and the Dardanelles// Cercetari Marine, I.r.c. m., 1986. No: 19 . P.109-130.
Murina V.V. & Antonovsky A.G. Chinese crab, *Eriocheir sinensis* is an invader into the basin of the Sea of Azov// Ecologiya morya, 2001, 55, p. 37-39 (in Russian).
Nastenko E.V. & Polishchuk L.N. The comb jelly *Beroe* (Ctenophora: Beroidea) in the Black Sea // Dopovidi Nation. Acad. Nauk Ukrainy, 1999, No 11, P. 159-161.
Naumov D.V. Hydroids and hydromedusas of the marine, brackish water and fresh water basins of the USSR.- M., L.: Academia nauk Publ., 1960, 626 pp. (in Russian).
Naumov D.V. Class Hydrozoa / In: Key book of the Black Sea and the Sea of Azov fauna.- Kiev: Naukova dumka Publ., 1968, T. 1, P. 56-70 (in Russian).
Nelson T.C. On the occurrence and food habits of ctenophores in New Jersey in laud coastal water // Biol. Bull., 1925, v. 28, No 2.
Nicolay K. Sempre piu diffuso il strombo del Mediterraneo. La Conchiglia, 1986, 202-203,P. 29.
Niederhöfer H., Enzenrob L., Enzenrob R. Neue Erkenntnisse über die Ausbreitung von "Lesseps'schen Einwanderern" (Mollusca) a der türkischen Mittelmeerküste// Club Conchilia Information, 1991, 23 (3-4),P.94-108.
Nordsieck F. A new Neritidae in the Mediterranean // La Conchiglia, 1973, 5 (7-8),P.4
Norse E. A. (ed.) Global Marine Biological Diversity: A strategy for building conservation into decision making. Washington DC: Island Press, 1993, 383 pp.
Okumuş İ. & Başçınar N. Population structure, growth and reproduction of introduced Pacific mullet, *Mugil so-iuy*, in the Black Sea // Fisheries Research, 1997, 33, P. 131-137.
Ostroumov A.A. On the occasion of American balanus in Seavastopol Bay // Vestn. estestvoispitateley, 1892. (in Russian).
Oviatt C.A. & Kremer P.M. Predation on the ctenophore, *Mnemiopsis leidyi*, by butterfish, *Periplus triacanthus*, in Narrangaset Bay, Rhode Island // Chesapeake Sci., 1977, 18, P. 236-240.
Özsoy E., Beşiktepe Ş., Latif M. A. Physical Oceanography of the Turkish Straits System / In Marmara Denizi 2000 Sempozyumu Bildiriler Kitabı. -

İstanbul: Turkish Marine Research Foundation, 2000P. 293-313. (in Turkish).
Öztürk B. Akdeniz Foku (Medit.Monk Seal).-İstanbul: Anahtar Publications. 1992. İstanbul 280pp. (in Turkish) .
Öztürk B. & Öztürk A.A. On the biology of the Turkish straits system// CIESM Science Series n°2, Bulletin de l'institut oceonographique, Monaco, No Special 17, 1996, P. 205-221.
Öztürk B. & Öztürk A.A. Problems related to the fisheries and threatened marine species in the Aegean Sea. /In: Proceedings of the International Symposium, "The Aegean Sea, 2000". İstanbul: Turkish Marine Research Foundation, 2000. P. 31-40.
Öztürk B. Öztürk. A. A. Marine Biodiversity and Ship Originated Pollution in the Turkish Strait System. In: Oil spill in the Mediterranean and Black Sea Regions. 2000. İstanbul: Bosphorus University , Institute of Environment Sciences .
Öztürk B., Öztürk A.A., Algan N. Ship orginated pollution in the Turkish Straits System. / Proceedings of the International Symposium on the Problems of Regional Seas Turkish Marine Research Foundation, İstanbul, 2001. P. 86-94.
Panov D.G. & Khrustalev Yu.P. On the history of the development of the Sea of Azov in Holocene // Doklady Academiy Nauk of the USSR, 1966, 2, P. 418-423 (in Russian).
Palazzi S &Micali P. Contributo alla conoscenza deı pyramidellidae della Turkhia , Con segnalozıone due nuove immigrazıoni dal Mar Ros 1992// Boll. Malacologico, 28(1-4),P. 83-90.
Papaconstantinou C. Distribution of the Lessepsian fish migrants in the Aegean Sea // Biologia Gallo-Hellenica, 1987, 13, P. 15-20.
Papaconstantinou C. Check-list of marine fishes of Greece / In: Fauna Graeciae, Athens, 1988, 4, 257 pp.
Papaconstantinou C. The spreading of Lessepsian fish migrants into the Aegean Sea (Greece) // Sci.Mar., 1990, 54(4), P. 313-316.
Partaly E.M. The influence of planktonic crustaceans upon the population of hydroid *Perigonimus megas* in the fouling biocenosis // Okeanologia, 1974, T. 14, v. 4, P. 719-723 (in Russian).
Partaly E.M. Seasonal changes in the fouling biocenosis formation in the Sea of Azov (Taganrog Bay).- Mariupol, 1980, 293 pp. (in Russian).
Paspalev G. Hydrobiogische Untersuchungen über den Golf von Varna. // Arb. Biol. Meeresst. in Varna., 1933, v. 2, P. 29-32.
Peres J.M. & Picard J. Nouveau Manuel de Bionomie Benthique de la Mer Mediterranee. Edition revue et augmentée // Reccueil des Travaux de la Station Marine d'Endoume. Bull. #31, fasc. 47, P. 5-137 (in French).
Perron F.E. & Turner R.D. Development, metamorphosis, and natural history of the nudibranch *Doridella obscura* Verrill (Corambidae: Opisthobranchia) // J. exp. mar. Biol. Ecol., 1977, v. 27, P. 171-185.
Petit G. Le crabe chinois est parvenu en Méditerranée // Vie et Milieu, 1960, 11,

P.133-136.
Petran A. & Gomoiu M.-T. The distribution of the bivalve *Mya arenaria* L. on the Romanian shore of the Black Sea // Cercetari marine, IRCM, 1972, No 3, P. 53-67.
Petrova-Karadjova V. Monitoring the blooms along the Bulgarian Black Sea coast // Rapp. Comm. Int. Mer. Medit., 1990, T. 31, v. 1, P. 209.
Popa A., Cociasu A., Popa L., Voinescu I., Dorogan L. Long-term statistical characteristics of several physico-chemical parameters of the nearshore waters in the Constantza zone // Cercetari marine, IRCM, 1985, T. 18, P. 7-51.
Por F.D. A study of the Levantine and Pontic Harpacticoida (Crustacea, Copepoda) // Zool. Verh. Rijksmus. Nat. Hist. Leiden, 1964, 64, 128 pp.
Por F.D. The Canalidae (Copepoda, Harpacticoida) in the waters around the Sinai peninsula and the problem of "Lessepsian" migration of this family // Israel Journ. Zool., 1969, 18, P. 169-178.
Por F.D. Lessepsian migration. The influx of Red Sea biota into the Mediterranean by way of the Suez Canal // Spreger-Verlag Berlin Heidelberg New York Publ., New York, 1978, P. 88-194.
Proshkina-Lavrenko A.I. Diatoms algae of the Black Sea plankton.- M.-L.: Acad. nauk of USSR Publ., 1955, 222 pp. (in Russian).
Proshkina-Lavrenko A.I. Diatoms algae of the Sea of Azov plankton.- M.-L.: Acad. nauk of USSR Publ., 1963, 190 pp. (in Russian).
Proshkina-Lavrenko A.I. & Makarova I.V. Plankton algae of the Caspian Sea.- L.: Nauka Publ., 1968, 291 pp. (in Russian).
Pughiuk D. From the Programme // Ballast Water News, 2001, 4, P. 1.
Quignard J. P. Tomasini, J. A. Mediterranean Fish Biodiversity// Biologia Marina Mediterranea , 2000,7, Fasc.3,P. 1-66.
Radu G., Nicolaev S., Radu E. Geographical distribution and biomass assessment for the ctenophore *Mnemiopsis leidyi* and jellyfish *Aurelia aurita* at the Romanian Black Sea littoral in 1991-1995 // Cercetari marine, I.R.C.M., 1996-1997, T. 29-30, P. 229-239.
Ray G.C. & Grassle J.F. Marine biological diversity.- Bioscience, 1991, 41, P. 453-461.
Remy P. Note sur un copepode de l'eau saumatre du canal de Caen a la mer, *Acartia tonsa*, Dana. // Ann. Biol. Lacustre, 1927, T. 15, P. 169-186.
Reshetnikov V. I. Water balance of the Black Sea and its changes under anthropogenic activities. Moscow State University, Department of Geography, Doctoral Thesis, 1992, 150 pp. (in Russian).
Rield R. Fauna und Flora des Mittelmeers. Hamburg, Berlin, 1983: Verlag Paul Parey, 836 pp.
Roginskaya I.S. & Grinzov V.A. Nudibranch Gastropod *Doridella obscura* Verrill – first record for the Black Sea // Okeanologia, 1990, T. 30, № 5, P. 855-857 (in Russian).
Roman M.R. Utilization of detritus by the copepod, *Acartia tonsa* // Limnol. Oceanogr., 1984, T. 29, v. 5, P. 949-959.

Romanova Z.A., Finenko G.A., Shadrin N.A. First record of alien species *Beroe ovata* (Ctenophora) near the Crimea coast // Vestnik zoologii., 1999, T. 33, v. 6, P. 90 (in Russian).

Rullier F. La propagation de *Mercierella enigmatica* Fauvel (Annelidae Polychete sedentaire) dans le monde entier, en moins de cinquante ans.- “Mem. Soc. nat. Sci. natur. et math.”.- Cherbourg, 1966, v. 51.

Ryabchikov P.I., Soldatova I.N., Tesahova S.E., Petukhova T.A. The beginning invasion of some species of shipworm teredo (fam. Teredinidae, Mollusca) in to the Sea of Azov // Trudy Inst. Okeanologii, 1963, T. 70, P. 157-178 (in Russian).

Ryabchikov P.L. & Nikolaeva G.G. Settlement on wood of the larvae of *Teredo navalis* L. (Teredinidae, Mollusca) in the Black Sea // Trudy Inst. Okeanologii, 1963, T. 70, P. 179-185 (in Russian).

Rzhepishevsky I.K. & Kuznetsova I.A. Growth of barnacles in Sevastopol Bay / In: Fouling and biocorrosion in aqueous medium.- M: Nauka, 1981, P. 89-95 (in Russian).

Saenkova A.K. New information on Caspian Sea fauna. // Zool. J., 1956, 35, 5, P. 678-679 (in Russian).

Salsky V.O. About the acclimatization of the Far East grass shrimp *Pandalus kessleri* (*P. latirostris*) in the Khadzhibeysky liman // Proceedings of the Odessa Biological Station, 1964, 5, P. 107 (in Ukrainian).

Senicheva M.I. Composition and quantitative development of phytoplankton in the neritic zone in the Sebastopol area in winter season 1968-1969 // Biologia Moria, 1971, 24, P. 3-12 (in Russian).

Seravin L.N. Brief history of the study of jelly-fishes of the genus *Beroe* and differential characters of *B. cucumis* (Ctenophora, Atentaculata, Beroidea) // Zoologichesky zhurnal, 1995, T. 74, v. 12, P. 3-15.

Shadrin N.V. New settlers in the Azov and Black Seas: reasons and consequences ? In: New settlers in Russian European Seas.- Apatyty, 2000, P. 76-90 (in Russian).

Shakirova F.M. & Sukhanova A.I. Ichthyofauna of Turkmenostan, specific composition and distribution // Izv. Acad. Sci. of Turkmenistan. Ser. Biol. Sci., 1993, 3, P. 35-45 (in Russian).

Shiganova T, Tarkan, A.N, Dede, A., Cebeci M. Distribution of the Ichthyo-Jellyplankton *Mnemiopsis leidyi* (Agassiz,1865) in the Marmara Sea (October 1992)// T. Jur. Mar. Sci., 1995. 1,. P.3-12.

Shushkina E.A. & Vinogradov M.E. Long term changes in the biomass of plankton in open areas of the Black Sea // Oceanol., 1991, T. 31, No 6, P. 716-721.

Shuysky Yu.D. The coastal zone of the sea.- Kiev: Ukr. Rad. Entsiclopedia, 1989, P. 83 (in Ukrainian)

Silina N.I. Species of the genus *Acartia* in the plankton of eastern part of the Gulf Finland Baltic Sea / In: The investigation of the water ecosystem.- Proceedings of the Zoological Inst.- Leningrad, 1989, T. 205, P. 108-118 (in Russian).

Simkina R.G. To the ecology of *Perigonimus megas* Kinne (Hydroidea, Athecata) – a new species in the fauna of the USSR // Trudy Inst. Oceanol., 1963, T. 70, P. 216-224 (in Russian).

Sinegub I.A. About expansion of natural habitat of nudibranch mollusc *Doridella obscura* Verrill in the Black Sea // Gydrobiol. zhurn., 1994, T. 30, v. 3, P. 107-109 (in Russian).

Skarlato O.A. & Starobogatov Ya.I. Class of bivalve molluscs - Bivalvia. / In: Key book of the Black Sea and the Sea of Azov fauna.- Kiev: Naukova dumka Publ., 1972, T. 3, P. 178-249 (in Russian).

Slastenenko E. Karadeniz Havzası Balıkları.-İstanbul: Et ve Balık Kurumu Umum Müd. Yayınları, 1955-1956, 711 pp. (in Turkish)

SR. Caspian Countries Move on Marine Invader. Ballast Water News, 2001, Issue 5, P. 4.

Starostin I.V. On fouling of the technical water pipes in our South seas and some ways of control // Trudy Inst. Oceanologiy AN SSSR, 1963, 70, P.101-123 (in Russian).

Starushenko L.I. Cold-resistance of haarder acclimatized in the Black Sea basin.- Rybnoe khozyaystvo (Moskva), 1981, 3, P. 26-27 (in Russian).

Steidinger K.A. & Jangen K. Dinoflagellates / In: Identifying marine phytoplankton / Ed. by Tomas C.R.- Academic Press: Harcourt Brace & Co, CA, USA., 1997, 858 pp.

Stepanok N.A. Peculiarities of steel corrosion destruction in the presence of fouling organisms // Physico-chemical mechanics of materials, 1983, 5, P. 61-66 (in Russian).

Stergiou K.I. Feeding habits of the Lessepsian migrant *Siganus luridus* in the Eastern Mediterranean (Kastellorhizo isle, Greece), its new environment // National Centre for Marine Research, Athens, 1988, P. 78-79.

Stoecker D.K. & Sanders N.K. Differential grazing by *Acartia tonsa* on a dinoflagellate and a tintinnid // J. Plankton Res., 1985, T. 7, v. 1, P. 85-100.

Stoettrup J.G., Richardson K., Kirkegaard E., Pihl N.J. The cultivation of *Acartia tonsa* Dana for use as a live food source for marine fish larvae // Aquaculture.- 1986, T. 52, v. 2, P. 87-96.

Studenikina E.I., Volovik S.P., Tolokonnikova L.I., Frolenko L.N., Selivanova E.V. Characteristic of the bottom-dwelling communities in the present-day period / In: Collected articles (1996-1997) “The main problems of fisheries and protection of waterbodies with fisheries in the Azov Sea basin”, Rostov-on-Don, 1998, P. 67-77 (in Russian).

Studenikina E.I., Volovik S.P., Myrzoyan Z.A., Tolokonnikova L.I., Gubina G.S., Safronova L.M. Characterization of the plankton biocenosis in the Azov Sea ecosystem from the results of studies in 1996-1997 / In: Collected articles (1996-1997) “The main problems of fisheries and protection of waterbodies with fisheries in the Azov Sea basin”.- Rostov-on-Don, 1998, P. 49-58 (in Russian).

Sullivan C.M. Bivalve larvae of Malpeque Bay, P.E.I. // Bull. Fish. Res. Bd. Can., 1948, T. 77, P. 1-36.

Tarkan A.N., Isinibilir M., Erk M.H. Dominant zooplankton species in the waters of the northern Gökçeada. / Ulusal Ege Adaları 2001 Toplantısı Bildiriler Kitabı, Turkish Marine Research Foundation, Istanbul,2001. P. 59-70. (In Turkish).

Tarasov N.I. & Zevina G.B. Fauna of the USSR. Crustacea. Cirripedia Thoracica of the USSR seas.- Moscow-Leningrad: Acad. Sci. USSR Publ., 1957, T. VI (1), 268 pp. (in Russian).

Tarverdieva M.I. The role of the acclimatized organisms in the feeding of sturgeon and stellate sturgeon in the Caspian sea in 1962 / In: Change biolog. composit. Casp. Sea.- Moscow: Nauka Publ., 1965, P. 234-256 (in Russian).

Taşkavak E., Mater S., Bilecenoğlu M. The Distribution of Red Sea immigrant fishes in the eastern Mediterranean coast (Mersin-Samandağ) and their impacts on the regional fisheries // East Anatolia Region III. Symposium on Fisheries, Erzurum, 1998, P.151-162 (in Turkish).

Terenko L.M. & Terenko G.V. Species diversity of the plankton phytocenosis in the Odessa Bay of the Black Sea // Ekologia morya, 2000, T. 52, P. 56-59 (in Russian).

Tiganus V. Fauna associated with the main macrophyte algae from the Romanian Black Sea coast // Cercetari marine, I.R.C.M., 1991-1992, T. 24-25, P. 41-123.

Torcu H. The investigations of the Indo-Pacific fish species living on the coasts of the Mediterranean and southern Aegean Sea, biology and ecology of *Upeneus moluccensis* (Bleeker,1855) and *Saurida undosquamis* (Richardson,1848) / Selçuk University. Enst. of Science, PhD thesis, Konya, 1995, 124 pp. (in Turkish).

Torcu H. & Mater S. An investigation on biology of *Upeneus moluccensis* (Bleeker, 1855) of Fethiye and Mersin Bays // Mediterranean Fisheries Congress, Ege Univ. Izmir, 1997, P. 545-554 (in Turkish).

Torcu H. & Mater S. Lessepsian fishes spreading along the coasts of the Mediterranean and the Southern Aegean Sea of Turkey // Turk J. Zool., 2000, 24, P. 139-148.

Trégouboff G. & Rose M. Manuel de Planctonologie Méditerranéenne / Tome 1. Paris: CNRS, 1957, 587 pp.

Tringali L. & Villa, R. Rinvenimenti malacologici dalle coste Turche (Gastropoda, Polyplacophora, Bivalvia). Notiziario del CISMA, 1990, 12, p. 33-41.

Tsikhon-Lukanina E.A., Reznichenko O.G., Lukasheva T.A. Predation rates on fish larvae by the ctenophore *Mnemiopsis* in the Black Sea inshore waters // Okeanologia, 1993, T. 33, No 6, P. 895-899 (in Russian).

Tsvetkov L. & Grencharova T. Underwater fouling in estuary of Ropotamo river. III. Composition and quantity development of zoocenosis // Hydrobiologia, 1979, 8, P. 26-43 (in Bulgarian).

Tuğrul S., Salihoğlu I. Chemical Oceanography of the Marmara Sea and the Turkish Straits System / Marmara Denizi 2000 Sempozyumu Bildiriler Kitabı, Turkish Marine Research Foundation, 2000. İstanbul, P. 327-346. (in Turkish).

Turk P.E., Krejci M.E., Yang W.T. Laboratory method for the culture of *Acartia tonsa* (Crustacea: Copepoda) using rice bran // J. Acuaricult. Aquat. Sci., 1982, T. 3, v. 2, P. 25-27.

Turpaeva E.P. System of symphysiological connections in biocenosis of marine fouling // Trudy VNIRO, 1972, 77, P. 168-185 (in Russian).

Ulanovsky I.B., Turpaeva E.P., Korovin Yu. M., Simkina Z.G. The barnacle *Balanus improvisus* as a factor of stainless steel corrosion // Trudy Inst. Okeanologyi, AN SSSR, 1961, 19, P. 235-242 (in Russian).

Unal E., Shmeleva A.A., Zagorodnyaya J., Kıdeyş A.E. Zooplankton structure and Copepod species of the Sea of Marmara in spring 1998 / In: Marmara Denizi 2000 Sempozyumu Bildiriler Kitabı, İstanbul, Turkish Marine Research Foundation, 2000, P. 450-460 (in Turkish).

Unluata U., Oguz T., Latif M.A., Ozsoy E. On the physical oceanography of the Turkish Straits / In: Physical Oceanography of the Straits. J.L. Pratt (ed), NATO/ASI Series, Dordrecht, Kluwer Academic Publishers, 1990. P. 25-60.

Unsal S. A new grey mullet for the Turkish Seas: *Mugil so-iuy*, Basilewsky // Doğa-Tr. J. Vet. Animal Sci., 1992, 16, P. 427-432 (in Turkish).

Usachev P.I. On the phytoplankton of the Sea of Azov // Dnevnik Vses. S'ezda bot., Leningrad, 1928, P. 64-70 (in Russian).

Usachev P.I. On the phytoplankton of the northwestern part of the Black Sea // Ibid. 1927 P. 163-164 (in Russian).

Usachev P.I. General characteristic of the phytoplankton in the seas of USSR // Uspekhy sovremennoy biologii., 1947, T. 23, v. 2, P. 265-288 (in Russian).

Valkanov A. Notizen über die Brackwasser Bulgariens. II. // God. Sof. Univ., Sofia, 1936, T. 32, P. 1-133 (in Bulgarian).

Valkanov A. Contribution to the investigations of our Black Sea fauna // Trudy Morsk. Biol. St., 1954, 18, P. 49-53 (in Bulgarian).

Vinogradov K.A. & Losovskaya G.V. Polychaeta / In: Key Book of the Black Sea and the Sea of Azov fauna.- Kiev: Naukova dumka Publ., 1968, T. 1, P. 251-359 (in Russian).

Vinogradov M.E., Shushkina E.A., Nikolaeva G.G. Mass bloom of the comb jelly *Mnemiopsis* as an anthropogenic influence on marine ecosystems / In: Practical ecology of the marine regions, Black Sea.- Kiev: Naukova dumka, 1990, P. 94-102 (in Russian).

Vinogradov M., Vostokov S., Arashkevich E., Drits A., Musaeva E., Anokhina L., Shushkina E. Peculiarity of the biology of exotic ctenophores and their role in the Black Sea ecosystem / In: Exotic species in European Seas of Russia.- Apatity, 2000, P. 91-113 (in Russian).

Vladimirskaya Y.B. Plankton and benthos near Southern coast of the Caspian // Trudy VNIRO, 1973, 80, P. 40-47 (in Russian).

Volovik S.P. (Ed.). Ctenophore *Mnemiopsis leidyi* (A. Agassiz) in the Azov and Black Seas: biology and consequences of its intrusion.- Rostov-on-Don, 2000, 497 pp. (in Russian).

Volovik S.P., Dubinina V.G., Semenov A.D. Hydrobiology and Dynamics of Fisheries in the Azov Sea // Studies and Reviews. General Fisheries Council for the Mediterranean, 1993, 64, Part 2, P. 1-58.

Volovik S.P. & Chikhachev A.S. Man-made transformation of the ichthyofauna of the Sea of Azov basin / In: The main problems of fisheries and protection of waterbodies with fisheries in the Azov Sea basin.- Rostov-on-Don, 1998, P. 7-22 (in Russian).

Volovik S.P., Myrzoyan Z.A., Studenikina E.I., Luts G.I. The evaluation of comb jelly introduction consequences in the Sea of Azov // Rybnoe khoziystvo, 1996, 1, P. 48-51 (in Russian).

Vorobyova L.V. Meiobenthos of the Ukrainian shelf in the Black and Azov seas.- Kiev: Naukova Dumka, 1999, 301 pp. (in Russian).

Vorobyova L.V., Zaitsev Yu.P., Kulakova I.I. Interstitial meiofauna of the Black Sea sandy beaches.- Kiev: Naukova Dumka, 1992, 142 pp. (in Russian).

Westheide W. Interstitial Polychaeta (excluding Archianelida) // Smithsonian Contributions to Zoology, 1971, 76, P. 57-71.

Whitehead P.J.P., Bauchot M.L., Hureau J.C., Nielsen J., Tortonese E. Fishes of the Northeastern Atlantic and the Mediterranean / Vol. I, Paris UNESCO, 1984, 510 pp.

Whitehead a. P.J.P., Bauchot M.L., Hureau J.C., Nielsen J., Tortonese E. Fishes of the Northeastern Atlantic and the Mediterranean / Vol. II, Paris UNESCO, 1986, 490 pp.

Whitehead b. P.J.P., Bauchot M.L., Hureau J.C., Nielsen J., Tortonese E. Fishes of the Northeastern Atlantic and the Mediterranean / Vol. III, Paris UNESCO, 1986, 458 pp.

Yokeş B. Shells of the Prosobranchia found in the coastline of the Bozcaada –In Meeting of the Underwater,Science and Technology Proceedings Book. -İstanbul. Bosphorus University. (eds: Egi M., Gümüşburun F., Özsoy Z., Yokeş.B.). 1996.P.193 201 . (in Turkish).

Yüce H. Water level Variations in the northwestern Aegean Sea // Doğa Tr. J.of Enginering and Environmental Sciences , 1989, 15, p. 179-187

Zagami G. & Guglielmo L. Prima segnalazione nel Mar Tirreno de copepode pelagico Acartia tonsa Dana // Mem. Biol. Mar. Oceanogr., 1990, 18, P. 71-74.

Zaika V.E., Kiseleva M.I., Mikhailova T.V., Makkaveeva E.B., Sergeeva N.G., Povchun A.S., Kolesnikova E.A., Chukhchin V.D. Long-term changes in the Black Sea zoobenthos.- Kiev: Naukova dumka, 1992, 248 pp. (in Russian).

Zaika V.E., Sergeeva N.G. Morphology and development of *Mnemiopsis mccradyi* (Ctenophora, Lobata) in the Black Sea // Zool. J., 1990, T. 69, v. 2, P. 5-11 (in Russian).

Zaitsev Yu.P. Marine Neustonology.- Translated from Russian. Jerusalem: Israel Program for Scientific Translations, 1971, 207 pp.

Zaitsev Yu.P. This Wonderful Sea.- Odessa: Mayak Publ., 1978, 159 pp. (in Russian).

Zaitsev Yu, P. Recent changes in the trophic structure of the Black Sea // Fisheries Oceanography, 1992, I, 2, P. 180-189.

Zaitsev Yu.P. Impact of eutrophication on the Black Sea fauna // Studies and Reviews. General Fisheries Council for the Mediterranean, 1993, 64, Part 2, P. 59-86.

Zaitsev Yu.P. Marine hydrobiological investigations of National Academy of Science of Ukraine during 90-s in XX century: Shelf and coastal water bodies of the Black Sea // Gydrobiol. zhurn., 1998, T. 34, No 6, P. 3-21 (in Russian).

Zaitsev Yu.P. The Black Sea in the publications of Ukrainian hydrobiologists of the XXth century. A rewiev. // Gydrobiol. zhurn., 2000, T. 36, No 2, P. 3-24 (in Russian).

Zaitsev Yu. Mediterranean-Black Sea faunal exchange // Proceedings of the International Simposium "The Aegean Sea 2000", 55-7 May 2000, Bodrum, Turkey, P. 1-7.

Zaitsev Yu.P. & Alexandrov B.G. (Comp.) Black Sea Biological Diversity. Ukraine. New York: United Nations Publications, 1998, 351 pp.

Zaitsev Yu. & Mamaev V. Marine Biological Diversity in the Black Sea. A Study of Change and Decline.- New York: United Nations Publications, 1997, 208 pp.

Zaitsev Yu. & Prokopenko V. The World of Delta. Dunayskiye Plavni Reserve.- Odessa: Mayak, 1989, 144 pp. (in Russian).

Zaitsev Yu.P. & Starushenko L.I. Harder (*Mugil soiuy* Basilewsky, 1855) a new commercial fish in the Black Sea and the Sea of Azov // Gidrobiol. Zhurn., 1997, 33, 3, P. 29-37 (in Russian).

Zaitsev Yu.P., Vorobyova L.V., Alexandrov B.G. A northern source of replenishment of the Black Sea fauna // Doklady AN Ukr.SSR, 1988, 11, P. 61-63 (in Russian).

Zakutsky V.P. The shells of *Balanus improvisus* as shelters for other organisms // Zoologich. zhurn., 1965, T. 44, v. 7, P. 1092 (in Russian).

Zambriborsch F.S. Representative of a new Class of invertebrate, Kamptozoa, in U.S.S.R. fresh waters // Zoologicheski zhurnal, 1958, 37, 11, P. 1741 (in Russian).

Zenetos A., *Scapharca demiri* (Piani, 1981): First finding in the North Aegean Sea. La Conchiglia, 1994, 271,p. 37-38.

Zenkevich L.A. Fauna and biological productivity of the sea.- Moscow: Sovetskaya nauka Publ., 1947, 2, 588 pp. (in Russian).

Zenkevich L.A. Seas of the URSS, their fauna and flora.- Moscow: Uchpedgiz Publ., 1956, 424 pp. (in Russian).

Zenkevich L.A. Biology of the Seas of URSS. Moskow: Acad. Sci. Publ., 1963, 739 pp. (in Russian).

Zenkevich L.A., Zevina G.B. Fauna and Flora / In: Caspian Sea. Moscow Univ. Publ., 1969, P. 229-255 (in Russian).

Zevina G.B. Cirripedia (*Balanus improvisus* Darwin and *B. eburneus* Gould) in the fouling of the ships and hydrotechnical constructions of the Caspian Sea // DAN SSSR 1957, T. 113, v. 2, P. 450-453 (in Russian).

Zevina G.B. New organisms in the Caspian Sea // Priroda, 1959, 7, P.79-80 (in Russian).

Zevina G.B. Fouling of the water engineering installations in the Caspian Sea // Trudy Inst. Oceanog. SSSR, 1961, T. 49, P. 65-96 (in Russian).

Zevina G.B. Fauna of the Caspian Sea is enriched // Priroda, 1962, 4, P.118-119 (in Russian).

Zevina G.B., Kuznetsova I.A., Starostin I.V. The composition of fouling in the Caspian Sea // Trudy Inst. Oceanol., 1963, T. 70, P. 3-25 (in Russian).

Zevina G.B. & Kuznetsova I.A. The role of shipping in the change of the Caspian fauna // Pr. Inst. oceanology AS USSR, 1965, 5, 3, P. 518-527 (in Russian).

Zibrowius H. Records of *Halophila stipulacea* from the "Calypso " cruises in Greek and Turkish waters, 1955-1977. Posidonia newsletter , 1993, 4, (2), P. 7-10.

Zillioux E.J. & Gonzalez J.G. Egg dormancy in a neritic Calanoid Copepod and its implications to overwintering in boreal waters // Fifth europ. Mar. Biol. Symp. / Ed. By Battaglia., 1972, P. 217-230.

Zingone A. & Enevoldsen H.O. The diversity of harmful algal blooms: A challenge for science and management // Ocean and Coastal Management, 2000, 43, P. 725-748.

Zinova A.D. A guide of Green, Brown and Red Algae of the Southern Seas of URSS.- Moscow-Leningrad: Nauka Publ., 1967, 398 pp. (in Russian).

Zolotarev V. The Black Sea ecosystem changes related to the introduction of new mollusc species // Marine Ecology, 1996, 17, P. 227-236.

Zolotarev V.N. & Zolotarev P.N. Bivalve *Cunearca cornea* a new element of the fauna in the Black Sea // Dokl. Akad. Nauk SSSR, 1987, 297, P. 501-503 (in Russian).

Zolotnitsky A.P. & Orlenko A.N. Ecological peculiarities of the Pacific oyster growth in different Black Sea areas // Rybne hospodarstvo Ukrainy, 1999, T. 2, No 5, P. 37-39 (in Russian).