January 2010

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GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN
SCIENTIFIC ADVISORY COMMITTEE
TWELFTH SESSION
BUDVA, MONTENEGRO, 25-29 JANUARY 2010
DRAFT DOCUMENT ON THE ALIEN SPECIES IN THE MEDITERRANEAN AND THE BLACK SEA (BY BAYRAM OZTURK)* -TO BE EDITED-

*** Only in English**

ISBN 978-92-5-10...........

CONTENTS

List of Figures

List of Tables

EXECUTIVE SUMMARY

Biota of the Black and Mediterranean Seas have started to change with the introduction of alien species in the last few decades due to Lessepsian migration, Atlantic influx, intentionally or unintentionally introduction and climate change. Dispersion of alien species is a dynamic process showing a sign of increasing and likely to continue for the future. This phenomenon causes severe ecological, socio-economical, and human health problems in the entire basin.

The main vectors for the introduction of alien species to the Black Sea are shipping and intentional introduction. In the Black Sea, several alien species dispersed and caused threats to the native biota due to the low biodiversity and a character as an enclosed sea. A comb jelly, *Mnemiopsis leidyi,* which was transported to the Black Sea with ship ballast water and caused ecological impacts and economical damages to the riparian countries' fisheries due to feeding on mostly the larvae and eggs of small pelagic fishes, mainly anchovy, horse mackerel and spratt. A gastropod*, Rapana venosa,* is the first alien commercial species in the Black Sea and after 1980's become an export product for all the Black Sea countries except Romania. Meanwhile, its impact on the native fauna especially mussel and oyster beds was detrimental.

Mediterranization is also a growing trend and many Mediterranean origin species have penetrated to the Black Sea, even stinging compass jelly fish, *Chrysaora hysoscella*. Recently, Lessepsian fish migrants such as blunt barracuda *Sphyraena pinguis, Sphyraena obtusata* and a coral-dwelling fish, *Heniochus acuminatus,* were reported for the first time. Contrarily, an intentionally introduced species *Mugil souyi* penetrated to the Aegean and Mediterranean Sea through Turkish Straits. It shows that two basins are closely interacting each other.

The Marmara Sea is a link between the Black and Mediterranean Seas and serves as a biological corridor, an acclimization area and a barrier for alien species. *M. leidyi* made a detrimental effect for the anchovy fisheries also in the Marmara Sea and the recovery of the stocks has started in the recent years. Poisonous Lessepsian fish migrant, *Legocephalus scelaratus,* and an alien stomatopod shrimp, *Erugosquilla massavensis,* are also reported from the Marmara Sea. Ship is the main vector for alien species in the Marmara Sea.

As for the Mediterranean Sea, alien species enter from the Atlantic Ocean through Gibraltar, Red Sea through the Suez Canal, Black Sea through the Canakkale Strait (Dardanelles) and by intentional or unintentional introduction. Recent studies show that among 664 fish species recorded in the Mediterranean Sea, 127 are alien, comprising 65 species of Indo-Pacific origin and 62 of Atlantic origin. Main vectors of the Mediterranean alien species are the Suez Canal, shipping and aquaculture. General trend is that the number of alien species is increasing in recent years and over 600 alien species are estimated in the Mediterranean Sea. Some Lessepsian sprinter fish species pass the Sicily Strait which is known as a biogeographical boundary between the eastern and western Mediterranean biota. On the other hand, some Atlantic-origin species penetrated farther east reaching the coast of Sicily from the originally established areas near the Gibraltar Strait.

Alien species have brought several consequences to the fisheries, biodiversity, human health and economy in the Mediterranean Sea. Some of the alien fish species have become economically important after establishing sustainable populations, such as lizard fish, goatfishes, Spanish mackerel and round herring mostly in the eastern Mediterranean region. Similarly some of the crustacean species have also commercial importance, such as kuruma prawn, green tiger prawn, mantis shrimp and blue crab. Some introduced mollusc species, such as Japanese oyster and Pacific carpet clam, already have market value. Besides, some species have negative impacts to the human health, mostly puffer fishes, *Legocephalus* spp., an alien jellyfish, *Rhopilema nomadica*, and a hydroid, white stinger *Macrorhynchia philippina* in the eastern Mediterranean countries. Eradication of *Caulerpa taxifolia* and *Caulerpa racemosa* negatively impact the fisheries and biodiversity in the Mediterranean Sea. Some species badly effect fishing gears by causing mesh clogging, fouling and damaging. Some alien species also impacted on marine biodiversity mainly habitat competition and species displacement.

Regional cooperation is essential to minimize and reduce the impacts of alien species both in the Black and Mediterranean Seas. In this context, regional and international organizations should establish a common alien species database easily accessible to all stakeholders or harmonize already existing databases on alien species. An early warning system needs to be developed for unpredictable alien species blooms or impacts. Catch statistics of most commercial alien species also should be collected by countries for better management of the fisheries. Specific studies mostly on the impacts on fisheries by alien species are highly required to develop fisheries reporting and monitoring system. Besides, capacity building programmes for some countries are highly recommended in terms of species identification and data collection. Finally, key species and key habitats, for example, *Posidonia* meadows, should be protected to combat alien species invasion.

INTRODUCTION

The phenomenon of alien or exotic species in the the Black Sea and Mediterranean Sea have been recorded for several decades. It has speeded up in recent years, with many examples of negative impacts on marine ecosystems, on the local marine fauna and flora, and on socio-economic activities, such as fisheries.

The Black Sea and Mediterranean Sea are interconnected by the Turkish Straits System. These narrow straits act as a biological corridor, a barrier or an acclimatization zone for some marine species. Since the Suez Canal opening, the Mediterranean Sea has been connected to the Red Sea, thus the Indian Ocean. Some Indo-Pacific species enter the Black and Marmara Seas and start to colonize in these seas. Besides, ship-transported species like *Rapana venos*a or introducted species like *Mugil souyi* to the Black Sea, dispersed to the Mediterranean Sea.

In recent years, the fish composition and fish catch amount have changed due to alien species. Moreover, some venomous fish and invertabrate species also established themselves mostly in the eastern Mediterranen Sea and start causing problems for the human health and biodiversity. As it happened in the Black Sea, some intentionally or unintentionally introduced species are found in the Mediterranean Sea. It is predicted that alien species may play a bigger role in the next years for the world fisheries.

In this report, the Black and Mediterranean Seas are examined separately to be more concise although they are interconnected each other.

1. STATUS OF ALIEN SPECIES IN THE BLACK SEA

The main characteristics of the Black Sea

The Black Sea is one of the world's most isolated seas from the major oceans, and the largest anoxic body of water on planet (87 per cent of its volume is anoxic). The total surface area of the Black Sea is 423,000 km^2 and its catchment area is over 2 million m^2. It is surrounded by Turkey, Bulgaria, Romania, Ukraine, Russia and Georgia (see Fig. 1.1). On the north-eastern corner, the Black Sea is connected to the Sea of Azov through the Kerch Strait, and on the south-western corner, to the Sea of Marmara through the Istanbul Strait (Bosphorus). The maximum depth is 2212 m. The most striking characteristic of the Black Sea is probably the high level of hydrogen sulphide (H_2S). The level of H_2S is 150-200 m deep and has been relatively stable, although seasonal and annual fluctuations have been observed.

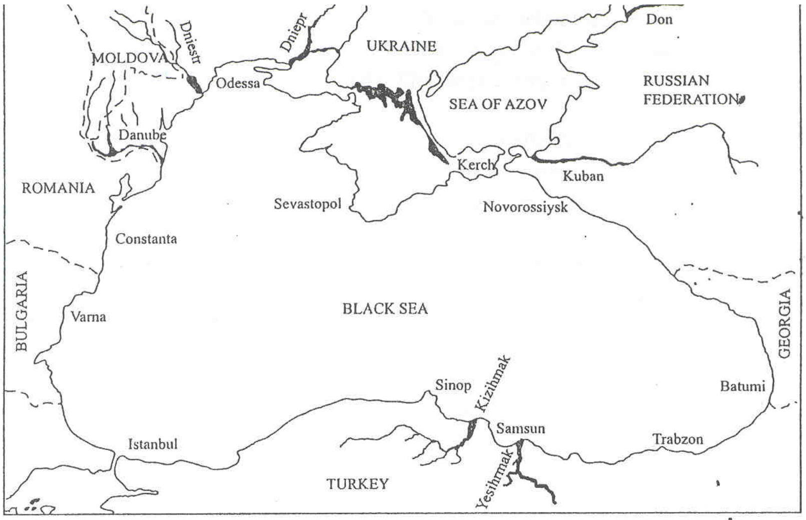

Fig. 1.1. The Black Sea.

The presence of a permanent halocline between 150 and 200m is another major distinguishing characteristic (Fig. 1.2). The stratification is affected by the fresh water input and the Mediterranean inflow of highly saline water. The average surface salinity is about 18-18.5 per mille during winter, and increases by 1.0-1.5 per mille in summer. The temperature shows more variation than the salinity, seasonally as well as regionally. The mean annual surface temperature varies from 16°C in the south to 13°C in the northeast and 11°C in the northwest. While the upper 50-70m water layer has seasonal fluctuations in temperature and there is considerable vertical variation, the temperature of the deeper water remains constant throughout the year. Typically, the temperature at a depth of 1,000m is about 9°C and shows only a slight increase of 0.1°C per 1,000m towards deeper sections (Balkas et al, 1990).

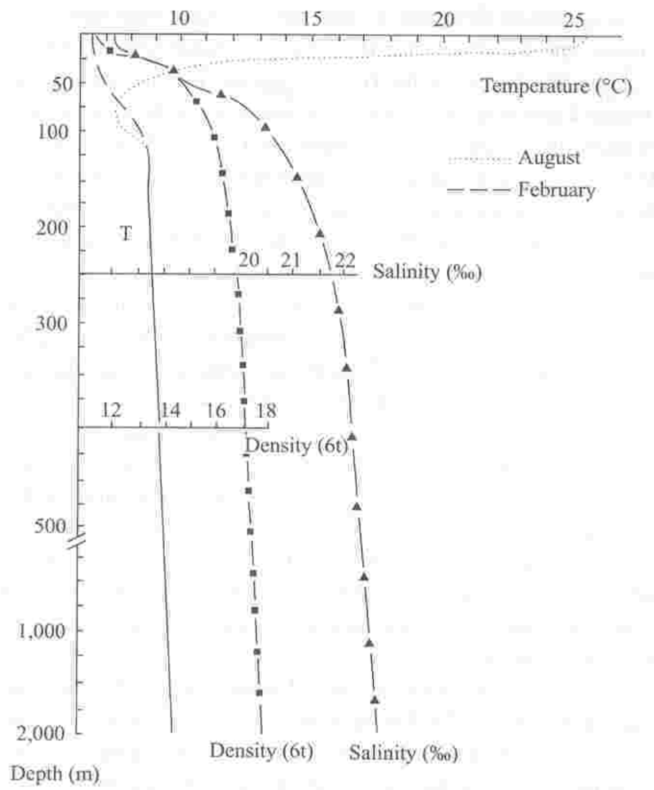

Fig.1.2. Vertical profile of salinity, temperature and density of the Black Sea.

The changes in the Black Sea ecosystem since the 1960s due to the concurrent impacts of eutrophication, overfishing, climatic fluctuation and alien species invasions have been studied extensively. A synthesis provided recently by the "State of the Environment Report" (BSC, 2008) documents the changes in pelagic and benthic ecosystems.

The Black Sea's biodiversity clearly reflects its geological history. Brackish water fauna known as 'Caspian relics' originated from the Neoeuxinian Lake, and the components of this fauna are found only in waters with low salinity. Some bivalves such as *Dressenia* and fishes such as many species of goby and sturgeons are good examples. Another group of species is called 'cold water relics' and includes ctenophores (Pleurobrachia), copepods (Calanus), and fishes such as spiny dog fish, sprat, flounder and whiting. This group is the second oldest inhabitants of the Black Sea, entering the sea sometime between the Neoeuxine Lake Period and the early stage of the formation of the Istanbul Strait (Bosphorus). After the Istanbul Strait (Bosphorus) established a connection with the Mediterranean Sea about 7,000-10,000 years ago, the salinity of the Black Sea rose gradually and soon the Mediterranean species were established in the Black Sea. Today, 80% of total fauna in the

Black Sea are Mediterranean origin. The last group of species is called 'alien species', which includes those introduced either intentionally or unintentionally by human activities.

Vectors for the alien species in the Black Sea

In recent years, the Black Sea has become home for a large number of alien plants and animals. There are three main vectors for alien species to reach the Black Sea. These are: a) shipping activities, which is the most common way; b) intentional or unintentional introduction by humans; c) Mediterranization, which means that Mediterranean originated species pass all ecological barriers in the Turkish Straits and penetrate to the Black Sea, probably due to climate change.

Shipping activities

The most common way of invasion of the alien species is via ocean-going ships. Marine organisms usually travel either as a part of the fouling attached to the ship hulls, or in the tank sediment or in ballast water (Zaitsev and Mamaev, 1997; Zaitsev and Öztürk, 2001; Öztürk, 2002). Shipping activities are intense in the Black Sea mainly due to the Caspian petrol transportation from Novorossisk, Russia to the Mediterranean countries (Fig. 1.3), thus shipping is the main vector of introductions in the Black Sea, responsible for 36% of introductions (EEA, 2002).

Hundreds of algal and animal species, both microorganisms and even smaller organisms, are known to travel by attaching themselves to the hulls of the ship. Most of them are attached to the living substrate such as algae, clams and barnacles. But active non-sessile forms can also be found, such as Amphipoda, shrimps, crabs and fishes. When the ship is in motion they hide in barnacles and other similar shelters, so as not to be swept away by the current.

Ballast water pumped to the tanks to stabilize a ship when it is not carrying any cargo. When ships fill their ballast tanks in ports or sometimes in certain areas, suspended matter and various planktonic organisms are also pumped into the tanks with the water. Many organisms survive the trip in the ballast water or sediment, sometimes as spores and eggs. Upon arrival at the ship's destination, the ballast water is discharged into the sea and the organisms find themselves in a new environment. If the conditions are favorable to their particular needs, the organisms may survive and even become naturalized. The huge number of ocean-going ships means that many new species are introduced into new environment constantly.

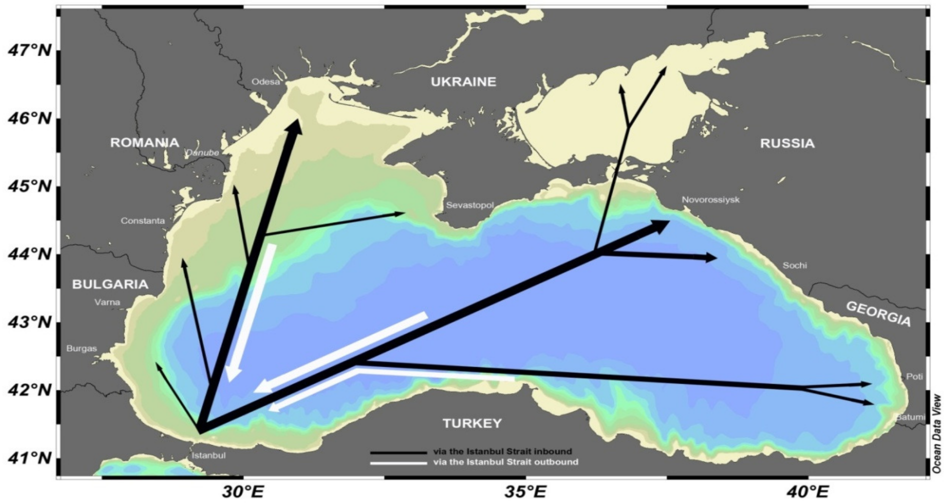

Fig. 1.3. Main shipping routes in the Black Sea.

Intentional or unintentional introduction by humans

Several alien species have been introduced to the Black Sea for aquaculture or other reasons. The mosquito fish *Gambusia affinis* is a good example for this type of introduction. This fish is well known for its ability to feed on neuston larvae and mosquito eggs, including those species which transmit malaria. It was, thus, introduced to the wetlands to combat malaria in the entire Black Sea basin. After the fish was adapted and reproduced, *Gambusia* turned to euryhaline species. Today *Gambusia* is widespread in the Black Sea basin. There are several other examples in the Black Sea for intentional introduction to the Black Sea.

Mediterranization effects

This is a relatively new phenomenon and the reason for the invasion of the Mediterranean originated species to the Black Sea seems to be related with climate change. Even though the Turkish Straits (Istanbul and Çanakkale Straits) serve as an ecological barrier for these species due to totally different oceanographic peculiarities of the Black Sea, some species penetrate to the Black Sea. Georgieva (1993) reported that 33 Mediterranean phytoplankton species were found near the Bosphorus in the Black Sea (Table 1.1).. This number may be increased with climate change effect for the next years.

Table 1.1. List of Mediterranean originated phytoplankton species in the Black Sea.

Biddulphia alternans (Bail.)V. H.
Eucampia cornuta (Cl) Grun
Rhizosolenia styliformis Brightw
Thalassiothrix mediterranus Pavill
Amphidinium conradi (Conrad) Schill.
A. vigrense Wolosz
A. mannanini Herd.
Ceratium hexacanthum f.contortum (Lemm.)Jorg.
C .massiliense (Gourret) Jorg
C. furca var.eugrammum (Eht.) Jorg.
C. fusus var.seta (Eht.) Jorg.
C .teres Kof.
C. trichoceros (Eht.) Kof.
C.tripos var. atlanticum Ostf.
C.hexacantum f. aestuarium (Schrod.) Schill.
Cochlodinium citron Kof.et Sw.
Gymnodinium paradoxum Schill.
G.pygmaeum Leb.
Oxytoxum parvum Schill.
O.variabile Schill
O. viride Schill.
Peridinium sinaicum Matz
Pronoctiluca acuta (Lohm.) Schill.
P. pelagica Pavill
Pyrocystis hamulus Cl.
P. fusiformis (W.Th.)Mur.
P. pseudonoctiluca (W.Th.) Schill.
Coccolithus pelagicus (Walich.) Schill.
Rhabdosphaera stylifera Lohm.
Syracosphaera coronata Lohm.
S. cornifera Schill. (Helladosphaera)
S. quadricornu (Anthosphaera) Schill.
S. spinosa Lohm.
Total 33 species

The alien species in the Black Sea

Twenty six alien species have been described from the Black Sea by Zaitsev and Mamaev (1997). According to Zaitsev and Öztürk (2001), there are 59 species of invasive marine organisms in the Black Sea and in terms of fisheries impacts only some species have been investigated, such as whelk *Rapana* and a ctenophore *Mnemiopsis leidy*. Çinar et al. (2005) reported 20 species from the Turkish part of the Black Sea. However, in recent years, the number of alien species has increased and 240 alien species, from unicelluler algae up to fish, were recorded from the freshwater, brakish water and marine water area of Ukraine, (Alexandrov et al., 2007). Later, Alexandrov et al. (2009) reported 244 species from the entire Black Sea. But these numbers do not only contain intentionally or unintentionally introduced species, but also Mediterranean originated species (see Appendix 1). Even these figures need to be debated and discussable because of some species being only casual or questionable, it shows that how the Black Sea become home for alien species from the Pacific, Atlantic or Mediterranean Sea. Shiganova and Öztürk (2009) reported 161 alien species from the Black Sea and most of alien species come from the Mediterranen coasts (see Fig. 1.4).

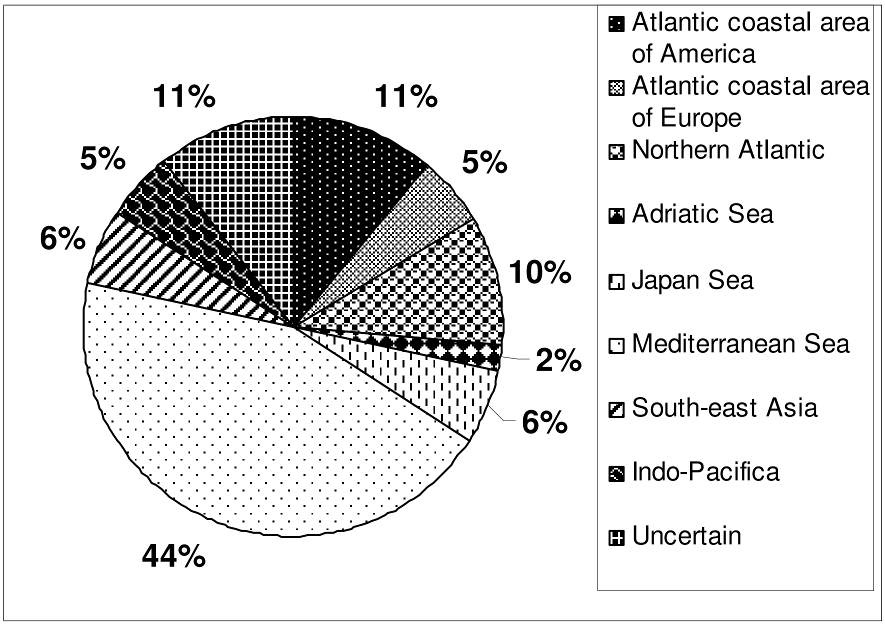

Fig 1.4. Donor areas of alien species and their proportions in the Black Sea (Shiganova and Öztürk, 2009).

1.3.1. Alien invertebrates in the Black Sea and their impacts on the biodiversity

Among several alien invasive species, a mollusc species *Rapana venosa*, bivalve species *Mya arenaria* and *Anadara inaequivalvis,* gelatinous carnivores *Mnemiopsis leidyi* and *Boreo ovata* have developed mass populations and gave rise to considerable impacts on the pelagic and/or benthic food webs of the Black Sea during the last several decades of severe ecosystem transformations.

1.3.1.1. *Mnemiopsis leidyi*

Mnemiopsis leidyi is a carnivorous ctenophore. It is characterized by the presence of two big lobes referred to as lateral or oral lobes. The oral lobes are derivated of the ctenophore body (Spherosome). Four smaller lobes are situated under the two principal oral lobes. The size of the animal varies between 40 to 180 mm in the Black Sea. There are 4 relatively short, simple auricles arising 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.

Mature specimens of *Mnemiopsis* spawn at night in summer temperatures of 20 to 23°C in upper layer of the sea. Embryonic development takes about 20-24 hours. Size of the larvae is 0.3-0.5mm (Zaika and Sergeeva, 1990). Average egg production of *Mnemiopsis* in the coastal zones of the Black Sea is very high and exceeds 1000 eggs per individual during a day. Total number of eggs in one laying is 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).

The origin of this species is the Atlantic coasts of North America. *Mnemiopsis* is found in coastal waters of North America from Cape Cod southwards to Carolina. It is abundant in ports and harbors of the above areas 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 this 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.

The first record of *Mnemiopsis* appearance in the coastal water of the Black Sea goes back to 1982 (Pereladov, 1988). The first registration of this species in open water was made in winter 1986-1987 (Zaitsev et al., 1988). The massive growth of the Black Sea population started in 1988 and at first covered only bays, gulfs and coastal waters. Its abundance reached 10-12 kg·m^{-2} at several coastal areas (e.g., Anapa, the southwestern Bulgarian coast), but did not exceed 1.5-3 kg·m^{-2} in the open sea (Shushkina and Vinogradov, 1991). Maximal development of this species was registered in 1989 and 1990 (about 1200 g·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·m^{-3} but decreased to 0.2 g·m^{-3} in 1995 (Radu et al., 1996-97). The same quantitative distribution was investigated in the Dnieper River influence zone of the Black Sea. Average biomass of *Mnemiopsis* during 1993-1997 was 3.2-5.1 g·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·m^{-2} in the Black Sea and at 500 to 600 g·m^{-2} in the Sea of Azov (GESAMP, 1997).

Detailed investigations on the interaction between two alien ctenophores, *M.leidyi* and *Beroe ovate*, 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·m^{-3}) and each year was higher and higher, reaching a maximum of 4000 ind·m^{-3} in 1998, despite of the newly introduced *Beroe* since 1997. At the same period, the average biomass of *M. leidyi* was maintained at a level 4 times more than that of the late 1980s.

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 showing the generalized distribution of *M. leidyi* was made for the water layer of 0-30 m (typical inhabited layer for this species) for September 1998 (Fig. 1.5).

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°C and 32°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 suepended materials, 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).

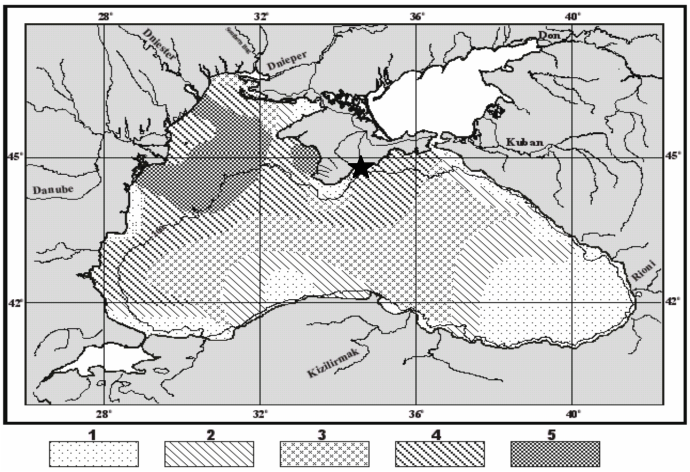

Fig.1.5. Distribution of *Mnemiopsis leidyi* in the Black Sea during the maximum development in September, 1998. Range of biomass (g·m^{-2}): **1**- <200; **2**- 200-600; **3**- 600-1000; **4**- 1000-1400; **5-**>1400.★: Place of the first registration. (Zaitsev and Ozturk, 2001)

M. leidyi is the most striking example of the negative impacts of alien 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 as:

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 Black Sea shad 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 (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 stocks in the Black Sea.

1.3.1.2. *Beroe ovata*

Another ctenophore species *Beroe ovata* needs to be examined as it is the competitor of *M.leidyi.*

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. 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.

The size of the eggs of Black Sea *Beroe* is 300-350 µm with gelatinous capsule 0.9-1.0 mm in diameter. Abundance of the eggs in one laying depends 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.

This species 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).

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* was 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.* 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 warm winters in 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. Interestingly, comb-jelly *Beroe ovata* was also recommended to the GEASMP commission to combat with *M. leidyi*.

The appearance of *Beroe ovata* during 1998 in the Black Sea, a predator of the ctenophore *M. leidyi*, led to a partial recovery of the planktonic food web structure by compensating its negative impacts *M. leidyi* made on the food web structure. *B. ovata* predominantly inhabit 30 mile-width of the coastal zone of the Black Sea. Most probably the reproduction of this species takes place in open waters.

Most experts 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). 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.

1.3.1.3. Sea snail *(Rapana venosa)*

Rapana venosa is known as a sea snail or a whelk and *Rapana thomasiana* is its synomym. It is assumed that this sea snail was brought to the Black Sea with ballast waters from its home sea of the Indian-Pacific Oceans (Sorokin, 1982). Near the Ukrainian coast, this sea snail becomes mature at the age of 2-3 old; it lives till 8-9 years and reproduces during the warm period (July-September). Pelagic larvae of sea snail feed on nanoplankton algae and their adults feed mainly on bivalves of families Cardiidae, Mytilidae, Veneridae, Archidae. They travel over large distances for feeding. In some period of a year it buries itself into the ground. Introduction of this predatory mollusk into the ecosystem of the Black Sea turned out to be a catastrophe for oyster biocenoses. Distribution of sea snail is associated with reduction in area and density of mussel settlements, in particular near the coasts of Anatolia and Caucasus. In the Ukrainian waters this sea snail destroyed the oyster banks in the area of the Kerch Strait and in Karkinitsky Bay, the biocenoses of other mollusks associated with depth down to 30 m suffered as well.

Turkey has been conducting large-scale harvesting of sea snail since the mid-1990s. The other Black Sea countries, except Romania, joined to its fisheries (see Fig. 1.6). The Turkish catch remained, however, much higher than other countries, followed by Bulgaria. It also became a commercially important resource in Bulgaria after 1994. Prior to beginnig of its regular harvesting, the biomass on the coastal grounds between Kaliakra and Pomorie was about 2,000 tons (Prodanov and Konsulova, 1993). Bottom trawling and dredging were officiallly forbidden, although these fishing gears were used for the sea snail fishery.

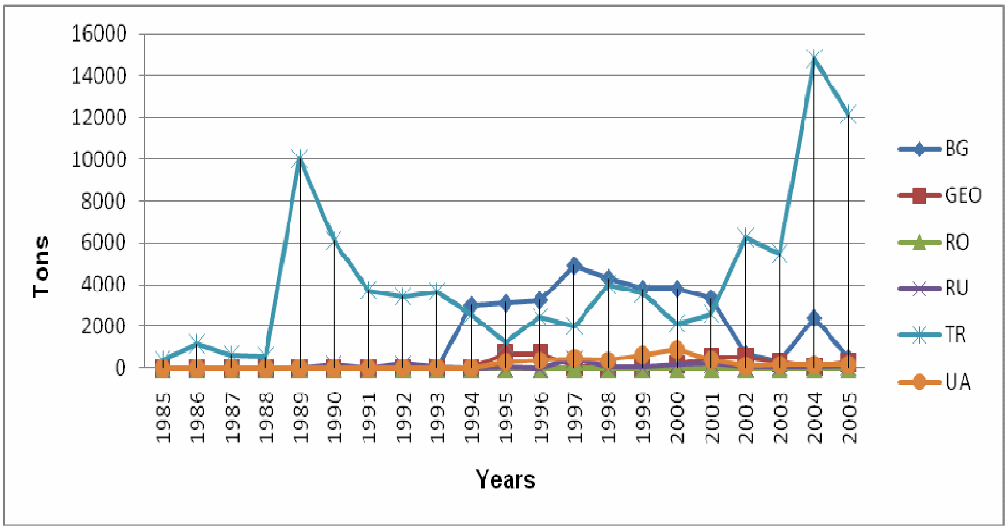

Fig. 1.6. Catch of *Rapana venosa* by the Black Sea countries.

In Turkey, harvesting of sea snail has been greatly increased for the recent years. Analysis of fisheries along the eastern coast of Turkey (Samsun Province) showed that number of vessels using dredges for sea snail harvesting in 2000-2005 increased by large rates, especially in the vessel group 33-149 HP. These are typical boats that combine sea snail dredging, bottom trawling and net fishing (Knudsen and Zengin, 2006). Although the resource of this mollusk is still withstanding such high intensity of fisheries, a large-scale implementation of dredges has a destructive effect on the bottom biocenoses and the ecosystems as a whole. In recent years, some studies have been initiated for new catching methods, such as pots and surface supplied diving system in the Black Sea (Saglam et al., 2007). The operational costs of new environmentally friendly system, however, are not preferred by fishermen because of the high cost of such operations.

Until the early1990s, along the Ukrainian coast, the sea snail was harvested in an amateurish way for fine shells used as souvenirs. The distribution and the stock assessment of sea snail in the Ukrainian territorial waters in the araea from Takil Cape to Chauda Cape were undertaken in 1990, 1994 and 1999. The stocks of this mollusk were, respectively, assessed as 2.8 thousand tons, 1.5 thousand tons and 1.3 thousand tons. The former two assessments belonged to the initial commercial exploitation of this ground, the latter to the period of the intensive fisheries. Reduction in sea snail stocks from 1.5-2.8 thousand tons (virgin population) to 1.3 thousand tons (exploited population) is the evidence of the impact made by the dredge fisheries. The use of knife-edge dredges adversely affected the bottom biocenoses.

In 1994, the sea snail stocks were assessed along the southern and western coasts of the Crimea from Cape Ilya to the Cape Evpatoriisky as 14 thousand tons, and the limit for its harvesting in the waters of Ukraine begin to be established as 3 thousand tons (Oguz, 2008).

Illegal bottom trawling for harvesting of *RAPANA VENOSA* along the Bulgarian Black Sea shelf has raised ecological concerns with respect to the benthic communities and especially the mussel beds. The population decline of the habitat-structuring species *MYTILUS GALLOPROVINCIALIS* in the impacted areas was accompanied by degradation of the associated benthic community from "mussel bed" type to "silt bottom" type dominated by opportunistic polychaetes and oligochaetes (Zenetos et al, 2007).

1.3.1.4. Other alien invertebrate species and impacts on the biodiversity

The bivalve *Mya arenaria,* native of the Northern Atlantic, was first detected in 1966 and became very abundant in a short time in the northwestern and western part of the Black Sea, reaching its peak abundance in 1972. It was later affected adversely by regular hypoxia-anoxia crisis that destroyed the entire benthos in the 1980s. But it still retains considerable abundance in western coastal waters. This species is a competitor for habitats with small local bivalve *Lentidium mediterraneum*, which avoids sandy bottoms siltated by *M. arenaria*. Large amounts of washed mollusks on the beach attract their consumers, such as gulls and crows.

Another bivalve of Indo-Pacific fauna, *Anadara inaequivalvis,* was found in the Black Sea in 1968, and has spread to the whole basin. They were followed by the invasion of *M. leidyi* that attained a massive basin-wide bloom in 1989-1990 following its first seen in 1982. This species seem to be commercialized soon (Sahin et al., 2006).

In 2001, two new non-native bivalvia species were found in Odessa Bay: edible *Mytilus edulis* and *Mytilus trossulus* (Alexandrov, 2004). *M. edulis* probably was brought with ballast waters from the Mediterranean, where it is cultured off the Spainish and Italian shores. A Pacific species *M. trossulus* was probably brought with ships from Far East Russian coasts, where it is a main cultivated species (Suprunovich and Makarov, 1990).

Other alien species such as ivory barnacle *Balanus eburneus* and acorn barnacle *Balanus improvisus* are typical organisms of fouling communities, which may have a significant role for the sea bass aquaculture net cages in the Trabzon areas in the Turkish Black Sea.

A Mediterranean jellyfish is a threat for humans in the Marmara and Black Sea. Corse jellyfish *Chrysaora hysoscella* (Linnaeus, 1767), a temperate planktophagous species, was firstly reported from the Sea of Marmara by Inanmaz et al. (2002). However, this species made a large bloom in the Marmara Sea, Istanbul Strait and Turkish part of the Black Sea in July 2009. Most of beach bathers used fishing nets to protect themselves from this stinging jellyfish. While this species is venoumous, this needs to be monitored in the Black Sea in terms of the impact on human health and interrelation with the entire Black Sea biota. *C. hysoscella* will establish its populationin the Black Sea shortly.

1.3.2. The impacts of alien species on the pelegic fisheries in the Black Sea

Alien species of the Black Sea were examined in several papers. There is, however, no accurate data for their impacts on the fisheries of the commercial pelagic fish species, such as bluefish, mackerel, and bonito, and commercial demersel fishes, such as whiting, turbot and red mullet, and striped mullet. Intensive studies have been carried out for *M. leidyi* and *B.ovata* and their impacts to small pelagic fish such as anchovy.

1.3.2.1. Sprat

Sprat *Sprattus sprattus* is one of the most abundant and commercially important pelagic fish species in the Black Sea, and it serves an important food source for larger fishes (Ivanov and Beverton, 1985). Sprat reaches maturity at one year and reproduces during the whole year, but its peak spawning takes place between November and March.

Its spawning during winter and spring in deeper layers was also relatively unaffected by *M. leidyi* because of its low biomass in those deep layers. Therefore, competition for prey and predation impacts on sprat eggs and larvae was weak.

In summer, the juvenile and adult sprats leave the upper warmed layer and thus avoid severe competition for food with other plankton-consumers including *M. leidyi*. During this period, their preferred food consists mainly of the cold-water *Calanus* and *Pseudocalanus* copepod species living below the cold intermediate layer of the water column. It should be noted that these preys are also available to *M. leidyi* as they migrate to the thermocline at night for their daily feeding where they can be consumed by the ctenophore. This can partly explain the reduction of the sprat stock during the *Mnemiopsis* population outburst in the early 1990s. As with the other commercial stocks, heavy overfishing took place before and during the *M. leidyi* outbreak as well, which must have aggravated the stock depletion (Prodanov et al., 1997; Daskalov, 1998).

1.3.2.2. Black Sea anchovy

The Black Sea anchovy *Engraulis encrasicolus* is the most important commercial pelagic fish species distributed over the whole Black Sea. In October-November, it migrates to the wintering grounds along the Anatolian and Caucasian coasts and forms dense wintering concentrations until March and becomes subject to intensive commercial fishery.

Anchovy competes for food with *M. leidyi* (Grishin et al., 1994) and this competition probably further affected the anchovy population growth (Oguz et al., 2008). The initial outbreakof *M. leidyi* was reported in 1988-89 in the Black and Azov Seas. It appears that the catastrophic reduction of the Black Sea anchovy stocks in the late 1980s was due to the combined effect of two factors: the excessive fishing and *M. leidyi* outburst (Grishin et al., 2007). It is noteworthy that the sharp decline in anchovy catch happened after the outburst of *M.leidyi* at the end of 1980s and the early 1990s (Fig. 1.7). In addition, Kideys (2002) mentioned that as *Mnemiopsis* feeds on the eggs and larvae of the anchovy, it was responsible for the collapse of the anchovy fisheries.

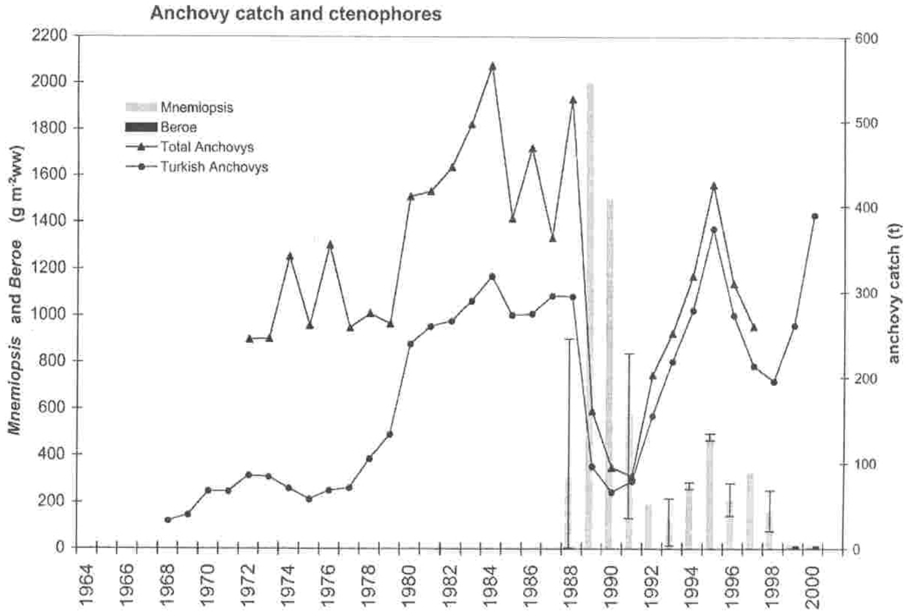

Fig.1.7. Anchovy catch and ctenophore biomass in the Black Sea (after Niermann, 2004).

The catch increased after the outburst of competitor species *Beroe ovata* at the end of the 1990s. In a way, *B. ovata* helped the ecosystem to recover feeds almost exclusively on *Mnemiopsis*. Catch of anchovy by Turkish fishermen was also stabilized after the 1990s to 2000s in the Black Sea (see Fig. 1.8) on the Turkish anchovy catch from 2000 to 2007.

The total loss of the anchovy catch over the years between 1989 and 1992 due to *M. leidyi* outbreak can be roughly estimated. According to Campbell (1993), total annual loss of fish processing factories was estimated to be USD 11 million and the total annual loss in fishing itself was very roughly about USD 330 million in 1992. The economic damage to the Turkish fishery alone is conservatively estimated at several hundred million dollars.

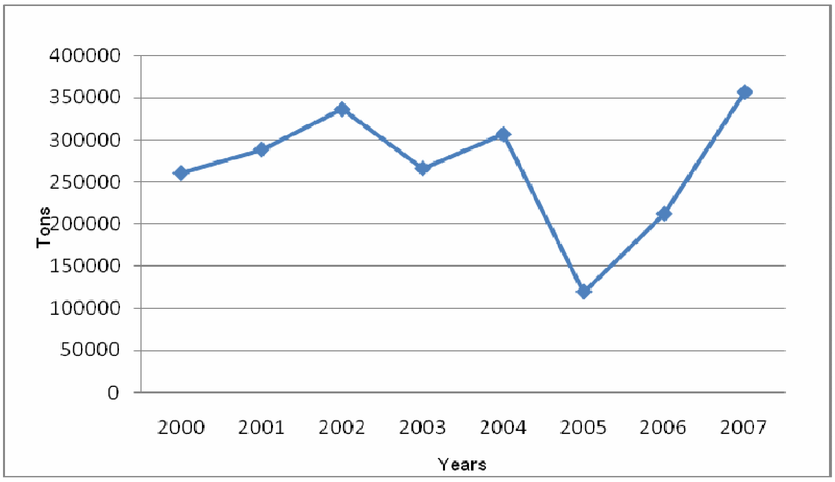

Fig. 1.8. Catch of anchovy by Turkey (2000-2007).

Damage by *M. leidyi* to the anchovy population was most likely done through food competition, as unusual low level of zooplankton was observed in the top 50 m layer in summer of the early 1990s (Oguz et al., 2008). Anchovy larvae could also be affected by *M. leidyi* predation. The abundance of anchovy larvae peaks in July and August when *M. leidyi* biomass also has a seasonal peak (Grishin et al., 2007). *M. leidyi* was capable of consuming a daily ration several times greater than its own weight (Lipskaya and Luchinskaya, 1990). Its food spectrum was quite wide and included anchovy eggs and larvae as well (Reznichenko, 1991). There was an overlap in the distributions of anchovy larvae and *M. leidyi*, even though anchovy larvae were predominantly found in the narrow coastal zone while the ctenophore was distributed further offshore. Oguz et al. (2008) reported that the switch of a large marine ecosystem to a totally gelatinous invader-dominated state requires extremly strong environmental perturbation. More often, environmental disturbance create a suitable niche for an alien gelatinous invader to become a member of the food web structure, and to share food resources with the native small pelagic fish community.

1.3.2.3. Horse mackerel

Dietary studies of juvenile and adult horse mackerel *Trachurus* spp. (Revina, 1964) have shown that both habitats and diet of juvenile horse mackerel and *M. leidyi* overlapped each other; therefore the strong feeding pressure by *M. leidyi* on zooplankton directly affected larval and juvenile horse mackerel.

As the first outburst of *M. leidyi* occured in the autumn of 1988, the zooplankton maximum production in summer did not suffer much from the devastating effect of *M. leidyi*. The copepods *Oithona nana* and *Oithona similis* which constituted the main food of larval horse mackerel (Revina, 1964) were especially abundant. However, the favorable trophic conditions for larvae in summer 1988 failed to ensure the formation of a strong year-class because juveniles were faced with strong feeding competition with *M.leidyi* further in the year. Sharp decline in *Oithona* under the predation pressure of *M. leidyi* in the subsequent years affected the survival of horse mackerel (Vinogradov et al., 1993). Meanwhile recent data shows that the stocks of the horsemackerel have been stabilized in Turkish coasts (see Fig. 1.9).

Fig. 1.9. Catch of horse mackerel of Turkey.

1.3.3. Alien fish species and their impacts

Total number of fish species found in the Black Sea is 189 according to Slestenenko (1955-1956), among which 34 species live in the estuary and lagoon areas in the Black Sea. Zaitsev and Alexandrov (1998) reported 180 fish species from the Black Sea. In recent years, however, some more fish species which are ecologically tolerant to temperature and salinity have settled in the Black Sea. These fishes migrated from the Mediterranean Sea and are extending their northern distribution up to the Crimian Peninsula. Besides, some Indo-Pacific species, such as blunt barracuda *Syhyraena obtusata* and Pennant Coral fish *Heniochus acuminatus* extended their distribution ranges to the Black Sea in recent years (Boltachev et al., 2002). These two fish species of the Indo-Pacific origin were reported from the Crimian Peninsula with a few individuals and its migration was explained with the ballast water of commercial ships (Alexandrov et al., 2007). Nevertheless, this two species are less than 2 % of total fish fauna in the Black Sea and not comparable to the Mediterranean Sea. This should be, however, monitored even a few individuals were observed in the southern Black Sea.

An intentionally introduced fish, haarder, *Mugil soiuy,* has become an important commercial species and distributed in the coastal waters of the Black Sea, Azov Sea, Sea of Marmara and Mediterranean Sea, even in the Algerian coasts. Its annual catch in the Black Sea exceeds 10,000 tons (Zaitsev and Öztürk, 2001). Okumus and Bascinar (2007) reported that this fish appears to establish a population in the Black Sea, the growth rates seem to be much better and the age at first sexual maturity is earlier than that of the native mullet species. Age at first maturity was estimated as 3-4 years for males and 4-5 years for females and the spawning period extends from the end of May to the beginning of July. Its pelagic eggs are 0.8-0.9 mm in diameter, have large oil droplets, which constitute up to 23% of the egg volume. This is the reason of high floatability of haarder's eggs, which can develop in low salinity in some coastal wetlands. The fries of the haarder are feeding on zooplankton and therefore can compete with local plankton-eating fish. This species feeds on small bottom living organisms mostly of meiobenthos, thus, compete with plaice and turbot juveniles in the coastal areas. 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. This consequence needs to be further investigated for human health and biota of the Black Sea. It is expected that this species will be more commercialized in next years in the Black and Mediterranean Seas.

Table 1.2. Alien species in the Black Sea, intentionally or unintentionally introduced from the Mediterranean Sea.

Species	**Purpose of introduction**	**Years**	**Origin of the Species**	**Inoculation Places**
Gambusia affinis (Mosquito fish)	To combat malaria	1925's	Mediterranean N. America	Russia, Turkey
Lepomis gibbosus (Freshwater sun fish)	Aquarium	1920's	N. America Europe	Odessa Gulf
Pandulus kesleri (Far eastern shrimp)	Aquaculture	1960's	Far east	Odessa, Kizilcay Region
Roccus saxatilis (Striped bass)	Aquaculture	1965-1972	Atlantic Ocean	Dnestrovsky
Plecoglossus altivellis (Salmon)	Aquaculture (Failed)	1963	Sea of Japan	Odessa

Salmo gaidneri (Steelhead trout)	Aquaculture (Failed)	1960's	Atlantic Ocean	Dnesterovsky
Oryzias latipes (Japanese medeka)	Aquaculture	1970's	Sea of Japan	Black and Azov Seas
Panaeus japonicas (Japanaese shrimp)	Aquaculture	1970's	Japan	Romania, USSR
Oncorhyncus keta (Far Eastern keta)	Aquaculture	1970's	Europe	USSR
Lateolabrax japonicas (Sea perch)	Aquaculture	1978	Japan	USSR
Dicentrarchus labrax (Sea bass)	Aquaculture	1979	Mediterranean Sea	USSR
Crassostrea gigas (Giant oyster)	Aquaculture	1980	Sea of Japan	USSR
Mugil soiuy (Haarder)	Acclimatizatio n	1972-1980	Sea of Japan	USSR
Salmo salar (Salmon)	Aquaculture	1990	Norway	Turkey,Ukraine
Onchorhynchus mykiss (Rainbow trout)	Aquaculture	1970	Denmark	Turkey,Ukraine
Carassius auratus	Aquaculture	1900's	Southeast Asia	Ukraine
Micropterus salmonides	Aquaculture	Late 19^{th} cent.	North America	Ukraine
Ictalurus nebulosus	Aquaculture	1935	North America	Ukraine
Ictalurus puncatus	Aquaculture	1935	North America	Ukraine
Perccottus glehni	Aquarium trade	1948	South Asia	Ukraine
Channa argus argus	Aquaculture	1950's	South Asia	Ukraine
Coregonus albula	Aquaculture	1950's	Holarctic	Ukraine
Tribolodon brandtii	Unintentional	1950's	Pacific	Ukraine
Aristichytys nobilis	Aquaculture	1953	Southeast Asia	Ukraine
Hypophthalmichthys molitrix	Aquaculture	1953	Southeast Asia	Ukraine
Coregonus nasus	Aquaculture	1954	Holarctic	Ukraine
Coregunus peled	Aquaculture	1954	Holarctic	Ukraine
Ctenopharyngodon idella	Aquaculture	1954	Southeast Asia	Ukraine
Coregonus autumnalis	Aquacultrue	1957	Holarctic	Ukraine
Coregonus lavaretus	Aquaculture	1960's	Holarctic	Ukraine
Salmo ischchan	Aquaculture	1960	Sevan Lake	Ukraine

Mylopharyngodon piceus	Aquaculture	1961	Southeast Asia	Ukraine
Orchynchus gorbuscha	Aquaculture	1961	Pacific, Asia	Ukraine
Pseudobrasbora parva	Unintentional introduction	1990	Asia	Ukraine
Oreochromis mossambicus	Aquaculture	1996	Africa	Ukraine
Coregonus laveratus	Aquaculture	1965	Holarctic	Ukraine
Morone saxatilis	Aquaculture	1965	N.America	Ukraine
Oreochromis niloticus	Aquaculture	1970's	Africa	Ukraine
Tilapia zilli	Aquaculture	1970's	Africa	Ukraine
Ictiobus bubalus	Aquaculture	1975	N.America	Ukraine
Ictiobus cyprinellus	Aquaculture	1975	N.America	Ukraine
Ictiobus niger	Aquaculture	1975	N.America	Ukraine

Sources: Zaitsev and Ozturk,2001; Gomoiu et al., 2002; Alexandrov et al., 2007.

A total of 45 fish species were intentionally or unintentionally introduced to the Black Sea by Russia, Romania, Ukraine and Turkey (Table 1.2). Distribution is very lttle known for these fishes. They need to be investigated in many aspects such as parasites, genetic diffentiation, etc.

Among intentionally introduced species, rainbow trout and salmon are also commercially produced mostly in the Turkish part of the Black Sea. Sea trout production is about 2,000 tons yearly and salmon production is 1,500 tons (Okumuş and Deniz, 2007). The problem of the intentionally introduced species is the risk of the genetic contamination when they escape from cages at sea. The risk of hybridization also needs to be investigated in a long term scale.

Most of other introduced species failed to survive in the Black Sea for various ecological reasons.

Impacts of the alien species to the native species may be to loss of ecological niches mostly in river mouths of rivers such as the Danube, Dnieper, Dniester, Kizilirmak, Yesilirmak and Sakarya. Because of low salinity brakish water of the Black Sea, euryhaline and eurytherm species is more suitable to settle.

Fishery statistics should be harmonized among the Black Sea countries for better understanding the impacts on the local fishery and native species by intentionally introduced alien species.

It should be reminded that new-comers or alien species may carry several parasites or fungi which can threaten native fauna and flora, thus may cause harm to the local fisheries.

International cooperation is essential to combat for the alien species in the entire ecosystem. Impacts of the climate change and Mediterranization should also be taken into account. Because of the climate change impacts, some Mediteranean species also enter the Black Sea, such as sardine, bouge and wrasse in recent years.

Besides, the penetration of alien species into the Black Sea puts pressure on the autochthonous Black Sea endemics. They retreated to the brackish water areas of the sea and took refuge in estuaries and deltas. This tendency a threat for the biodiversity of the Black Sea.

1.3.4. Alien marine mammal species in the Black Sea

The white whale *Delphinopterus leucas* (Pallas) was captured in the Sea of Okhosk and accidentally it was released from the Sevastopol aquarium to the Black Sea in 1991. The northern fur seal *Callorhinus ursinus* L. was captured from the Bering Sea and accidentally released to the Black Sea. The Steller sea lion *Eumetopias jubatus* (Schreber) was originally from the Sea of Okhotsk and accidentally released to the Black Sea. It should be noted that except dolphins, the Black Sea is not hospitable for large fish-eating marine mammals (Zaitsev and Ozturk, 2001).

1.4. Conclusion and recommendations for the Black Sea

The introduction process of alien species is still continuing in the Black Sea and need to be monitored at the national, regional and international level.

More attention should be paid to the toxic phytoplankton species and harmful organisms due to possible damage to mussel and fish farms.

The impact of the alien species is complex and most of time unpredictable due to lack of monitoring and poor scientific knowledge about those species.

Experts on alien species, such as taxonomists, should be trained and encouraged. Capacity building for reparian countries is essential for the monitoring of alien species. In this way, toxic phytoplankton blooms should be monitored and mussel and oyster farms should be alarmed in case of such dangerous events.

Initiatives for the database management on *Mnemiopsis* and other jellyfish should be continued by BSEP.

Legal measures for intentional introduction to the Black Sea should be taken by national authorities and international conventions, such as Bucharest and Bern Conventions.

Public awareness and sensibilization programmes for local people, fishermen, boat crew, harbor masters and coast guards are needed to explain alien species and their impacts to nature, human health and fisheries. Special education progarmmes should be given to the fisheries cooperatives to educate and mitigate the impacts of alien species.

International Convention of for the Control and Management of Ship's Ballast Water and Sediment (BWM Convention) was already adopted in 2004. This convention is not into force but some countries like Ukraine, Russia and Turkey request ballast water reporting and follow ships to their ports. In a Russian port, Novorossisk, ballast water is monitored for chemical contamination. Ukrainian authorities sample ballast water to assess possible chemical contamination (Matej and Gollash, 2008). Turkish authorities conduct a project for the impacts of the ship ballast waters to Turkish Seas. This kind of implementation should be encouraged to prevent alien species to enter local seas. To control alien species via coming ships, a defined concerted area for discharging ballast water should be established in the Black Sea.

Fishery statistics should be harmonized among the Black Sea countries for better understanding the impacts on the local fishery and native species by intentionally introduced alien species. Separate alien species catch and fleet statistics should be established with the guidance of GFCM and its relevant subcommittee. For that purpose, an informative booklet shold be prepared for the national fisheries authorities.

It should be reminded that alien species may carry several parasites or fungi which may threaten native fauna and flora, thus may cause harm to local fisheries. Thus they should be monitored by the riparian governments with national capacity as well as relevant international agencies.

Because of climate change, some Mediterranean species also penetrate to the Black Sea, such as sardine, bouge and wrasse, in recent years and it is expected that the fishing catch amount change in a certain period. Mediterranean originated species need to be monitored in the Black Sea. General trends show that a Mediterranean Sea is going to be established within the Black Sea since several species penetrate to the Blak Sea with various vectors. Besides, alien species penetration into the Black Sea put pressure on the autochthonous Black Sea endemic species. They retreat to the brackish water areas of the sea and take refuge in estuaries and deltas.

Due to overfishing, the reduction of total fish biomass in the Black Sea in the end of 1980s to less than one third of its maximum value in the 1970s has caused a partial emptiness of the occupied ecological niche. According to the general rule *"Natura abhoret vacuum"* they were occupied by invader planktophagous *M.leidy*. Overfishing, therefore, should be avoided for all fish species to minimize the risk of alien species invasion. *M.leidyi* has already penetrated to the Mediterranean Sea and the lesson learned in the Black Sea should be applied to the Mediterranean Sea case in terms of impacts on the fisheries and whole biota.

Ecological balance should be protected in all seas but mostly in enclosed seas where this ecological concept is more important. In the Black Sea, the mackerel and Black Sea shad stocks were depleted and no main competitor remained to consume jellyfish-like organisms such as *Mnemiopsis* sp. and others.

International cooperation is essential to combat for the alien invasive species in the entire ecosystem. Impacts of climate change and Mediterranization should also be taken into account.

2. STATUS OF ALIEN SPECIES IN THE MARMARA SEA

2.1. The main characteristics of the Marmara Sea

The Marmara Sea, including the Istanbul Strait (Bosphorus), Marmara Sea and Canakkale Strait (Dardanelles), is situated between 40°00’ and 41°10’ N and 26°15’ and 29°55’ E. The surface area of the sea is 11,500 km² and the volume is 3,378 km³. The length of the coastline is 927 km. This sea is surrounded by the Anatolia and Trace regions in Turkey (Fig. 2.1).

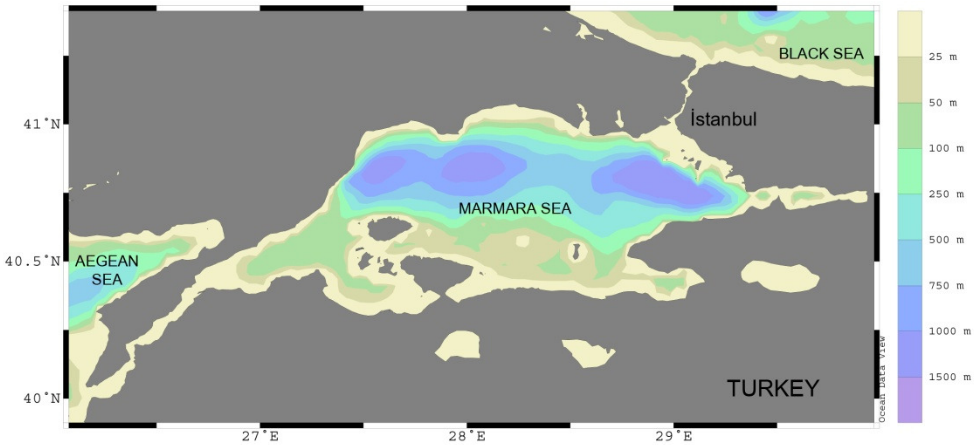

Fig. 2.1. The Marmara Sea.

It is one of the busiest water ways in the world because of shipping activities between the Mediterranean and the Black Sea basins; about 55,000 ships pass every year (Ozturk et al., 2006).

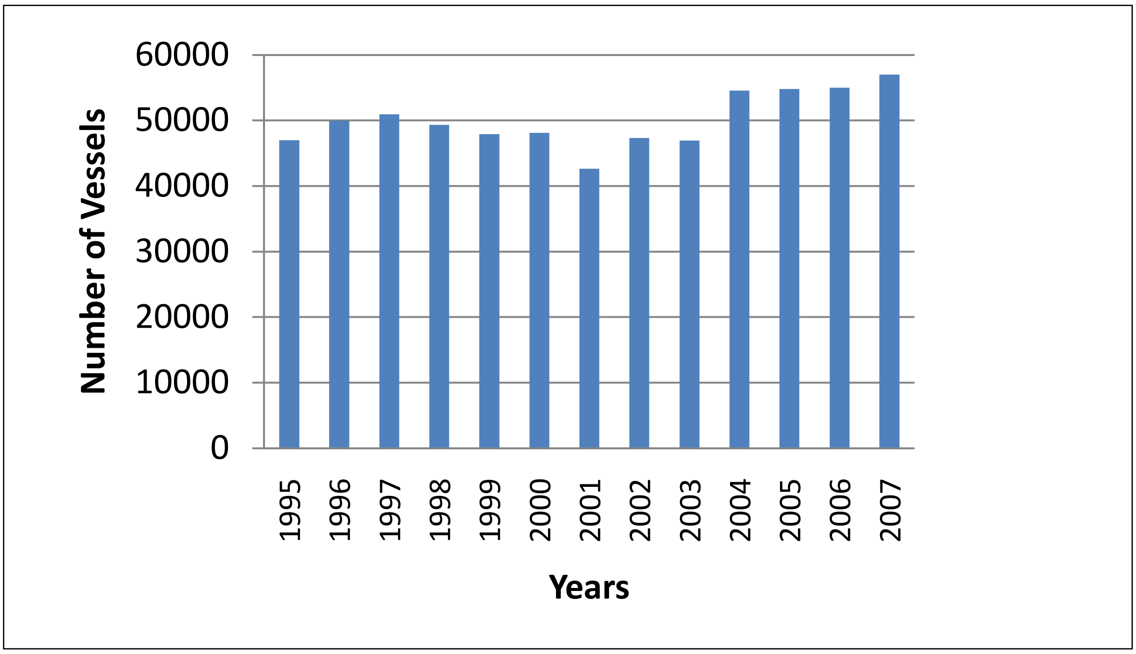

Fig. 2.2. Shipping traffic in the Straits of Istanbul (1995-2007).

As seen in Fig. 2.2., shipping traffic trend is growing in the Istanbul Strait and thus poses new risks for the Black Sea while shipping is the main vector for alien species in this region.

Due to the geographical and hydrographical characteristics of the Marmara Sea, it represents a peculiar ecosystem as it is a transitional zone between the Mediterranean and the Black Sea. As such, it constitutes a barrier, a corridor or an acclimatization zone for living organisms (Ozturk and Ozturk, 1996). The Marmara Sea serves as a barrier because it limits the distribution of both warm water marine species of Mediterranean origin and cold water, low saline species from the Black Sea. On the other hand, the Marmara Sea is the most important biological corridor for many species of migratory fish, birds and marine mammals between the Mediterranean and the Black Sea. In this acclimatization zone, some Mediterranen species adjust slowly to the new environment of the Black Sea, or the Black Sea species to the Aegean Sea.

The Marmara Sea is made up of two layers of either Black Sea or Mediterranean origin, separated by a transitional layer of 8-10 m. Therefore, the hydrography of the Marmara Sea is dominated by the conditions of the adjacent basins. The Black Sea water enters the Marmara Sea through the Istanbul Strait as an upper current of 15-20 m depth and exits through the Canakkale Strait. Likewise, the Aegean water enters through the Canakkale Strait in a deeper layer flow, and enters the Black Sea with the Istanbul Strait underflow. The upper layer has a volume of 230 km³ and an average renewal time of 4-5 months. The deeper layer has a volume of 3,378 km³ and an average renewal time of 6-7 years (Besiktepe et al., 2000). Life in the upper layer is nourished primarily by brackish water of the Black Sea (Tugrul and Salihoglu, 2000). The temperature of the surface water of the Marmara Sea, which is under the influence of the Black Sea, ranges from 4 to 24°C. The salinity varies between 10 and 18 per mille. Deeper water shows pronounced changes in salitiny and temperature. The salitiny at 20 m depth rises to 30 per mille at 40-50 m depth to 37 per mille. The temperature of the surface water of the Canakkale Strait is 6 to 26°C and the salinity 24 to 36 per mille. In deeper water, at 70m depth, the temparature ranges from 14 to 17°C. The salitiny at a depth of 30 m rises to 37.5 per mille and below it to 39 per mille (Kocatas et al., 1993).

2.2. Alien species of the Marmara Sea

Zaitsev and Ozturk (2001) reported 14 alien species and Cinar et al. (2005) reported 48 alien species in the Marmara Sea (Table 2.1). However, these numbers do not include Mediterranean species although there are several species found in the Marmara Sea which are originally from the Mediterranean Sea. This factor is mostly related with climate change and the cause of Mediterranization is not discussed in this report.

Alien fauna and flora of the Marmara Sea have been introduced in two different ways: by ships in ballast water, sediment tank or on ship's hull, e.g. *Mnemiopsis leidyi*, or through man-made introduction, e.g. *Gambusia affinis*. Lessepsian species, which enter the Mediterranean Sea from the Red Sea through the Suez Canal, are only a few yet in the Marmara Sea as it serves as a barrier for many thermophilic fish species. However, the Marmara Sea is likely to act as a major transitional acclimatization and colonization zone prior to settlement in the Black Sea. For example, Katagan et al. (2004) and Tuncer et al. (2008) reported for the first time the settlement of a Lessepsian migrant stomatopod shrimp *Erugosquilla massavensis* and fish *Lagocephalus spadiceus*, in the Sea of Marmara whereas they have not been reported yet in the Black Sea.

Table 2.1. List of alien species in the Marmara Sea. Modified from Zaitsev and Ozturk (2001); Ozturk (2002); Cinar et al. (2005).

Phytoplankton

Rhizosolenia calcar-avis M. Schultze, 1858
Alexandrium monilatum (Howell) F.J.R. Taylor, 1979
Phaeocystis pouchetii (Hariot) Lagerherim, 1893
Acanthophora nayadiformis (Delile) Papenfuss, 1968
Acrochaetium codicolum Børgesen, 1927
Asparagopsis armata Harvey, 1855
Bonnemaisonia hamifera Hariot, 1891
Codium fragile Suringar, 1867
Chondria collinsiana Howe, 1920
Chondrophycus papillosus (C. Agardh) Garbary & Harper 1998
Ganonema farinosum (Lamouroux) Fan & Wang, 1974
Gracilaria arcuata Zanardini 1858
Griffthsia corallinoides (Linnaeus) Trevisan, 1845
Hypnea variabilis Okamura, 1909
Radicilingua thysanorhizans (Holmes) Papenfuss, 1956
Rhodophysema georgii Batters, 1900
Chorda flum (Linnaeus) Stackhouse 1797
Ectocarpus siliculosus (Dillwyn) Lyngbye, 1819
Halothrix lumbricalis (Kützing) Reinke, 1888
Pilayella littoralis (Linnaeus) Kjellman, 1872
Protectocarpus speciosus Boergesen, 1902
Sargassum latifolium (Turner) C. Agardh, 1820
Sphaerotrichia divaricata (Agardh) Kylin, 1940
Bryopsis pennata Lamouroux, 1809
Ulva fasciata Delile, 1813
Copepoda
Centropages furcatus (Dana, 1846)
Parvocalanus latus Andronov, 1972
Parvocalanus elegans Andronov, 1972
Acartia tonsa Dana, 1848
Ctenophora
Mnemiopsis leidyi (Agassiz, 1865)
Beroe ovata Mayer 1912
Polychaeta

Lepidonotus carinulatus (Grube, 1870)
Harmothoe boholensis (Grube, 1878)
Harmothoe minuta (Potts, 1910)
Ancistrosyllis rigida Fauvel, 1919
Sigambra constricta (Southern, 1921)
Nereis zonata persica Fauvel, 1911
Glycera alba adspersa Fauvel, 1939
Lumbrineris debilis Grube, 1878
Dasybranchus carneus Grube, 1870
Timarete dasylophius (Marenzeller, 1879)
Timarete anchylochaeta (Schmarda, 1861)
Ficopomatus enigmaticus (Fauvel, 1923)
Crustacea
Callinectes sapidus (Rathbun, 1896)
Erugosquilla massavensis(Kossmann,1880)
Decapoda
Marsupenaeus japonicus (Bate, 1888) (Intentionaly)
Stomatopoda
Erugosquilla massavensis (Kossmann, 1880)
Mollusca
Gastropoda
Rapana venosa (Valenciennes, 1846)
BIVALVIA
Teredo navalis (Linnaeus, 1758)
Anadara inaequivalvis (Bruguière, 1789)
Crassostrea gigas (Thunberg, 1793)
Mya arenaria Linnaeus, 1758
Echinodermata
Asterias rubens
PISCES
Osteichthyes
Mugil soiuy Basilewsky, 1855 (Intentionaly from the Balck Sea)
Solea senegalensis Kaup, 1858
Gambusia affinis holbrooki (Intentionally)
*Lagocephalus spadiceus(Spadiceus,1845) (*Indo-_pasific,poisonous)

2.2.1. Ctenophore, Mnemiopsis leidyi, and its impacts on the fisheries and fish stocks in the Marmara Sea

Mnemiopsis leidyi had severe negative impacts on the fisheries and needs to be evaluated in terms of fisheries and fishery stocks in the Marmara Sea. This species was first introduced to the Black Sea and via the surface current to the Marmara, Aegean and Mediterranean Seas. It was first recorded in the Marmara Sea by Artuz (1991). In October 1992, an extremely vigorous outbreak was recorded in the Marmara Sea (GESAMP 1997). The abundance of *M. leidyi* was as high as 4.3 kg m^{-2} near the Istanbul Strait and 9.7 kg m^{-2} near the Canakkale Strait, mostly in 10-30 m deep water (Shiganova et al., 1995). This species was also reported from the Turkish coasts of the Aegean and Mediterranean Seas (Kideys and Nierman, 1994). *M. leidyi* is a euryhaline organism tolerating a wide range of salinity of 4-75 per mille (Burrel and Van Engel, 1976). Since *M. Leidyi* is a voracious predator, it has caused a decline of zooplankton. Masses of carcasses of this ctenophore caused anoxia in bottom-near waters. They have also been entangled to the fishing nets causing substantial damage. If more than 1,000 fishing boats which are of various size and type are considered, socio-economical aspects of the damage may be better understood.

The pelagic fish stocks in the Marmara Sea declined since the pelagic fish feed mainly on copepods and cladocerans, which are also foraged by *M.leidyi.* Furthermore, *M.leidyi* feeds on fish eggs and larvae, seriously affecting the economically important fishes, such as *Scomber scombrus, Sardina pilchardus, Sprattus sprattus*, *Engraulis encrasicholus*, *Trachurus trachurus* and *Pomatomus saltator,* which use the Marmara Sea as spawning grounds. Isinibilir (2007) reported that the abundance of the *M.leidyi* become limited in summer, when *Beroe ovata* is present in Izmit Bay. It means that like in the Black Sea *B.ovata* could control the *M.leidyi* stocks. Since the outbrust of *Mnemiopsis* during 1989 in the Black Sea (which could be assumed for the Marmara Sea as well), fish catches were increasing steadly until 1999 (up to almost 55,000 tons). As clearly seen in Fig. 2.3, the catch of the main pelagic commercial fish specis declined in 1989. While the Sea of Marmara representing about 15 % of total catch amount of Turkey, any alien species which is substantially harmful for fisheries stocks and resilient community.

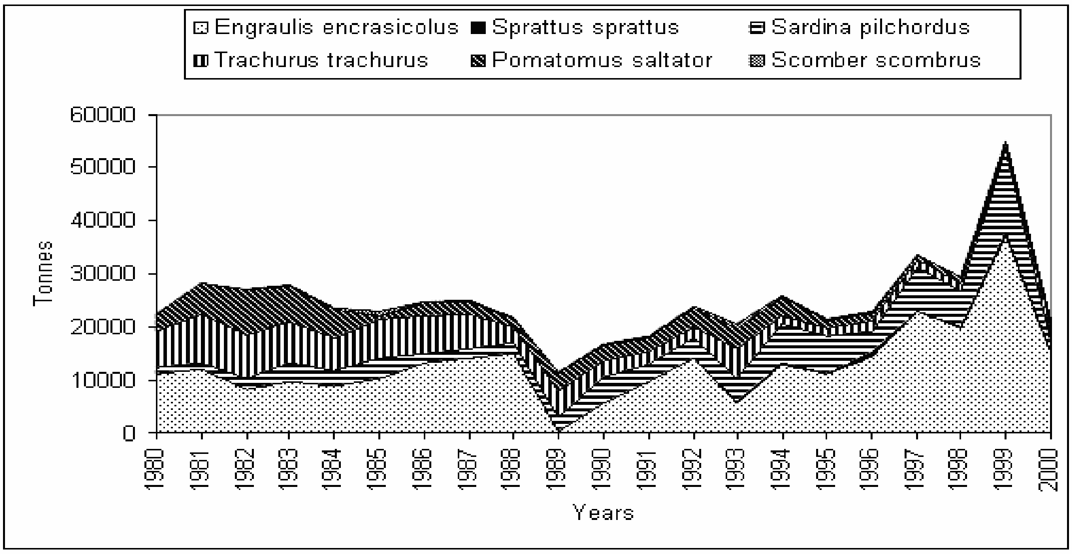

Fig. 2.3. Catches of some pelagic fish species in the Marmara Sea (1980-2000).

Source: Isinibilir et al. (2001).

In that period, the decline of the fish stocks and economic loss of fisheries was estimated at 400,000 USD for Turkey only (Ozturk and Ozturk, 2000). However, Yuksek et al. (2007) reported that biomass and abundance of *M. leidyi* decreased sharply between 1995 to 2006. Some authors also mentioned that between 1997 and 1998, according the size frequency data, small individuals were abundant through the year, while highest increase has been observed in July-September, when water temperature was higher. Fig. 2.4 shows that between 2000 and 2007 main pelagic fish stocks were recovering themselves even anchovy which is negatively impacted from the *Mnemiopsis*, the catch amount was increased even bigger than previous amount.

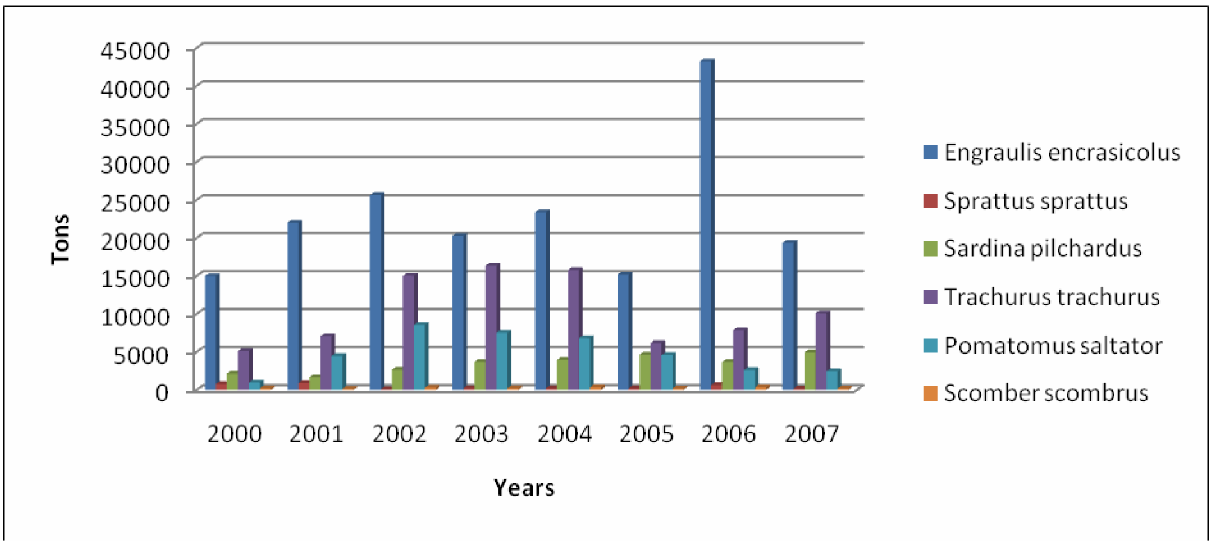

Fig. 2.4. Catches of some pelagic fish species in the Marmara Sea (2000-2007).

Another economic impacts made by *M. leidyi* was also important. The fresh water reservoir of the Istanbul City was invaded by this species and it caused a serious economic loss due to the damage of the pipeline (Ozturk et al., 2001).

2.2.2. Sea snail, *Rapana venosa*, and its impacts on the fisheries in the Marmara Sea

Rapana venosa is a whelk shell and native to the Sea of Japan. Its possible way of introduction into the Black Sea, is by ballast water and eggs attached to ship hulls. *R.venosa* penetrated the Marmara Sea in the 1960s and later in the Aegean Sea as well (Fig. 2.5).

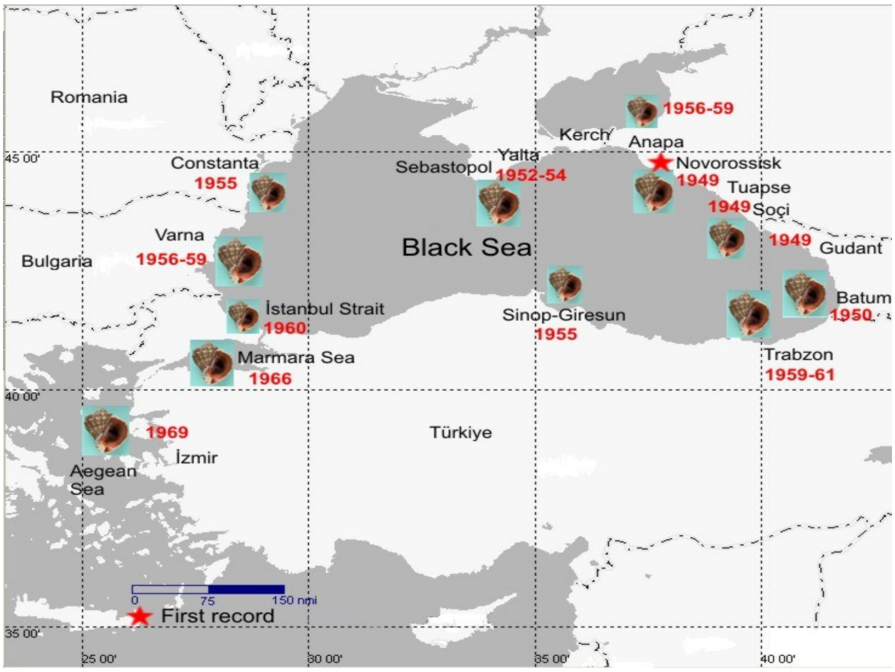

Fig. 2.5. Distribution of *Rapana venosa* in the Black, Marmara and Northern Aegean Seas.

R. venosa feeds mainly on mussels and oysters on rocky bottoms. In the Marmara Sea, it is quite abundant at 5-25 m depth (maximum density is 15-20 ind m^{-2}).Total distribution area of *R. venosa* had increased to 170 km² (Ozturk, 1999). Due to the high population density of *R.venosa* along the Marmara coasts, oysters and mussels have been exterminated from these areas where the bivalve harvesting used to be commercially important. This gastropod is harvested by diving and by dredging. The dredging method is harmful to benthic ecosystem, as it is a non-selective method, unlike diving. For the first time in 1982, this speices gained an economic importance and was exported as *Rapana* meat to Japan. Then it became beneficial to the Turkish fisheries economy; about 2 million USD profit was estimated from the export and about 600 persons were directly involved in this business (Ozturk, 2002). Annual production was 4,000 tons in 1997 (DIE, 1998). Between 1999 and 2007, a total of 1,444 tons of *Rapana* were caught in the Marmara Sea (see Fig. 2.6).

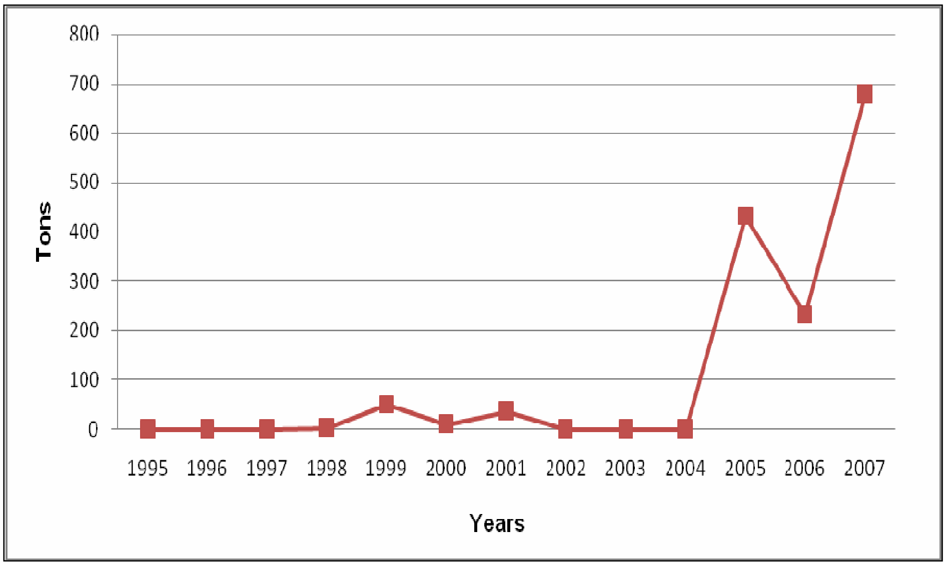

Fig. 2.6. Catch of *Rapana venosa* in the Marmara Sea from 1995 to 2007.

2.2.3. Other alien species and impacts on the fisheries in the Marmara Sea

The Indo-Pacific prawn *Marsupenaeus japonicus* (Bate, 1888) was intentionally introduced to the Marmara Sea in the late 1960s from Iskenderun Bay on the Turkish coast of the Mediterranean Sea (M. Demir, pers. comm.). However, its population did not increase as much as expected.

Another Indo-Pacific crustacean is *Erugosquilla massavensi* (Kossmann,1880), a mantis shrimp, was found in the central Marmara Sea in 2004 (Katagan et al., 2004). This is the second Indo-Pacific crustacean species reported from the Marmara Sea. Mantis shrimps do not have commercial value so far in Turkey.

An intentionally inroduced fish, haarder, *Mugil soiuy* (Basilewsky, 1855), native to the Amu Darya River basin, reached the Turkish Black Sea coast from the Sea of Azov, migrated to the west, reaching the Marmara Sea and later the coasts of the Aegean Sea. This species has potential commercial importance (Fig. 2.7). Annual catch of this species is 15 tons in the Marmara Sea and 10 tons in the northern Aegean Sea (DIE, 1998).

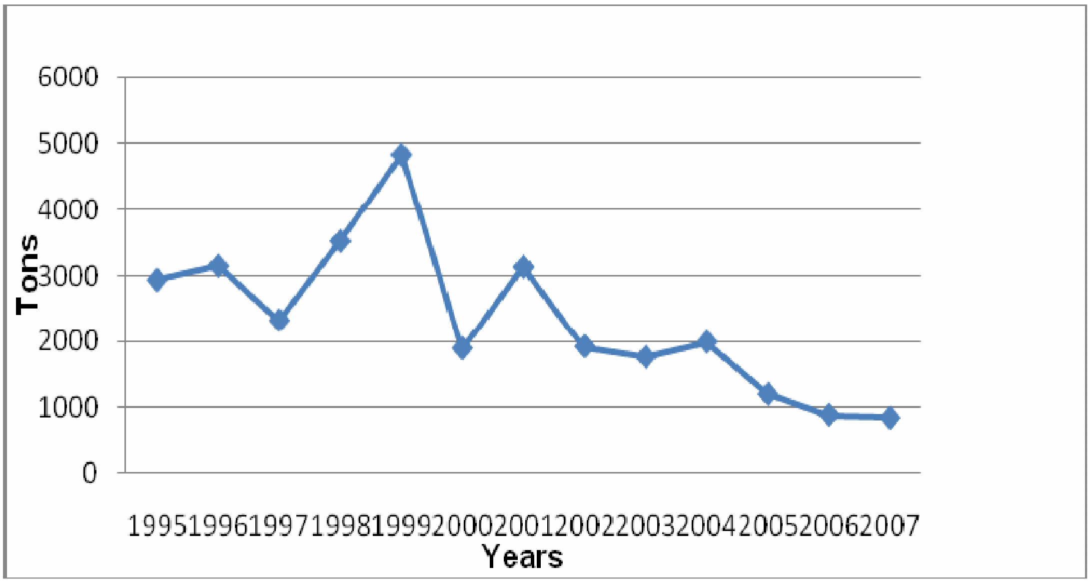

Fig 2.7. Catch of *Mugil soiuy* in the Marmara Sea (1995-2007).

The Indo-Pacific originated *Lagocephalus spadiceus* (Richardson, 1845) is one of the most abundant non-indigenous pufferfishes of the eastern Mediterranean Sea, distributing along the entire Levantine basin coasts from Port Said to the southern Aegean Sea (Golani et al., 2002). It is known to be poisonous to eat. Colonization of this species need to be monitor in term of fisheries and human health and impacts of native fish fauna in the Marmara Sea.

The bivalves *Anadara inaequivalvis* and *Mya arenaria* are also remarkable alien mollusc species in the Marmara Sea. These bivalves are found between 3-15 m depth dominantly. *M. arenaria* is preyed on by *Rapana venosa* and demersal fishes, such as turbot, goby and mullet, in the Marmara Sea. Around the Prince Islands, its average biomass was 1kg.m^{-2} in 1999. The alien starfish species *Asterias rubens* was observed in the Marmara Sea – Istanbul Strait in 1996 (Albayrak, 1996). But the interaction with mussel community seems to be slow in the Marmara Sea.

A Mediterranean originated jellyfish *Chrysaora hysoscella* (Linnaeus, 1767) were reported from the Sea of Marmara (Inanmaz et al., 2002). Blooms of this species were observed in the Marmara Sea, Istanbul Strait and the Black Sea in July 2009 (Ozturk and Topaloglu, 2009: Fig. 2.8).

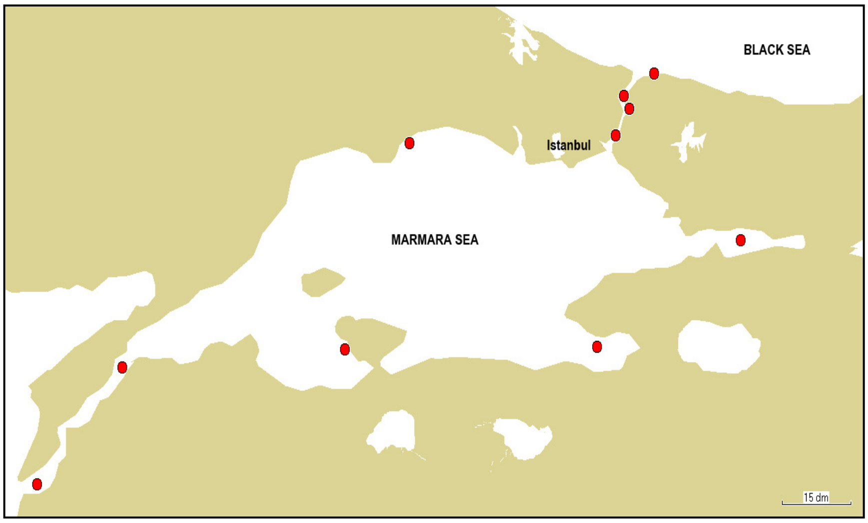

Fig. 2.8. Sightings of *Chrysaora hysoscella* in the Marmara and Black Sea in 2009 (red dots).

Due to this jellyfish blooms, beach bathers used fishng nets to protect themselves from these animals in 2009. As this species is venomous, it needs to be monitored in the Marmara Sea in terms of impacts on human health and interrelation with fishing. Sesonal blooms of *C. hysoscella* damage fishing nets, mostly purse-seines and gill nets thus affect fishing yields and cause socio-economical problems for mostly artisanal fishermen.

2.3. Conclusion and recommendations for the Marmara Sea

The Marmara Sea is a link between the Mediterranean and Black Sea, which is the reason why alien species, originally introduced to either of the two seas, are found here. However, for certain species, the Marmara Sea serves as a barrier which limits their distribution, while for others, it serves as a corridor for enlarging their distribution.

Interestingly, some alien species have turned out to be highly valuable resources, such as *Rapana venosa* and *Mugil soiuy.* On the contrary, some species, such as *Mnemiopsis leidyi*, have turned out to be extremely harmful to the native fauna and flora, creating a considerable economic loss. Rest of the species given in Table 2.1 are not of great importance in terms of fisheries. Besides, toxic phytoplankton species, such as *Alexandrium monilatum* and *Phaeocystis pouchetii,* need to be specially investigated for mussels, which may pose a risk for human health.

It is predicted that more alien species will be observed in the near future due to heavy shipping activities between the Mediterranean and Black Sea. The Istanbul Strait (Bosphorus) plays a crucial role for dispersion of marine organisms. A permanent plankton runoff from the Black Sea to the Sea of Marmara take place in the Istanbul Strait due to surface water current, and the Black Sea origin organisms are commun in the northern part of the Sea of Marmara, some of them reaching the Aegean Sea. On the other hand, the bottom Istanbul Strait current of saline water transport Mediterranean organisms to the Black Sea. Few of them can survive in low salinity water. Hence, the Black and Marmara Sea interactions should always be considered. The Marmara Sea is also a small acclimatization area for alien species. Consequently, more detailed investigations and monitoring studies are needed for the alien species and impacts to the biota and fisheries.

Total number of the alien species in the Marmara Sea is 48. Although vectors of the most species is shipping, some species were intentionally introduced in the Black Sea and subsequently settled in the Marmara Sea: *Gambusia affinis, Panaeus japonicus,* and *Mugil souiy. M. souiy* needs to be monitored due to the possibility of displacement with other native mullet species. A pufferfish species, *Lagocephalus spadicus,* and a jellyfish, *C. Hysoscella,* are poisonous and need special attention for public health, biota and impact of fisheries.

Special monitoring programs are needed for the toxic phytoplankton species, jellyfish, such as *B.ovata,* and *M. Leidyi,* due to their important impacts on the fisheries not only in the Marmara Sea but also in the Mediterranean and Black Seas.

3. STATUS OF ALIEN SPECIES IN THE MEDITERRANEAN SEA

3.1. The main characteristics of the Mediterranean Sea

The Mediterranean Sea is the largest semi-enclosed Sea (Fig. 3.1), characterized by a narrow shelf, a narrow littoral zone and a small drainage area especially in the northern part. The Sicilian Channel (150km wide, 400m. depth), separates two distinct basins, as the western and eastern, a plays a geographical and hydrographical border between them. This and others channels play a significant role in determining the oceanographic characteristics of the each regional sea, such as the Adriatic, Aegean and Levantine Sea. The size of the Mediterranean Sea from west to east from Gibraltar to Syria is about 4000km. At its greatest breath, from the coast of France to that of Algeria, the distance is 900km. The area of the Mediterranean, including all of its adjacent seas except the Black Sea, is 2,523,000 km^2 and its volume is 3,708,000 km^3, giving a mean depth of 1470 m (Miller, 1995).

Oxygen level is almost saturated in the surface layer (6 ml/l in winter and 4.8 ml/l in summer). In deep water the oxygen concentration is around 4.5 ml/l in the western and 4.2 ml/l in the eastern basin.

Fig.3.1. Mediterranean Sea

The Mediterranean Sea is an oligotrophic sea and has low phytoplankton biomass and low primary production. The Mediterranean fauna and flora have evolved over millions of years and by the mixture of temperate and subtropical elements include a large proportion (28 %) of endemic species (Fredj et al., 1992). However, in last 50 years, many alien species have been observed in the Mediterranean Sea (Fig. 3.2). Ship transportation is the main vector for the alien species in the Mediterranean Sea. Meanwhile, after the opening of the Suez Canal, some species pass to the Eastern Mediterranean Sea from the Red Sea. It is called Lessepsian migration (Por, 1978). Some commercial species have been intentionally introduced, like Japanese oyster *Crassostera gigas* or the venerid *Ruditapes philippinarum*, which have also been established in the Mediterranean Sea. Accidentally introduced *Caulerpa taxifolia* has also spread around the Mediterranean. All these alien species dispersed over the Mediterranean have changed marine biodiversity and fisheries in this unique sea.

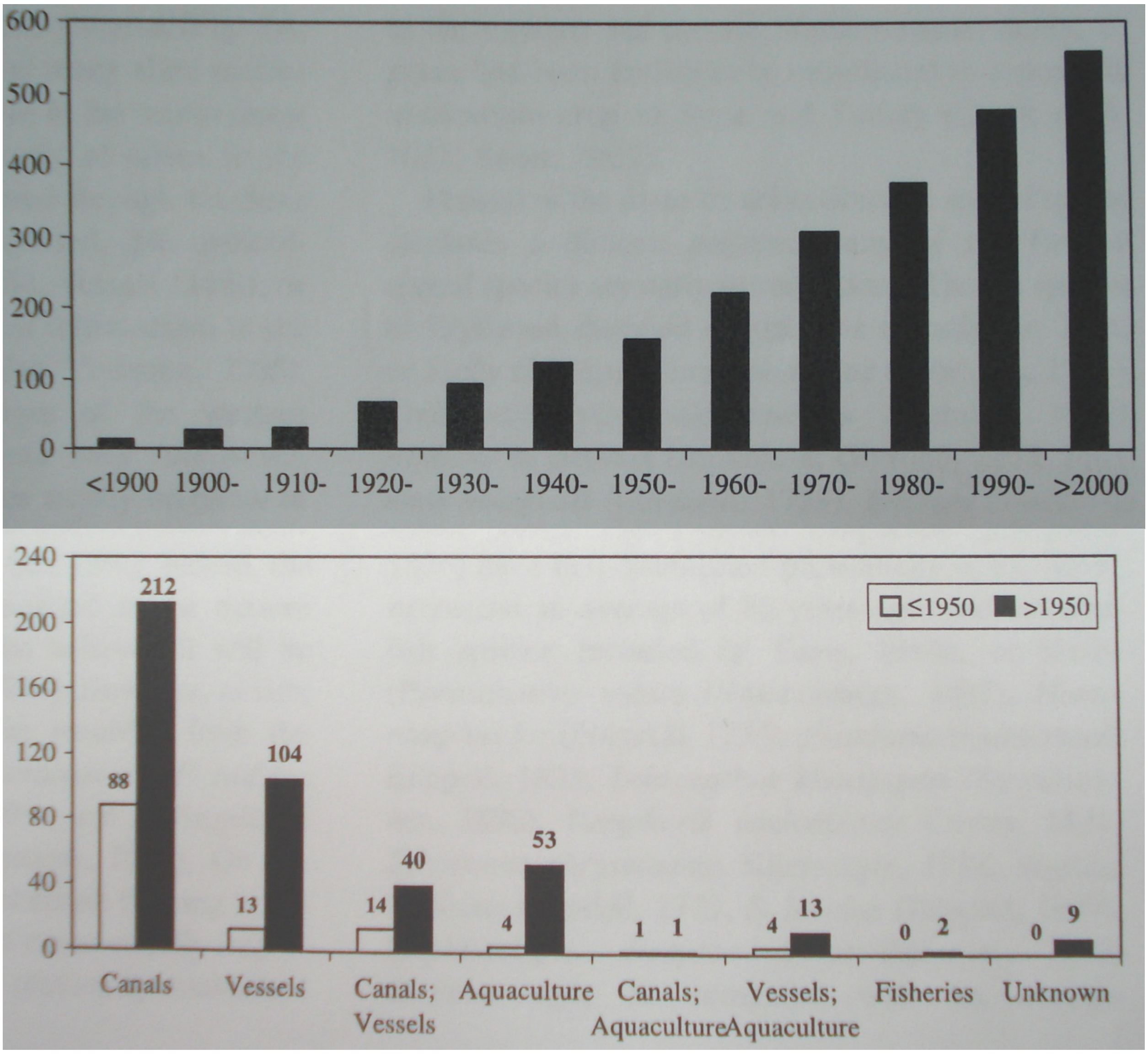

Fig. 3.2. Cummulative number of alien species recorded in the Mediterranean Sea 1900-2007 (top) and number of alien species in the Mediterranean Sea, presented by means of introduction, before and after 1950 (bottom) (Galil, 2008).

The present Mediterranean fauna and flora are mixture of the Mediterranean and Red Sea biota components due to the Suez Canal. It is possible to mention a Lessepsian Province in the eastern Mediterranean Sea after this biotic change. Nevertheless, a total 10,000 to 12,000 marine species have been recorded in the Mediterranean Sea and this rich biodiversity represents 8-9 % of the total number species in the world's seas (EEA, 2006). It should be noted that the deep sea part of the Mediterranean Sea is still poorly studied and more potential species may be discovered in the next years if the research intensity is increased in the region.

3.2. Vectors for alien species in the Mediterranean Sea

In the Mediterranean Sea aliens species can be distributed with a) shipping, ship's ballast waters, tank sediments and hull fouling, b) the Suez Canal: one of the major vectors for the Indo-Pacific originated species or Lessepsian species, c)Intentionally or unintentionally introduction by humans: this introduction is generally for aquaculture or aquarium, and d) the straits: the Turkish Straits System for the Black Sea species and the Gibraltar Strait for the Atlantic species. These straits also play an important role for the introduction of the Black Sea originated alien species, such as *Mnemiopsis leidyi* and *Rapana venosa*, and the Atlantic originated alien species, respectively.

3.2.1. Shipping

Ship-transported species spread over many parts of the world ocean. Transfer of the organisms by ships is realized in ballast water tanks, sediment tanks, or in the form of fouling or clinging. In the Mediterranean Sea shipping is the biggest factor for the introduction of alien species. It is estimated that about 22,000 vessels of more than 100 gross tons in the Mediterranean travel annually, carrying 30 % of the international cargo volume, and 20 % of the petroleum (Fig. 3.3). With some 2000 merchant ships sailing in the Mediterranean at all times, the transfer of biota stemming from the regular operation of these ships is significant. Inter Mediterranean and North/South (Black Sea -

Mediterranean Sea via Turkish Straits, Mediterranean Sea - Indian Ocean via Suez Canal) marine traffic is increasing due to the expansion of global trades.

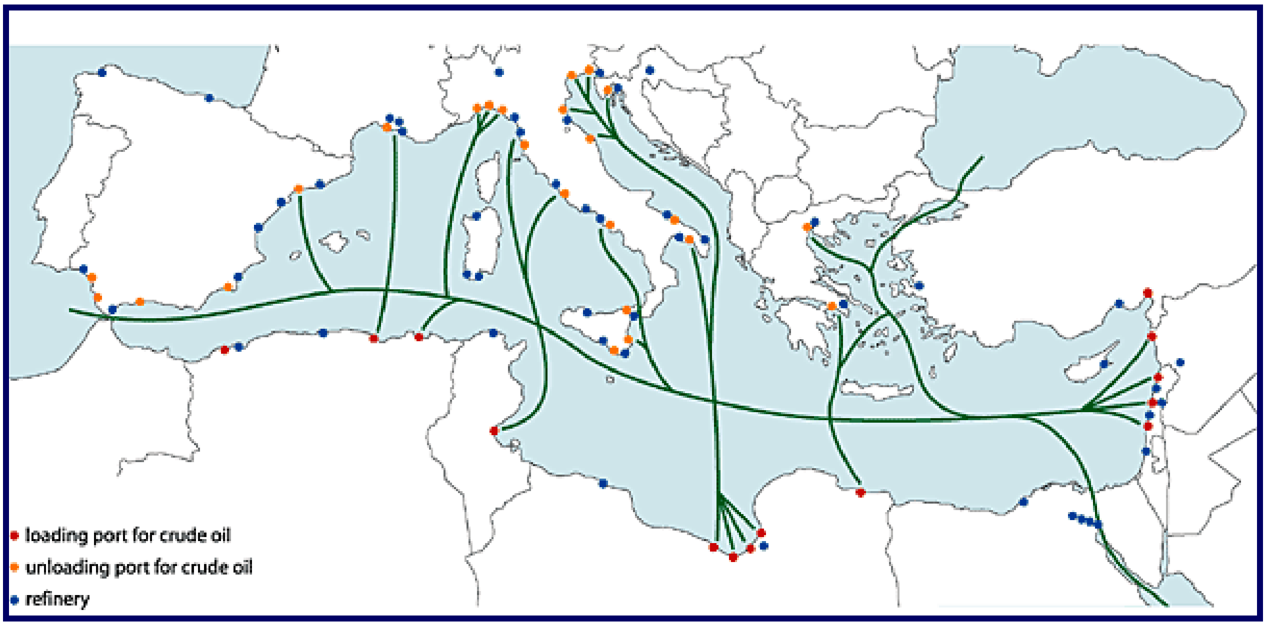

Fig 3.3. Main routes of shipping in the Mediterranean Sea

http://www.unep.org/geo/geo3/english/fig195.htm

Many alien macrophytes, invertebrates and fish are found in the coastal and marine habitats of the Mediterranean Sea. The routes of the access of alien species by ship transportation may be categorized such as transportation with ballast water, sessile (fouling) and vagile (clinging) form on ship hulls, or even drilling platforms.

Fouling seems to be more important as a vector of macrophyte introduction than ballast water. Ballast water plays a minor role as a vector for introduction of macrophytes to the Mediterranean (Bouduresque and Verlaque, 2002).

Concerning the macrophytes, 98 marine plant species have been introduced to the Mediterranean Sea: 63 Rhodophyta, 20 Phaeopyceae, 11 Chlorophyta, 3 Dinophyta and 1 Spermatophyta. Among them, 9 species are invasive and cause economical and ecological impacts. The main introduction vectors are aquaculture activities, the opening of the Suez Canal and maritime transport. Oyster transfers which is probably responsible for the introduction of 44 macrophyte species is most important in Thau Lagoon in France (Ribera, 2002; Verlaque, 2001).

Maritime transport is an essential factor for the worldwide dispersal of alien species. In the Mediterranean, 13 % of alien plant species were carried on ship's hulls and 3 % deballasting process (Siguan, 2002). Twayt and Carlton (2002) reported 7 phytoplankton species introduced to the European coastal waters with ballast water, oysters or multiplee as possible vectors. These species are *Thalasiosira punctigera, Thalassiosira tealata, Odontella sinensis, Pleurosigma simonsenii, Coscinodiscus wailesii, Karenia mikimotoi* and *Alexandrum catenella*. Some ship-transported species gain economic importance like swimming (blue) crab *Callinectes sapidus*. Besides, some species like serpulid worms cause nuisance in ports and marinas. *Halophila stipulacea* is the only succesful colonizer among sea grasses in the eastern Mediterranean Sea.

3.2.2. The Suez Canal

The Suez Canal was opened in 1869 in order to shorten the trade route between the Mediterranean and Indian Ocean. The Red Sea and the Mediterranean removed a geographic barrier between them, then the migration began from the Red Sea to the Mediterranean (Golani, 1998).

Many Indo-Pacific origin species have penetrated to the Mediterranean. As a result, various changes have occurred in the biota of the Mediterranean.

Migrating species from the Red Sea to the Mediterranean are called 'Lessepsian species' by Dov Por (1978) after Ferdinand de Lesseps, (1805–1894) who was a FRENCH engineer in charge of the construction of the SUEZ CANAL, which joined the Mediterranean and Red Seas for the first time in 1869, and substantially reduced sailing distances and times between the West and the East. Lessepsian migration (also called Erythrean migration) is the ongoing migration of marine species through the SUEZ CANAL, usually from the RED SEA to the MEDITERRANEAN SEA, more rarely in the opposite direction. On a wider context, the term "Lessepsian migration" is used to describe any animal migration over man-made structures, i.e. that which would not have occurred had it not been for the presence of an artificial structure, the Suez Canal.

The opening of the Suez Canal in 1869 created the first salt-water passage between the Mediterranean and Red Seas. The Red Sea is higher than the Eastern Mediterranean, so the canal serves as a TIDAL STRAIT that pours the Red Sea water into the Mediterranean. The BITTER LAKES, which are hypersaline natural lakes that form part of the canal, blocked the migration of Red Sea species into the Mediterranean for many decades, but as the salinity of the lakes gradually equalized with that of the Red Sea, the barrier to migration was removed, and plants and animals from the Red Sea have begun to colonize the eastern Mediterranean.

The Red Sea is generally saltier and more nutrient-poor than the Atlantic, so the Red Sea species have advantages over the Atlantic species in the less salty and nutrient-rich Levant Basin. Accordingly, most invasions are of Red Sea species into the Mediterranean, and only few in the opposite way (Ben-tuvia, 1966; Avşar, 1999). With higher salinity, temperature and as an oligotrophic sea, the Levant Basin has poor species diversity compared to other parts of the Mediterranean Sea.

The construction of the ASWAN HIGH DAM across the NILE RIVER in the 1960s reduced the inflow of freshwater and nutrient-rich silt from the Nile into the eastern Mediterranean, making conditions there even more like the Red Sea, thus increasing the impact of the invasions and facilitating the occurrence of new ones.

Through the Suez Canal, several marine species migrate to the Mediterranean Sea such as marine phanerograms, coelenterates, molluscs, crustaceans and echinoderms as well. Rate of this migration is growing and the eastern Mediterranean may be called as “Lessepsian Province” in terms of biodiversity or due to various Red Sea originated species: a new geographic region have appeared.

In the last decade, this migration is followed by several scientific institutions, regional and international organizations, such as CIESM, RAC/SPA, IUCN, GFCM and European Union. Most of the researches have been carried out on fish species because fish has much more economic value than other species. Other species need to be deeply investigated.

The colonization of the Mediterranean Sea by Red Sea marine species has been reviewed by several authors, such as Ben-Tuvia (1978) who listed 36 Red Sea immigrants. Interestingly in that time, Red

Sea immigrants constitute 12% of the population in the Levant Basin and 7 % for the Mediterranean as a whole, but only 1% of the population in the central part of the sea. None of the Red Sea immigrants had reached the western basin. Por (1978, 1990) reported that, as far as the fauna was concerned, Lessepsian alien species represented about 4 % of the Mediterranean specific diversity and 10% of the Levantine Basin. These percentages, however, have changed in the last ten years. Galil (2008) reported that of the 124 alien species known in 1950, 82% entered the Mediterranean through the Suez Canal, 10 % were vessel-transported and 4% were mariculture introduction (see Fig 3.2). Another important issue is that some Lessepsian species migrate not only to the Levantine Basin, but also to the central Mediterranean Sea, even up to the Black Sea.

Golani (1996) reported that 59 Lessepsian fish species comprise 14% of the ichthyofauna of the eastern Mediterranean, the east of the line connecting from Antalya to Port Said. These species represent 42 families, of which 15 families were not present in the Mediterranean prior to the Lessepsian migration. Golani (2002) also pointed out that 38 Lessepsian fish species established sustainable populations in the eastern Mediterranean, with an evident of a significant impact on the local ecosystem Later, Golani (2006) reported 65 Lessepsian fish migrants from the eastern Mediterranean Sea.

Zenetos et al. (2003) reported a total 126 Indo-Pacific origin mollusc species in the "CIESM atlas of exotic species in the Mediterranean". This number is increasing in recent years with parallel to research intensity in the region.

The number of Lessepsian alien mollusc species also has been growing. Ozturk (2006) reported 120 mollusc species from Turkey only. Cevik et al. (2001) reported *Crasostre gigas* and *Saccostrea commercialis* from Iskenderun Bay which are alien commercial and edible species. Another commercial mollusc species, *Strombus persicus* is also reported from Turkish waters. Ozgur and Ozturk (2007) stated that in rocky reefs in Oludeniz/Fethiye this species is found in dense colonies. *Tapes philippinarium* has reached the Adriatic Sea and is now a commercially exploitable species.

About 400 alien mollusc species and 29 alien opisthobranch species are reported in the Mediterranean Sea by Zenetos et al. (2006) and Zenetos et al. (2008) and the main vector was given as shipping. Çevik et al. (2006) reported 16 alien ophisthobranches from the Turkish coastline. A list of total 135 alien mollusc species is given in Appendix 2, using various sources such as scientific papers, articles and www.ciesm.org. Among the Turkish coasts, the highest number of alien species is known from the Levantine coast. Among 277 alien species reported from the Turkish coasts (of which 90 are molluscs), 216 were alien species (84 are molluscs) occurred in the Levantine Sea (Cinar et al., 2005). Some of the alien species may thrive in their new environment by displacing the native fauna species. The number of the alien species into the Mediterranean will probably increase in the future and parallel to the species richness increasing, the gene pool of the recipient regions will also change.

Alien crustacean species in the Mediterranean Sea have been also reported by several experts, such as Galil (1992), Kocatas and Katagan (1994), Yokes and Galil (2006), Pancucci-Papadopulous and Naletaki (2007). Galil (1992) reported that 20 % of the decapod fauna in the Levant Basin migrated through the Suez Canal. Kocatas and Katagan (1994) reported 20 Lessepsian alien species recorded from the Turkish coasts. Galil et al. (2002) reported 27 Indo-Pacific and Red Sea decapods along the Turkish Mediterranean coasts. Cinar et al. (2005) reported 45 alien species. A compiled table is prepared according to various sources, including CIESM atlas of exotic crustacean species (Appendix 3).

3.3. Lessepsian migration and species

3.3.1. Lessepsian fish species

The first Lessepsian fish species was *Atherinomorus lacunosus,* 33 years after the opening of the Suez Canal (Ben-tuvia, 1985). Nowadays, Eastern Mediterranean ichthyo-fauna includes approximately 15% Lessepsian species (Golani, 1996; Mavruk and Avsar, 2008). Before the opening of the Suez Canal, there were not enough data about the Mediterranean Sea, thus comparison cannot be made. Lessepsian fish species have extended their distribution up to France (Daniel et al., 2009), Tyrrhenian Sea (Psomadakis et al., 2009), Tunisia (Ktari and Ktari, 1974; Ben Soussi et al., 2004) and Adriatic Sea (Dulcic and Azarro, 2004).

Dispersion of the Lessepsian fish in the Mediterranean Sea depends on several factors such as cyclonic Mediterranean shore currents to the Levantine Sea, similar temperature conditions. Most of the successful species are euryterm and euryhaline species and they can adapt to other ecological conditions such as feeding and habitat type (Mavruk and Avsar, 2008). Gucu and Gucu (2002) reported that low native species diversity were effecting the rate and the success of immigrant colonization. Furthermore, absence of *Posidonia oceanica* meadows was found to be another important factor, effecting the success of Lessepsain invasion. The endemic seagrass that is the key species of the Mediterranean coastal ecosystem was found responsible for defending the Levant Sea's ecological integrity and its native characteristics against invasion. Its absence resulted in successful invasion of Lessepsian species.

In Appendix 4, a total of 73 Lessepsian alien species are listed according to various sources including www.ciesm.org and www.fishbase.org.

Lessepsian fishes are also utilized for several purposes like aquaculture, aquarium, game fish and as bait in the fishing industry (see Table 3.1).

Table 3.1. Lessepsian fish species used for various purposes.

Species name	Fisheries*	Aquaculture	Aquarium	Game fish	Bait fish
Abudefduf vaigensis (Quoy and Gaimard, 1825)	x		x	x	
Crenidens crenidens (Forsskal,1775)	xxx				x
Decapterus russelli (Rüppell, 1830)	xxxx				x
Dussumieria elopsoides Bleeker, 1849	xx				
Epinephelus coioides (Hamilton, 1822)	xxx	x			
Epinephelus malabaricus (Bloch and Schneider, 1801)	xxxx	x		x	
Etrumeus teres (Dekay, 1842)	xxxx				
Fistularia commersonii Rüppell, 1835	xx		x		
Hemiramphus far (Forsskal,1775)	xxx			x	x
Herklotsichthys punctatus (Rüppell, 1837)	xx				
Heniochus intermedius Steindachner, 1893			x		

Himantura uarnak (Forsskal,1775)	xxx			x	
Hippocampus fuscus Rüppell, 1838	xx				
Iniistius pavo (Valenciennes, 1840)	xxx		x	x	
Lagocephalus sceleratus (Gmelin, 1789)			x		
Liza carinata (Valenciennes, 1836)	xxx				
Lutjanus argentimaculatus(Forsskal,1775)	xxx	x		x	
Mugil soiuy Basilewsky, 1855	xxxx	x			
Muraenesox cinereus (Forsskal,1775)	xxxx	x		x	x
Nemipterus japonicus (Bloch, 1791) 47	xxx				
Nemipterus randalli Russell, 1986	xx				
Oxyurichthys petersi (Klunzinger, 1871)			x		
Platax teira (Forsskål, 1775)			x	x	
Papilloculipes longiceps (Ehrenberg in Valenciennes, 1829)	x				
Parexocoetus mento (Valenciennes, 1846)	xx				
Pelates quadrilineatus (Bloch, 1790)	xx				
Platax teira (Forsskål, 1775)	xx				
Platycephalus indicus (Linnaeus, 1758)	xxx	x		x	
Plotosus lineatus (Thunberg, 1787)	xxx		x		
Pomadasys stridens (Forsskal,1775)	xxx				
Pteragogus pelycus Randall, 1981			x		
Pterois miles (Bennet, 1803)			x		
Rastrelliger kanagurta (Cuvier, 1816)	xxxx			x	x
Rhabdosargus haffara (Forsskal,1775)	xxx				
Sargocentron praslin (Lacepède, 1802)	xx				
Sargocentron rubrum (Forsskal,1775)	xx		x		
Saurida undosquamis (Richardson, 1848)	xx				

Scarus ghobban Forsskål, 1775	xxx		x		
Scomberomorus commerson (Lacapede, 1800)	xxxx			x	
Scorpaenopsis ramaraoi Randall & Eschmeyer, 2001	xxxx				
Siganus luridus (Rüppell, 1828)	xx				
*Siganus rivulatus*Forsskal,1775	xx	x			
Sillago sihama (Forsskal,1775)	xxx	x			
Silhouetta aegyptia (Chabanaud, 1933)			x		
Sphyraena chrysotaenia Klunzinger, 1884	xx				
Sphyraena flavicauda Rüppell, 1838	xxx				
Sphyraena obtusata Cuvier, 1829	xxx			x	
Sphyraena pinguis Günther, 1874	xxxx				
Spratelloides delicatulus (Bennett, 1831)	xx				x
Stephanolepis diaspros Frase- Brunner,1940	xx				
Terapon puta (Cuvier, 1892)	xx				
Tetrosomus gibbosus (Linnaeus, 1758)	xx		x		
Tylosurus choram (Rüppell, 1837)	xxx				
Upeneus moluccensis (Bleeker, 1855)	xxx				
Upeneus pori Ben-Tuvia and Golani, 1989	xxx				

Fisheries*: x subsistence, xx minor commercial, xxx commercial, xxxx highly commercial

3.3.2. Evaluation of the catch of Lessepsian fish

Many alien fish species are fished for the economical purpose in the Eastern Mediterranean Sea (Table 3.1). However, there is no available accurate data for most of the species from riparian countries. It should be noted that Lessepsian fishes are not only demersal fish anymore, but they include pelagic fishes as well in the eastern Mediterranean Sea (see Turkey below).

Egypt

Not much data are provided for the Egyptian fisheries concerning Lessepsian fish species. Rabbitfishes acquired economic importance in the Egyptian coasts (Hamza et al., 2000).

Greece

Papaconstantinou (1990) reported that at least 11 species have reached the Aegean Islands and *Sargocentrom rubrum, Siganus rivulatus, Siganus luridus, Lagocephalus spadiceus, Stephanolepis diaspros, Upeneus mollucensis, Leiognathus klunzingeri, Saurida undosquamis, Pemperis vanicolensis, Hemiramphus far* and *Parexocoetus mento* were fished in Greece. Corsini-Foka and Kalogirou (2008) reported that *Scomberomorus commerson* was found for the first time around the Rhodes Island.

Israel

The most comprehensive catch records have been made for the Israeli fishery and the catch of the Erythrean (Lessepsian) species has been almost a third of the total landings since 1954 (Galil, 1993). Nearly half of the trawl catches along the Israeli coast consists of Lessepsian fish (Golani and Ben Tuvia, 1995). The lizard fish, *Saurida undosquamis* was the first caught in Israel in 1952; only three years later 266 tons was landed by local trawlers, constituting almost 20% of the total trawler catch (Ben-Yami and Glaser, 1974). The dominant fishes in the inshore fisheries (trammel-netting and hook-and-lining) are the rabbit fish *Siganus rivulatus* and *S. luridus,* the obtuse barracuda *Sphyraena chrysotaenia*, and the Erythrean jack, *Alepes djedaba*. The above species, together with *Sillago sihama* and *Scomeromorus commerson*, two species that underwent population explosion in the early 1980s, are common in purse-seine landings.

The annual catch of the lizardfish which reached 400 tons in 1960 soon after its arrival declined to 100 tons in the mid 1960s, but has since increased, and catch fluctuations are correlated with CPUE. Catch statistics for mullids do not distinguish between the natives, *Mullus barbatus* and *M. surmuletus* and the alien fish *Upeneus moluccensis* and *U. pori*, but a study of the frequency of the latter in trawl catches conducted in the mid 1980s showed they formed 87 % of the mullid catch off the coast of Israel at depths of 20 m, and 50 % at 55 m, whereas the native mullids are more abundant in deeper waters (Golani and Ben Tuvia, 1995). The percentage of the Erythrean mullids in the total mullid catch has been increasing steadily, from 30 % in 1980, 42 % in 1984, to 47 % in 1989 (Golani and Ben Tuvia, 1995). Similarly, the catch statistics of sphyraenids do not separate the Red Sea obtuse barracuda from native Mediterranean species *S. sphyraena* and *S viridensis*. However, the examination of the landed catch showed that the Lessepsian barracuda had outnumbered the native sphyraenids in inshore trawl and purse-seine catches (Grofit, 1987). Golani (2006) reported the Indian shad, *Decapterus russelii,* from the Israeli coast. If this fish successfully colonize, it may become one of the commercial fish species in the region. Israeli fisheries statistics since the mid 1980s underscores the growing prominence of the Lessepsian fish species.

Lebanon

In southern Lebanon, Lessepsian fish species constituted 37 % in the weight of the total landings of the artisanal fishery (Carpentieri et al.,2008). In Lebanon, Spanish mackerel *S. commerson* has become abundant in recent years and this species is exploited by large mesh size gillnet. Among crustaceans *Marsupenaeus japonicus* is also commercially exploited (Carpentieri et al., 2008). Several alien fishes have now become common in the local landing and markets, characterizing the fish community of the southern Lebanon coasts as a mixed Mediterranean-Red Sea composition and even export to the gulf countries.

Libya

Shakman and Kinzelbach (2007) mentioned that six species (37.5 % of all Lessepsian species) have become commercially valuable in the Libyan coasts. These species are now found regularly in the Libyan catch. Ten species (62.5 %), however, are characterized as having no commercial value.

Syria

Saad (2005) recorded 37 Lessepsian fish species from Syria which represents 16.5% of the total number of bony fish species recorded in the Syrian marine water. However, no commercial catch data from Syria has been reported for the alien fish species. In Lattikia harbour, some alien fish species, such as *U. mullucensis* and *U .pori,* were sold in 2007 and 2008 (unpublished data, B. Ozturk).

Turkey

Can and Demirci (2003) reported that the lizard fish *Saurida* spp. have provided approximately 50% of the total economic catch in Iskenderun Bay. Gucu and Bingel (1994) summarized that there is no specific catch statistics to evaluate the contribution of the Red Sea species in the total landing. However, their importance in the total demersal fish biomass as 62% in the Gulf of Iskenderun, 34%

in Mersin Bay and 27% in the coastal strip between Incekum and Anamur. Cicek and Avsar (2003) reported that 17 species were Lessepsian among 90 fish species collected by trawl samplings during 2002-2003 in the Northeastern Mediterranean Sea. They found that Catch Per Unit Effort (CPUE) for Lessepsian fishes ranged from 3.39 kg/h in November to 11.73 kg/h in September 2002, and its mean value was calculated as 5.28 ± 3.32 kg/h, most of the Lessepsian biomass was obtained the near shore, which is located in 0-20 m depth ranges, the number of Lessepsian fish species constituted 18.9% in total fish species, while 26.66 % of total biomass was shared by Lessepsian fishes. Among them the most abundant Lessepsian fish was S.*undosquamis* with the value of 47.16%, followed by *Upeneus pori* (29.92 %), and *Leiognathus kluzengeri* (13.25 %). Basusta et al. (1997) found 22 Indo-Pacific origin fish in Iskenderun Bay, which is one of the important fishing grounds for Turkey in the eastern Mediterranean Sea. Ismen (2006) stated that in the eastern Mediterranean, 98% of the total biomass of *U. pori* were trawled from less than 50 m deep water and its market increased during the recent years.

Lessepsian fishes are not only demersal fish anymore, but they include pelagic fishes as well in the eastern Mediterranean Sea. Yilmaz and Hossucu (2003) reported that round herring, *Etrumeus teres,* has been caught in Antalya Bay with 360 tons, according to the unofficial fish market record in Turkey.

Beside the above mentioned countries, in Tunisia, Italy and Croatia, some Lessepsian fish species are found but caught only as by-catch and have no market value.

Marttin et al. (2006) largely examined the fisheries sector in the eastern Mediterranean under the Medfisis Project and found that abundance of some native species has declined and there has been an increased abundance of Lessepsian species. Competition within the same ecological niche and direct interference are among the possible explanations for the successful colonization (Golen and Galil, 2005). It has been reported that the increasing exploitation of non-native species caused a shift of the trawl fishing ground towards shallower waters where their biomass density is highest (i.e. at bottom depth up to 50 m), and a consequent increase of the ratio of non native to native species in Levantine trawl landings (Pisanti and Grofit, 1991). Marttin et al. (2006) listed the species successfully established and commercially important in Levantine fisheries according to the CIESM atlas (2005). In 2005, seven fish and three crustacean species were reported as commercially exploitable alien species from the Eastern Mediterranean Sea.

A success story of a Lessepsian fish: the narrow-barred Spanish mackerel, *Scomberomorus commerson* (Lacepede, 1800)

Among the alien fish species, the narrow-barred Spanish mackerel, *Scomberomorus commerson* (Lacepede, 1800) is an epipelagic, neritic species, known to undertake lengthy coastal migrations (Collette and Nauen, 1983). This species entered the Mediterranean where it was recorded in Palestine in 1935 (Hornell, 1935). In the following years the species was in Lebanon (George and Athanassiou, 1965), Turkey (since 1981, in Gucu et al., 1994), Egypt (El Tayep, 1994) and Aegean Sea (Buhan et al., 1997; Golani et al., 2002). At present, fishery statistics show commercial quantities in Israel, Lebanon, Egypt and Algeria, commercial quantities are reported also for the Libyan Arab Jamahiriya (Shakman and Kinzelbach, 2007); a few specimens have been also recorded in Sicily. The maximum length in the Mediterranean was recorded in Turkish waters: 113 cm FL.

The only information existing in the Mediterranean was reported by Ogretmen et al. (2005) in the Turkish waters. According to this information, the minimum, maximum and mean values of TL and TW were 520 mm, 870 mm, 618 mm, and 1 050 g, 3 300 g, 1 553 g, respectively in Gulluk Bay and Gokova Bay (South Aegean Sea) in November and December, 1994. One large specimen, with a FL of 113 cm, was collected in Gulluk Bay.

Among all Mediterranean countries, only three countries declared the catch of this species (Algeria, Egypt, and Israel; Fig. 3.4). The largest catch have been declared by Algeria (499 tons) followed by Egypt with (309 tons). Israel has not declared any catch since 1992. Biggest catch was from Egypt in recent years. New, unpublished information from Lebanon gives a rough estimate on the catch of this species, as about 30 tons in 2007 (Di Natale et al., 2009).

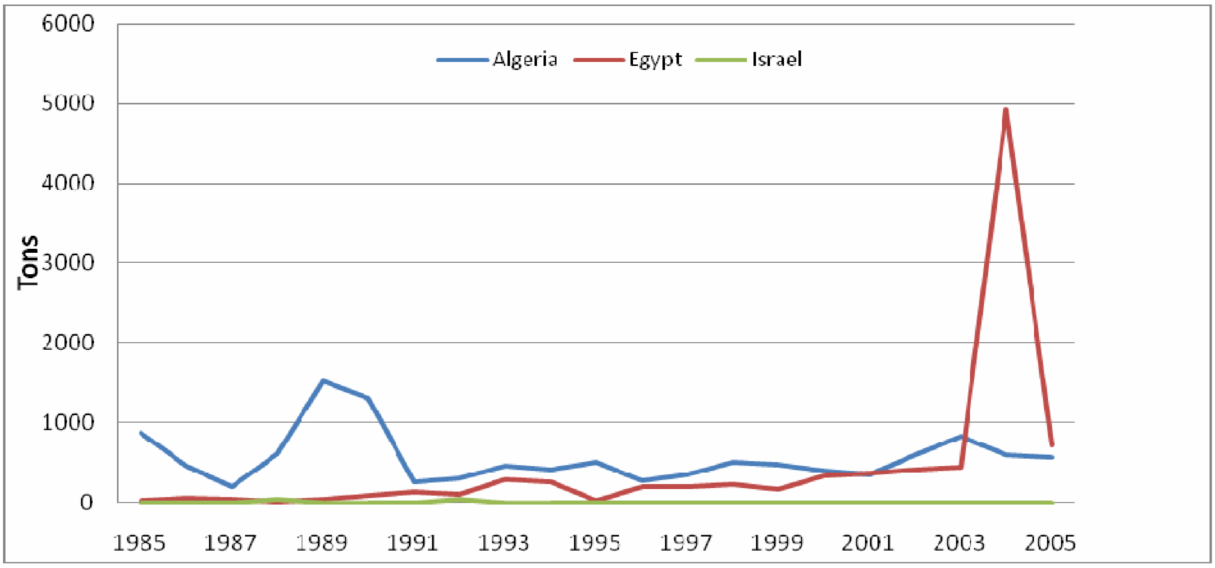

Fig. 3.4. Catch of the narrow-barred Spanish mackerel from 1985 to 2005

(Algeria, Egypt, and Israel).

3.3.3. Evaluation of the catch of Lessepsian crustaceans

Geldiay and Kocatas (1972) reported that in Iskenderun Bay *Penaeus kerathurus* was substantially caught by fisherman but it replaced by *M japonicus.* Similarly the blue crab is common in Turkey, Greece, Syria, Lebanon, Israel and Egypt. In Turkey, it was caught at 22 tons in 2007 and 17 tons in 2008 between Antalya to Iskenderun Gulf. Off the southeastern coast of Turkey, the alien shrimps *M. japonicus* and *Penaeus semisulcatus* are the most important species in the landings (Duruer et al., 2008). Lessepsian penaeid shrimps make up most of the shrimp catches along the southeastern Levantine coasts. The Lessepsian shrimps, in particular *M. japonicus* (Bate, 1888), *Metapenaeus monoceros* (Fabricius, 1798) and *Penaeus semisulcatus* de Haan, 1844, are highly prized (Galil, 2008)

Chaouachi et al. (1998) found out that *Metapenaeus monoceros* has rapid expansion and may be threat for *Metapenaeus kerathurus* fisheries in the Gulf of Gabes in Tunisia.

The crab, *Portunus pelagicus,* and shrimps *Penaeus japonicus, P. monoceros* have been caught commercially for many years in Egypt. Facia et al. (2009) reported that a single individual of red king crab, *Paralithodes camtschaticus,* a boreal species was found in the Ionian Sea and the most likely way of introduction was ballast water. This species also has a commercial potential in the future.

Commercialized alien crustaceans species are listed in Table 3.2. A total 6 species are sold in the markets.

Table 3.2. Commercialized alien crustacean species in the Mediterranean Sea.

Species name	Country	Catch amount	Statistics available
Calinectes sapidus	Turkey, Greece, Lebanon, Israel,	17,000 ton (Turkey)	Yes

	Syria, Egypt		
Portunus pelagicus	Egypt, Lebanon		No
Marsupenaeus japonicus	Egypt, Israel, Lebanon		No
Trachysalambria palaesinensis	Lebanon		No
Trachypenaeus curvirostris	Lebanon		No
Metapaneus monocerus	Egypt, Israel		No

Beside crustaceans, the conch, *Strombus persicus* Swainson, 1821, is served in seafood restaurants in Israil and Greece.

4. HARMFUL ALIEN SPECIES AND IMPACTS

4.1. Venomous alien fish species

The issue concerning the venomous fish species is one of the important matters and needs to be deeply investigated in many aspects such as public health and damage to fishermen. Venomous alien fish species are known from the eastern Mediterranean countries, such as Greece (Kasapidis et al., 2007), Israel (Golani, 1996), Syria (Saad, 2005), and Turkey (Akyol et al, 2005; Bilecenoglu et al., 2006). Four tetraodontid species (pufferfish), namely *Lagocephalus sceleratus* (Gmelin, 1789), *Lagocephalus spadiceus* (Linnaeus, 1758), *Lagocephalus suezensis* Clark and Gohar, 1953, *Torquigener flavimaculosus* Hardyand Randall, 1983, invaded the Mediterranean Sea and even up to the Marmara Sea and are causing severe problems for local people due to poison in the internal organs and meat. Besides, they cut hooks of longlines and bite off the captured fish in the nets, which cause economical damage for fishermen. For venomous fish species, public awareness campaigns by posters or leaflets have been started in some countries, such as Turkey, Greece and Israel.

4.2. Harmful alien jellyfish and its impacts

In recent years, more alien jellyfish species has been observed in several coasts of the Mediterranean Sea. Jellyfish extention caused severe anxiety among fishermen and tourists in many countries. Even some of the jellyfish species are not harmul and native to the Mediterranean Sea, their distribution has been enlarged. For examle, *Cassiopeda hysoscella* has never made big blooms in the northern Aegean but in recent years the situation has changed. Some of the alien combjelly like *M. leidyi* also spread to the Northern Aegean Sea (Isinibilir and Tarkan, 2002), further to the Adriatic Sea and up to the Sicily Island (Faris, 2009).

Jellyfish of Indo-Pacific origin like *Rhopilema nomadica* and *Cassiopede andromeda* established in the eastern Mediterranean Sea and cause damage to local economies to some extent when entangled in the fishing nets or stranded on the beach, frightening visitors.

Upside-down jellyfish *Cassiope andromeda,* is frequently encountered in the eastern Mediterranean Sea. (Bilecenoglu, 2002). Ozgur and Ozturk (2008) reported that the distribution of these stinging species extended from south to further north.

4.3. Impacts on fisheries

Mostly in the eastern Mediterranean Sea, several alien species cause damage for fisheries. *Caulerpa. taxofilia* cause considerable fouling on fishing nets. *Calinectes sapidus* also damages net with entangling and cutting, pufferfishes cut longlines, etc. *Synaptula reciprocans* is found in all detritic bottom, mostly around polluted fish cages in the Aegean Sea and feeds on some baits, detritus or organic particles. This species extent it ranges to the Northern Aegean Sea. Table 4.1 summarizes the harmful effects on the fishing nets mostly in the eastern Mediterranean Sea.

Table 4.1. Harmful effects (Net damages, mesh clogging, fouling, extra labour) of the alien species on fishing gears in the Mediterranean Sea.)

	Long lining	**Beach net**	**Gill net**	**Trawlin g**	**Purse seining**	**Fish farming cages**	**Buoys**

Caulerpa taxifolia	-	+	+	-	-	-	-
Macrorhynchia philippina	-	+	+	-	-	-	+
Ropilema nomadica	-	+	+	+	+	+	-
Diadora setosum	-	+	-	-	-	-	-
Callinectes sapidus	+	+	+	-	-	-	-
Synaptula resiprocens	-	+	+	-	-	-	-
Pufferfish species	+	+	+	-	-	-	-
Serpulids polycaetes	-	-	-	-	-	+	+

The large jellyfish, *Rhopilema nomadica,* developed excessively on the shores of Israel and blocked gill-netting for several weeks (Spanier and Galil, 1991).

Kideys and Gucu (1995) reported that the proliferation of *R. nomadica* off the eastern Mediterranean coast of Turkey has a potential risk to human health, tourism and fisheries. During August 1995, many swimmers were stung and sought medical treatment. Local fishermen claimed that the catch from the gill net fisheries decreased and that the jellyfish entangled in their nets were a major nuisance. In Iskenderun, due to mass jellyfish blooms, fish farmers could not lift their nets to the surface when they want to take fish from the cages. *R. nomadica* do not move actively, thus penetrates the Levant Sea with current system. Firstly they reached Lebanon and Syria, then Turkish eastern Mediterranean coasts (Avsar, 1999).

4.4. Impacts on tourism, human health and other socio-economic activities

Alien jellyfish species also a threat for the tourism and some hospitalized events occurred in the eastern Mediterranean Sea countries. Jellyfish can be dangerous for people in case of allergic impacts are made. The most important factor is the amount of the poison put into blood. Death rarely occurs, but other effects are seen on all people. These can be itching, severe poisoning, muscle cramps, abdominal rigidity, decrease in touch sensation, nausea, vomiting, serious back pain, speech difficulties, involuntary muscle contractions, and breathing difficulty. Certainly venomous jellyfish makes negative impacts on tourism (Spanier and Galil, 1991). Table 4.2 summarizes the impacts of the alien species to the tourism and human health.

Table 4.2. Harmful alien species and impacts on tourism and human health in the Mediterranean Sea.

Alien species	**Target groups**	**Results**
R. nomadica, C.andromeda	Tourists, fishermen, divers, sailors, yatchman	Injury, hospitalized
Macrorhynchia phillipina	Tourists, divers, fishermen	Injury, hospitalized
Diadoma setosum	Tourists, divers, fishermen	Injury
Lagocephalus spp.	Anybody	Hospitalized
Torquigener flavimaculosus	Anybody	Hospitalized

White stinger, Hydrozoa, Cnidaria, *Macrorhynchia philippina* (Kirchenpauer, 1872) is a common circumtropical species (Watson, 2002) and a Lessepsian migrant found along the coast of Lebanon in 0-40 depths (Bitar and Bitar-Kouli 1995, Zibrowius and Bitar 2003) and abundant near Mersin and Iskenderun. Colonies of 10-15 cm height were frequently found at 1- 2 m depth, on rocks. They are distributed in Turkey, Cyprus, Syria, Lebanon and Israel. Dense populations of this species in shallow waters may pose a risk for tourism, as it causes a painful, itching sting (Cinar et al, 2005). White stinger is harmful for the skin divers and sponge divers.

Alien echinoderm species needle-spined urchin *Diadema setosum* (Leske, 1778) poses a threat for humans due to its spines. This species is found in shallow waters. Another Indo-Pacific alien echinoderm, a holothuroid, *Synaptula reciprocans* (Forskal,1775) was reported in several regions, such as in the Turkish coast of the Meditrranean and Aegean Sea in Ayvalik, Greece coasts, Israel, Cyprus, Lebanon and Syria (Galil, 2006; Yokes and Galil, 2006; Antoniadou and Vafidis, 2009**).**

Finally, there are economical damages to the societies made by alien species, i.e. clogging the waters pipes in Turkey. Galil (2008) mentioned that jellyfish-blocked water intake pipes poses a threat to the cooling systems of port-bound vessels and coastal power plants: In summer 2001, Israel Electric removed tons of jellyfish from its seawater intake pipes at its two largest power plants, at the estimated costs of USD 50,000.

4.5. Impacts on the biodiversity

Besides the harmful effects of alien species on human activities mentioned above, the most important impact made by alien species is on the local or native biodiversity. In recent year *Rhizostoma pulma* has been replaced with *Rhopilema nomadica* in the eastern Mediterranean Sea (Boudouresque, 1999). Galil et al. (2009) mentioned that *Phyllorhiza punctata* reappeared in the Israel coast. *M. leidyi* is reported in several parts of the Mediterranean Sea from Turkey to France (Uysal and Mutlu 1993; Kideys and Niermann, 1994; Shiganova, 1997; 2001, 2004; Boreo, 2009; Galil et al., 2009; Shiganova and Malej, 2009). This species is also known as one of the'100 world's worst' invaders by IUCN. While this species was the cause of the hypoxia and the collapse of the fisheries in the Black Sea fisheries, major questions are how *Mnemiopsis leidyi* will impact on the Mediterranean fisheries and if the same things will happen in the Mediterranean as in the Black Sea, or to what extent it will impact on or threat the fisheries in the Mediterranean Sea.

Since both Mnemiopsis and anchovies inhabit mainly the upper mixed layer and the peak of spawning of the anchovy and ctenophore coincide in time and space, both being correlated with high water temperatures and both consume mainly the same prey organisms. This is also important for the Mediterranean Sea. While *M. leidyi* and *B. ovata* invade up to the Central Mediterranean Sea, it should be reminded that since 1992 this species was found in the eastern Mediterranean Sea (Uysal and Mutlu, 1993) and has not made any major impact on the pelagic fisheries, such as anchovy, horse mackerel and sardine fisheries, at least in the Turkish part of the Aegean and Mediterranean coasts so far. In addition, the Mediterranean ecosystem is totally different from the Black Sea in terms of the number of species, biodiversity, competition, current systems, etc. Moreover, there are combjelly *Beroe forskalii*, *B. cucumis* and *Balinopsis vitrea* which are native to the Mediterranean Sea and predators of *M. leidyi.* Besides, *Beroe ovata* is also a competitor for *M. leidyi* in the Mediterranean Sea and is found in several Mediterranean countries. Nevertheless, the main reason of the jellyfish invasion is more substantial and a shifting process which is from a fish to a jellyfish in the Mediterranean Sea is evolving . Most of the fish suffer overfishing in the Mediterranean and the alien species can easily find empty niches to establish themselves in the new environment. Certainly more research is needed to better understand impacts of the *M. leidyi* to the fisheries, local communities and Mediterranean biota.

5. INTENTIONAL INTRODUCTION AND ALIEN SPECIES IN THE MEDITERRANEAN SEA

Some accidental introduction is seen with the species like *Caulerpa taxifolia* which escaped from aquaria (Boudouresque, 1996). This species is introduced in 1984, and later dispersed in France, Italy, Monaco, and Croatia, and finally reported from Turkey (in the Gulf of Iskenderun (Cevik et al., 2007). Impacts of *C. taxifolia* are the impoverishment of the Mediterranean algal communities which may reach 75%; most of autochthonous algae tend to disappear dramatically (Verlaque and Fritayre, 1994). The number of polychaeta and especially amphipod species decreased in the *C. taxifolia* meadows; on contrary, the species diversity of molluscs may increase (Bellan-Santini et al.,1994). Fish populations in sites highly colonized by *C.taxifolia,* the mean number of species per census, the mean fish density and the mean biomass are significantly lower (Harmeli-Vivien et al., 1996). Population of sea urchins, fish, amphipods and polychaetes are also affected (Bouduresque et al., 1995). Francour et al. (1995) reported that *C. taxifolia* meadows seem to be a favorable environment for the recruitment of some species of Labriadae (*Coris julis, Symphodus ocellatus*), Sparidae (*Diplodus annularis*) and Serranidae (*Serranus caprilla*) in fall.

Besides *C. taxifolia, C. racemosa* is also important in terms of dispersion. This species has been already reported in several Mediterranean countries, such as France, Italy, Spain, Greece, Croatia, Turkey, Cyprus, Libya and Syria. *C. racemosa* impacted on the benthic communities of macroalgal assemblages by causing impoverishment in the number of species. Sponges, sea urchins and some other benthic species are also covered by *C. racemosa* and die after a certain period at the bottom. Akçali and Cirik (2007) reported that *C. racemosa* and *Halophia stipulacea* affects the biota in the Turkish coasts.

Sargassum muticum found in several areas of Spain, some lagoons of France like Thau, and Venice, inhibits the recruitment and growth of other algae species. *Laminaria japonica* and *Asparagopsis armada* also show invasive caharcteristics in the Mediterranean Sea. *Womersleyella setacea* and *Acrothamnion pressii* are invasive in the Italian coasts and clog up the fishing nets and impact on fishing (Verlaque, 1989). Bainchi and Morri (2000) reported 1351 marine macrophytes from the Mediterranean Sea and Bouduresque and Ribera (1994) estimated in 2050, between 250 to 1000 alien marine macroalgae species may be found in the Mediterranean Sea and if this estimation is realized, indigenous species and alien species may be almost equal in the Mediterranean Sea. Verlaque et al. (2007) reported that, in the 34 Mediterranean coastal lagoons, 67 exotic macrophyte species were found and oyster transfer as a most efficient vector for macrophyte introduction into Mediterranean Sea. At least 30 introduced species were recorded in the Venice Lagoon and many of which have established large populations and have subplanted native species (Occhipinti-Ambrogi, 2000).

Aquaculture is main reason of intentionally introduction of alien species. Aquaculture is one of the growing sectors in the Mediterranean Sea due to high demand of sea food and this demand will be increased in future. However, in bad weather conditions, some of the sea bass and sea bream cages are broken and many fish escape from the cages in winter in Greece, Israel and Cyprus (UNEP/MAP/MEDPOL, 2004). In Turkey, mostly in the Aegean Sea, several fish cages were also broken and several times tons of fish escaped from the cages. Genetic impact of escaped or released cultured fish is a concern mostly for the genetic hybridization. In the Mediterranean Sea, only two commercial invertebrate species, namely, *Crasostrea gigas* and *Tapes philipinarium,* have been introduced for the aquaculture purpose between the 1960s and 1970s. Some problems related to disease occur with Japanese oyster, *Crassostrea gigas,* which was introduced to France. Intentional introduction may cause some problems and risk to human health and marine biodiversity. Some species like pearl oyster *Pinctada radiate* intentionally introduced to Greece aquaculture purposes (Serbestis, 1963).

6. CONCLUSION AND RECOMMENDATIONS FOR THE MEDITERRANEAN SEA

Total 558 metazoan species have been identified in the Mediterranean Sea and the majority of them in the Eastern Mediterranean entered through the Suez Canal, whereas mariculture and shipping are powerful means of introduction in the northwestern Mediterranean and the Adriatic Sea (Galil, 2008). However, Zenetos et al. (2008) reported 903 alien species from the Mediterranean Sea and the eastern Mediterranean is still destination for alien species, but the centre of introduction seems to have spread from Israel to Turkey, a total number of the alien fish was 125 in the Mediterranean Sea. It is expected that more alien species will enter the Mediterranean Sea not only from the Suez Canal but also Atlantic Ocean or from the Black Sea.

Alien species may alter the evolutionary pathway of native species and by competitive exclusion, niche displacement, predation and other ecological and genetic mechanisms (Mooney and Cleland, 2001) In case of Levantine basin, rapid reduction in abundance of the herbivorous sparid *Salpa salpa*, a very abundant species in the rest of the Mediterranean, has been stsrted to the settlement of the competitor *Siganus rivulatus,* a Lessepsian migrant, recorded in the Levantine basin since the early 1990's (Baric he et al, 2004). Niche deplasment also reported native and Red Sea competitors in Red mullet *Mullus barbatus* and Hake *Merluccius merluccius* that have been displaced in deeper waters by their competitors (Por, 1978).

Sea water temperature rise due to climate change would likely have a significant influence on the Lessepsian alien species distribution. It has been said already that Mediterranean Sea is in the tropicalization process and extension of the warm water species to the western part has already occurred. Some Atlantic originated species also migrated to the Mediterranean Sea with Atlantic influx. Classic biogeographic boundaries between west and east Mediterranean has been changed .

In the eastern Mediterranean Sea, the dispersion of the alien species to the central Mediterranean Sea or further up north already shows that environmental adaptation is not difficult for these species. Lessepsian aliens are more successful at shallower part and Por (1978) considers that temperature is the most important and single factor for the colonization success of the Lessepsian migrants and their success in the intermediate layers at about 20-40 m is attributed again to relatively higher and stable temperature at this isobath. If this assumption is correct, climate change may be one of the other factors for the successful colonization of the Lessepsian species in recent years.

To stop Lessepsian aliens species from the Suez Canal is not seems to be possible however, slowing down of the alien species passage to the Mediterranean Sea should be urgently studied in term of biodiversity, human health and to protect natural heritage of the entire Mediterranean and Black Seas. Deepening of the Canal may be one of the catastrophes for the Mediterranean Sea as well.

Mediterranean Straits (Kerch, Istanbul, Canakkale, Otranto, Bonafacio and Gibraltar Straits) are hot spots and dispersal points for the alien species these straits plays an ecological corridors.

Rivers and Lagoon of the Black and Mediterranean are sensitive to the alien species and easier to the introduced species. According to the protocol concerning biological diversity in the Mediterranean Sea, contracting parties to take all appropriate measures to regulate the intentional or accidental introduction of non-indigenous species (Article 13). Besides, UNEP/MAP Action Plan in 2003 called and recommended to the parties to give importance to shipping-mediated introductions of non-indigenous species into the Mediterranean. Due to oil transportation from the eastern Mediterranean

Sea mostly from the Ceyhan terminal in Turkey, ship transported alien species number will be increased to parallel oil transportation.

Close cooperation with IMO/MEPC for the ballast water convention is needed for all Mediterranean countries.

Co-ordinating of the efforts data mase efforts in the Black and Mediterranean Seas. Institutional efforts such as CIESM, RAC/SPA, IUCN, IMO, CBD, IOC, EU and other organizations. Specifically, Exotic species in the Mediterranean (www.ciesm.org/atlas) very useful in many ways for the alien species. Besides, RAC/SPA published a booklet and CD as species introductions and invasive species in the Mediterranean Sea (www.ra-spa.org). Several EU funded project also available in term of alien species inventory and activities.

Top ten commercial alien fish species statistics such as landing, catch amount to be targeted by GFCM for next years. A working group established by GFCM to monitor mpacts of fisheries and biodiversity .

A warning system or alarming system is needed for toxic phytoplankton species to mitigate negative impacts to the fish, mussel and oyster farming and human health.

A special alarm system and data base is needed mainly for the venomous fish and others species like jelly fish, hydroids and others.

Some parasite species also found in the Mediterranean Sea. Fishes like *Siganus rivulatus, S.luridus*, *Aphanius dispar* and *Pranesus pinguis* continue to host in the Mediterranean Sea their monogenean ectoparasites of erythrean origin (Paperna 1972). (Shakmar et al 2009) recorded two native ectoparasitic isopods, cymothid species from the Siganus lurides and *Siganus rivulatus* from the Libyan waters. This parasite species should be monitor for the health of human and biodiversity.

Eradication or completely removal of the alien species from the ecosystem is almost impossible but the control or containment may be possible for some species like *Caulerpa taxifolia* or C. *racemosa* case.However , There is no succces story for the caulerpa species even several initiatives has been developed for eradiction of the species to the entire Med.Sea .

Public awareness campaigns and educational materials is important to recognize, identify or dissemination of information for alien species distribution or harms for all stake holders like fisherman, harbour authorities, divers, tour operators, fisheries cooperatives so on.

To collect new and accurate information on the occurrence of alien species, a reporting and monitoring system is required. In this system, fishermen must report to fisheries cooperatives or relavent fisheries authorities whenever they find unusual organisms in their catch. Then, the relevant authorities report to the Ministry in charge of fisheries. GFCM or other international organizations collect these data regularly to update the database.

Global and regional research initiatives concerning alien species should be encouraged.

Finally, a healthy pristine ecosystem may defend the native fauna and flora of the Mediterranean and Black Seas. Stress on marine environment favours the spreading and facilating of alien species. Key species and key habitats, for example, *Posidonia* meadows, should be protected for maintaining such healthy ecosystem to combat alien species invasion.

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Appendix 1. Alien species in the Black Sea. (Sources: Zaitsev & Ozturk (2001), Alexandrov et al. (2009), Shiganova & Ozturk (2009)) *This table is not completed yet (28 nov 2009).

	Name of Species	**Cited in**	**Donor area***
	Carbosphaerella leptosphaerioides I. Schmidt, 1969	Andrienko & Kopytina, 1998	AO, TO
	*Cirrenalia basiminuta K*aghu-Kumar et Zainal. 1988	Aleksandrov et. al., 2007; TDA, 2007	SE,IO
	Corollospora lacera (Linder) Kohlm., 1962; = *Peritrichospora lacera* Linder,	Andrienko & Kopytina, 1998	AO, TO
	Cumulospora marina I. Schmidt. Mycotaxon, 1985 = *Vesicularia marina* I. Schmidt, 1974; *Basramyces marinus* Abdullah, Abdulkadder and Goos, 1989	Aleksandrov et. al., 2007; TDA, 2007	AO,IO,SE
	Cumulospora varia Chatmata et Somrithipol, 2004	Aleksandrov et. al., 2007; TDA, 2007	SE
	Gloniella clavatispora T. D. Steinke, K. D. Hyde, 1997	Aleksandrov et. al., 2007; TDA, 2007	IO,Af
	Haligena elaterophora Kohlm., 1961	Andrienko & Kopytina, 1998	AO
	Halosarpheia phragmicola O. K. Poon & K. D. Hyde, 1998	Kopytina, 2008	IO
	Lulworthia grandispora Meyers, 1957	Kopytina, 2008	IO

	Lulworthia uniseptata Nakagiri, 1984	Aleksandrov et. al., 2007; TDA, 2007	SE
	Savoryella lignicola Jones, Eaton, 1969	Aleksandrov et. al., 2007; TDA, 2007	Co
	Zopfiella latipes (N. Lundq.) Malloch & Cain, 1971	Aleksandrov et. al., 2007; TDA, 2007	PO,SE
	Alexandrium acatenella (Whed. et. Kof.) Balech, 1985 = *Gonyaulax acatenella* Whedon and Kofoid. 1936; *Protogonyaulax acatenella* (Whedon and Kofoid) Taylor, 1979	Aleksandrov et. al., 2007; TDA, 2007	PO
	Alexandrium affine (Inoue et Fukuyo) Balech, 1985 = *Alexandrium fukuyoi* Balech, 1985; *Protogonyaulax affine* Inoue et Fukuyo, 1985	Aleksandrov et. al., 2007; TDA, 2007	SE
	Alexandrium minutum Halim	Vershinin, 2008	MS
	Alexandrium monilatum (Howell) (F.J.R. Taylor 1979) = *Gonyaulax monilata* J.F. Howell, 1953; *Gessnerium mochimaense* Halim, 1967	Zaitsev & Ozturk, 2001; TDA, 2007	AO
	Alexandrium ostenfeldii (Paulsen) Balech et Tangen	Vershinin, 2008	
	Alexandrium pseudogonyaulax (Biecheler) Horiguchi ex Yuki et Fukuyo, 1992 = *Goniodoma pseudogoniaulax* Biecheler, 1952; *Alexandrium pseudogonyaulax* (Biecheler) Horiguchi, 1983	Aleksandrov et. al., 2007; TDA, 2007	SE
	Alexandrium tamarense (Lebour) Balech, 1995 = *Alexandrium excavatum* (Braarud) Balech et Tangen, 1985; *Gonyaulax exavata* (Braarud) Balech, 1971; *Gonyaulax tamarensis* Lebour, 1925; *Gonyaulax tamarensis* var. *excavata* Braarud, 1945; *Gessnerium tamarensis* (Lebour) Loeblich et Loeblich, 1979; *Protogonyaulax tamarensis* (Lebour) Taylor, 1979	Aleksandrov et. al., 2007; TDA, 2007	Co
	Apedinella spinifera (Throndsen) Throndsen, 1971 = *Pseudopedinella spinifera* Throndsen, 1969; *Apedinella radians* (Lohmann) Campbell 1973	Aleksandrov et. al., 2007; TDA, 2007	AO,MS,PO
	Asterionellopsis glacialis (Castracane) Round 1990 =*Asterionella japonica* Cleve 1878	Aleksandrov et. al., 2007; TDA, 2007	AO

	Bacteriastrum hyalinum Lauder, 1864	Aleksandrov et. al., 2007; TDA, 2007	AO
	Chaetoceros diversus var. papilionis Senicheva, 2002 = *Chaetoceros diversus* Cleve 1873	Aleksandrov et. al., 2007; TDA, 2007	PO
	Chaetoceros tortissimus Gran, 1900	Aleksandrov et. al., 2007; Vershinin, 2008; TDA, 2007	NE
	Cochlodinium polykrikoides Margelef, 1961 = *Cochlodinium heterolobatum* Silva, 1967	Aleksandrov et. al., 2007; Vershinin, 2008; TDA, 2007	NA,IO
	Detonula pumila (Castracane) Gran 1900	Prodanov et al., 2001; TDA, 2007	Co
	Dinophysis odiosa (Pav.)Tai & Scogsberg, 1934 = Phalacroma odiosum Pav., 1930; Protodinophysis odiosa Pavillard Loeblich III	Senicheva, 2002	AO, MS
ques	*Diplopsalopsis orbicularis* (Paulsen)	Vershinin, 2008	MS
excl	*Distephanus speculum* f. *octonarius* (Ehrenberg) S. Locker & E. Martini	Senichkina, 1983; TDA, 2007	AO
ques	*Gymnodinium aureolum* (Hulburt) Hansen, 2000 = *Gyrodinium aureolum* Hulburt, 1957	Aleksandrov et. al., 2007; TDA, 2007	NA
	Gymnodinium radiatum Kofoid et Swezy, 1921	Aleksandrov et. al., 2007; TDA, 2007	PO
	Gymnodinium uberrimum (Allmann) Kofoid et Swezy, 1921 = *Gymnodinium bogoriense* Klebs, 1912; *Gymnodinium irregulare* Christen, 1959; *Gymnodinium limitatum* Skuja, 1956; *Gymnodinium limneticum* Woloszynska, 1935; *Gymnodinium mirabile* Penard, 1891; *Gymnodinium mirabile* var. *rufescens* Penard, 1891; *Gymnodinium obesum* Schiller, 1933; *Gymnodinium poculiferum* Skuja, 1956; *Gymnodinium rotundatum* Klebs, 1912; *Gymnodinium rufescent* Lemmermann, 1910; *Gymnodinium uberrimum* Skuja, 1956; *Gymnodinium uberrimum* var. *Gyrodinium traunsteineri rotundatum* Popovsky, 1968; Lindemann, 1928; *Glenodinium uberrimum* Remil, 1913; *Melodinium uberrimum* Saville-Kent, 1880; *Peridinium uberrima* Allman, 1855	Zaitsev & Ozturk, 2001; Aleksandrov et. al., 2007; TDA, 2007	EW

	Gyrodinium impudicum Fraga et Bravo,1995 = *Gymnodinium catenatum* Graham in Carrada et al.,1991; *Gyrodinium* sp., in Fraga et al. 1995	Aleksandrov et. al., 2007; TDA, 2007	AO,MS,PO
	Gyrodinium instriatum Freudental et Lee, 1963	Aleksandrov et. al., 2007	AO,PO
	Hillea fusiformis (Schiller) Schiller, 1925 = *Chlamydomonas fusiformis* Schiller, 1913	Aleksandrov et. al., 2007; Vershinin, 2008; TDA, 2007	MS
	Lioloma pacificum (Cupp) Hasle, 1996 = *Thalassiotrix mediterraneae* var. *pacifica* Cupp, 1943	Zaitsev et al., 2004; Aleksandrov et. al., 2007; TDA, 2007	AO, MS
	Mantoniella squamata Manton & Parke (1960)	Zaitsev & Ozturk, 2001; TDA, 2007	?
	Octactis octonaria (Ehrenb.) Hovasse, 1946 = *Dictyocha octonaria* Ehrenb., 1844; (Ehrenb.) *Haeckel speculum* var. *octonarius* (Ehrenb.) Jorgensen 1844	Aleksandrov et. al., 2007; TDA, 2007	MS
	Oxyphysis oxytoxoides (Kofoid, 1926)	Moncheva et al., 1995; TDA, 2007	NA
excl	*Pentapharsodinium dalei* Idelicato et Loeblich	Vershinin, 2008	MS
excl	*Pentapharsodinium tyrrhenicum* (Balech) Montresor, Zingone et Marino	Vershinin, 2008	MS
	Petalodinium porcelio J.and M. Cachon 1968	Stoyanova, 1999; TDA, 2007	AO, MS
	Phaeocystis pouchettii (Hariot) (Lagerheim, 1893)	Zaitsev & Ozturk, 2001; TDA, 2007	NA, NE. PO, Antarctic
	Poropila dubia Schiller, 1925	Senichkina, 1983; Aleksandrov et. al., 2007; TDA, 2007	MS
	Pronoctiluca pelagica Fabre-Domergue, 1889 = *Pelagorhynchus marina* Pavillard, 1917; *Protodinifera marinum* Kofoid et Swezy, 1921; *Rhynchomonas marina* Lohmann, 1902	Aleksandrov et. al., 2007; TDA, 2007	AO, MS

excl	*Prorocentrum minimum* (Pavillard) Schiller, 1933 = *P. cordatum* (Ostf.) Dodge, 1975; *Exuviaella cordata* Ostenfeld, 1901	Morozova-Vodianitskaya, 1948; Aleksandrov et. al., 2007; TDA, 2007	Co
exc	*Protoperidinium parthenopes* Zingone et Montresor	Vershinin, 2008	MS
excl	*Protoperidinium minutum* (Kofoid) Loeblich III	Vershinin, 2008	MS
quest	*Pseudo-nitzschia calliantha Lundholm,* Moestrup & Hasle, 2003	Ryabushko et al., 2008	Co
excl	*Pseudonitzschia inflatula (*Hasle) Hastle, 1993 = *Nitzschia inflatula* Hasle, 1974; *Pseudo-nitzschia inflatula* (G.R. Hasle, 1993	Senicheva, 2002	AO, MS
exc	*Pseudonitzschia pungens* Hasle	Vershinin, 2008	MS
cryptogeni c	*Pseudosolenia calcar-avis* (Schultze) Sundström, 1986 = *Rhizosolenia calcar-avis* Schultze, 1858	Zaitsev & Ozturk, 2001; Aleksandrov et. al., 2007; TDA, 2007	AO,PO,IO
	Pterosperma cristatum Schiller, 1925	Aleksandrov et. al., 2007; TDA, 2007	MS, PO
	Pterosperma joergenseni Schiller, 1925	Morozova-Vodianitskaya, 1948; Aleksandrov et. al., 2007; TDA, 2007	MS
	Pyramimonas longicauda Van Meel 1984 = *P. ostendensis* Van Meel, 1969	Aleksandrov et. al., 2007; TDA, 2007	PO
	Rhizosolenia setigera Brightwell 1858	Velikova et al., 1999; TDA, 2007	MS
	*Scaphodinium mirabile M*argalef	Stoyanova, 1999; TDA, 2007	MS
excl	*Sceletonema subsalsum* (A. Cleve) Bethge, 1928 = *Melosira subsalsa* Cleve-Euler, 1912; *Stephanodiscus subsalsus* (A. Cleve) Hustedt, 1930, *Stephanodiscus subtilis* (Van Goor) A. Cl.	Nesterova, 2001; Aleksandrov et. al., 2007; TDA, 2007	EW
excl	*Scrippsiella trochoidea* (Stein) Balech ex Loeblich III, 1965 = *Peridinium trochoideum* (Stein) Lemmermann; *Glenodinium acuminatum* Jorgensen, 1899; *Peridinium faeroense* Paulsen, 1905; *Scrippsiella faeroense* Dickensheets & Cox, 1971	Cınar et al., 2005; Vershinin & Velikova, 2008; TDA, 2007	AO

	Spatulodinium pseudonoctiluca (Pouchet) Cachon et Cachon 1967 = *Gymnodinium pseudonoctiluca* Pouchet, 1885; *Gymnodinium lebourii* Pavillard; *Gymnodinium fulgens* Kofoid et Swezy, 1921	Stoyanova, 1999; Aleksandrov et. al., 2007; TDA, 2007	NA,AO,MS
ZB	*Streptocyllis varians*	Reporting to the Black Sea Commission	
	Thalassiosira nordenskioeldii Cleve, 1873	Zaitsev & Ozturk, 2001; Aleksandrov et. al., 2007; TDA, 2007	NE
	Achnanthes pseudogroenlandica Hendey, 1964	Nevrova, 2003; Aleksandrov et. al., 2007	NE,AO
	Cocconeis britannica Naegeli, 1849	Aleksandrov et. al., 2007; TDA, 2007	NE
	Navicula finmarchica Cleve et Grunow, 1880	Nevrova, 2003; Aleksandrov et. al., 2007; TDA, 2007	NE,PO
	Nitzschia sigmoidea (Nitzsch) W. Smith, 1853 = *Bacillaria sigmoidea* Nitzsch, 1817	Aleksandrov et. al., 2007; TDA, 2007	NE,EW
	Pinnularia trevelyana (Donkin) Rabenh., 1861	Aleksandrov et. al., 2007; TDA, 2007	NE
	Toxonidea insignis Donkin, 1858	Aleksandrov et. al., 2007; TDA, 2007	NE
	Undatella quadrata (Brebisson) Paddock et Sims, 1980	Aleksandrov et. al., 2007; TDA, 2007	NE
	Ahnfeltiopsis furcellata (C. Agardh) P.C. Silva et DeCew	Milchakova, 2007	
	Amphiroa rigida J.V. Lamouroux	Milchakova, 2007	AO
	Asparagopsis armata (Harvey, 1855)	Çinar , 2005; TDA, 2007	AO
	Bonnemaisonia asparagoides (Woodward) C. Agardth	Milchakova, 2007	AO
	Chondrophycus papillosus (C. Agardh)(Garbary & Harper, 1998)	Cınar et al., 2005; TDA, 2007	Red Sea
	Chrysymenia ventricosa (J.V. Lamouroux) J. Agardh = *Dumontia ventricosa* J.V. Lamouroux	Milchakova, 2007	AO

	Cladophora flexuosa (O.F. Muller) Kutz.	Milchakova, 2002	IO, AO
	Cladophora hutchinsiae (Dillw.) Kutz.	Milchakova, 2002	Pantropical zone
	Colaconema codicola (Borgesen) H. Stegenga, J.J. Bolton et R.J. Anderson = *Acrochaetium cordicolum* Borgesen, *Audouinella cordicola (Borgesen) Garbary*	Milchakova, 2007; Çinar , 2005; TDA, 2007	AO
	Cymodocea nodosa (Ucria) Ascherson	Milchakova, 2007	IO, PO
	Cystoseira corniculata (Wulf.) Zanard.	Milchakova, 2002	IO, PO
	Desmarestia viridis (Müll). (Lamouroux, 1813) = *Fucus viridis* Müller, 1782	Aleksandrov et. al., 2007; TDA, 2007; Milchakova, 2007	NA,AO
	Ectocarpus caspicus Henckel, 1909	Aleksandrov et. al., 2007; Milchakova, 2007	CS
	Ectocarpus siliculosus (Dillwyn) (Lyngbye, 1819)	Çinar , 2005; TDA, 2007	AO
	Enteromorpha kylinii Bliding	Milchakova, 2002; Milchakova, 2007	IO, AO
	Gelidium pusillum (Stackhouse) Le Jolis	Milchakova, 2007	AO
	Halothrix lumbricalis (Kützing) (Reinke, 1888)	Çinar , 2005; TDA, 2007	AO
exc	*Laurencia caspica* Zinova et Zaberzh.	Milchakova, 2002	CS
	Laurencia intermedia (Yamada, 1931)	Çinar , 2005; TDA, 2007	Red Sea
	Pilayella littoralis (Linnaeus), (Kjellman, 1872)	Çinar , 2005; TDA, 2007	AO
	Polysiphonia fucoides (Hudson) (Greville, 1824)	Çinar , 2005; TDA, 2007	AO
	Polysiphonia paniculata (Montagne, 1842)	Çinar , 2005; TDA, 2007	AO
	Pterocladiella melanoidea (Schousboe ex Bornet) Santelices et Hommersand - var. *melanoidea* = *Gelidium melanoideum* Schousboe ex Bornet var. *melanoideum*	Milchakova, 2007	AO

	Sargassum hornschuchii C. Ag.	Milchakova, 2002	MS
	Ulva fasciata (Delile, 1813)	Çinar , 2005; TDA, 2007	Red Sea
	Azolla caroliniana Wild.	Ciocarlan, 2000; Zaitsev & Öztürk, 2001; TDA, 2007	NA
	Azolla filiculoides Lamarck	Ciocarlan, 2000; Zaitsev & Öztürk, 2001; TDA, 2007	NA
	Azolla mexicana C.Presl. (auct non Willd.)	Ciocarlan, 2000; TDA, 2007	NA
	Elodea canadensis Michaux, 1791	Ciocarlan, 2000; TDA, 2007	NA
	Elodea nuttallii (Planchon) St.John	Ciocarlan, 2000; TDA, 2007	NA
excl	*Acartia tonsa* (Dana, 1849)= *Acanthacartia tonsa* Dana, 1849	Aleksandrov et. al., 2007; TDA, 2007	AO,PO,IO
	Beroe ovata Bruguière, 1789; = *Medusa infundibulum* Turton, 1806; *Idya mertensii* Mertens, 1833; *Idyiopsis affinis* Agassiz, L., 1866; *Beroe punctata* McCady, 1859; *B. clarkii* Mayer, 1900; *B. shakespeari* Behnam, 1907 (inaccurate identify as *Beroe cucumis*)	Zaitsev & Ozturk, 2001; Aleksandrov et. al., 2007; TDA, 2007	AO,MS
excl ZB	*Callianassa truncata* (Giard et Bonnier, 1890)	Bacescu, 1967; TDA, 2007	MS
	Calocalanus pavo (Dana, 1849)	Porumb, 1980; TDA, 2007	MS
	Clausocalanus arcuicornis (Dana, 1849)	Porumb, 1980; Aleksandrov et. al., 2007	AO,PO,IO (equatorial)
double	*Clausocalanus arcuicornis* (Dana, 1849)	Porumb, 1980; TDA, 2007	MS
	Ctenocalanus vanus Giesbrecht, 1888	Porumb, 1980; TDA, 2007	MS
	Cymbasoma rigidum Thompson, 1888	Porumb, 1975; TDA, 2007	MS
	Cymbasoma thompsoni (Giesbrecht, 1892)	Porumb, 1975; TDA, 2007	MS
	Eudoxoides spiralis (Bigelow, 1911)	Porumb, 1980; TDA, 2007	Atlantic

			Mediterranean
	Eutintinnus apertus Kofoid & Campbell, 1929	Aleksandrov et. al., 2007	PO
	Eutintinnus hastae Taniguchi & Hada, 1981	Aleksandrov et. al., 2007	PO
	Eutintinnus lusus-undae Entz, 1885	Aleksandrov et. al., 2007; TDA, 2007	AO,MS,PO,IO
	Eutintinnus tubulosus Kofoid & Campbell, 1939	Gavrilova, 2005	AO,SE,PO (equatorial)
	Favella brevis Jörgensen, 1924	Aleksandrov et. al., 2007	MS
	Ischnocalanus plumulosus (Claus, 1863)	Porumb, 1980; TDA, 2007	MS
ZOOB	*Magelona mirabilis* (Johnston, 1845) = *M. papillicornis* (Muller, 1858)	Aleksandrov et. al., 2007	MS, NE
	Mecynocera clausi I.C. Thompson, 1888	Porumb, 1980; TDA, 2007	MS
	Mesocalanus tenuicornis (Dana, 1849)	Porumb, 1980; TDA, 2007	MS
	Mnemiopsis leidyi (Agassiz, 1865) (inaccurate identify as *Bolinopsis infundibulum*, *Leucothea multicornis*, *Mnemiopsis mccradyi*)	Gomoiu, Skolka, 1996; Aleksandrov et. al., 2007; TDA, 2007	NA,AO
	Monstrilla grandis Giesbrecht, 1891	Porumb, 1975; TDA, 2007	MS
	Monstrilla helgolandica Claus, 1863	Porumb, 1975; TDA, 2007	MS
	Monstrilla longicornis Thompson, 1890	Porumb, 1975; TDA, 2007	MS
	Neocalanus gracilis (Dana, 1849)	Porumb, 1980; TDA, 2007	MS
	Oithona brevicornis Giesbrecht, 1891	Aleksandrov et. al., 2007; TDA, 2007	AO,PO,IO
	Oithona plumifera Baird, 1843	Aleksandrov et. al., 2007; TDA, 2007	AO,PO,IO (equatorial)
	Oithona setigera Dana, 1852	Aleksandrov et. al., 2007; TDA, 2007	AO,PO,IO (equatorial)

	Oncaea mediterranea (Claus, 1863)	Porumb, 1980; TDA, 2007	MS
	Oncaea minuta Giesbrecht, 1892	Aleksandrov et. al., 2007; TDA, 2007	PO,IO
	Paracalanus aculeatus Giesbrecht, 1888	Porumb, 1980; TDA, 2007	MS
	Paracalanus nanus Sars, 1907	Porumb, 1980; TDA, 2007	MS
	Phaenna spinifera Claus, 1863	Porumb, 1980; TDA, 2007	MS
	Rhincalanus sp.	Aleksandrov et. al., 2007; TDA, 2007	?
	Salpingella sp. (*rotundata*?) Kofoid & Campbell, 1929	Aleksandrov et. al., 2007; TDA, 2007	PO
	Scolecetrix sp.	Aleksandrov et. al., 2007; TDA, 2007	?
	Stylocheiron sp.	Porumb, 1980; TDA, 2007	MS
	Verruca spengleri Darwin, 1854	Porumb, 1959; TDA, 2007	MS
	Alpheus dentipes Guerin-Meneville, 1832	Bulgurkov, 1973; TDA, 2007	MS, AO
	Ameiropsis reducta	Zagorodnyaya & Kolesnikova, 2003	
	Amphiascus parvus	Zagorodnyaya & Kolesnikova, 2003	AO,PO
	Amphiascus tenuiremis (Brady & Robertson in Brady, 1880)	Aleksandrov et. al., 2007; TDA, 2007	AO,PO
	Anadara inaequivalvis (Bruguière, 1789) = *Arca inaequivalvis* Bruguière, 1789; *Scapharca inaequivalvis* (Bruguière): Ghisotti & Rinaldi, 1976; *Cunearca cornea* (Reeve, 1844) is nomen nudum, not synonym	Gomoiu, Skolka, 1996; Aleksandrov et. al., 2007; TDA, 2007	PO,SE,IO

	Ancistrosyllis tentaculata Treadwell, 1941 = *Sigambra tentaculata* (Treadwell, 1941	Kiseleva, 1964	AO
	Aporrhais pespelecani (Linne, 1758)	Mordukhay-Boltovskoy, 1972; Anistratenko, 1998; Aleksandrov et. al., 2007	MS
	Balanus eburneus (Gould, 1841)	Aleksandrov et. al., 2007; TDA, 2007	NA,AO
	Balanus improvisus (Darwin, 1854)	Aleksandrov et. al., 2007; TDA, 2007	NA,AO,MS
	Blackfordia virginica (Mayer, 1910); = *Eugenia cimmeria* Iliyn, 1930*; Campanulina pontica* Valkanov, 1936	Bacescu et al., 1971; Zaitsev, Ozturk, 2001; Aleksandrov et. al., 2007; TDA, 2007	NA
	Callinectes sapidus (Rathbun, 1896)	Makarov, 2004; Aleksandrov et. al., 2007; TDA, 2007	NA
exc	*Capitellethus dispar*	Shadrin, 2000	IO
exc	*Chthamalus stellatus* (Poli 1795)	Gomoiu, Skolka, 1996; TDA, 2007	MS
	Corambe obscura (Verrill, 1870) = *Doridella obscura* (Verrill, 1870)	Roginskaia & Grintsov, 1990; Gomoiu & Skolka, 1997; Micu, 2004a; Zaitsev & Ozturk, 2001; TDA, 2007	NA
	Corbicula fluminalis (Müller, 1774)	Aleksandrov et. al., 2007	SE

	Corbicula fluminea (Müller, 1774)	Aleksandrov et. al., 2007; TDA, 2007	SE
	Cordylophora caspia (Pallas, 1771)	Aleksandrov et. al., 2007	CS,BS
	Crassostrea gigas (Thunberg, 1793)	Telembici A. NIMRD internal reports, Aleksandrov et. al., 2007; TDA, 2007	SE
	Crassostrea virginica (Gmelin 1791)	Csernok E. NIMRD internal reports; Micu 2004, TDA, 2007	NA, NE
	Dipolydora quadrilobata Jacobi, 1883	Todorova & Panayotova, 2006; TDA, 2007	AO, MS, PO
exc	*Dreissena bugensis* (Andrussov 1897)	Micu & Telembici, 2004; TDA, 2007	BS (Dniepr River basin)
exc	*Electra crustulenta Pallas 1766 = Membranipora crustulenta Stevenson 1926*	AG CBD report to the Black Sea Commission	?
	Ercolania viridis (A. Costa, 1866) = *E. funerea* (A. Costa, 1867)	Aleksandrov et. al., 2007; TDA, 2007	NA,AO
	Eriocheir sinensis (Milne-Edwards, 1853)	Zaitsev & Ozturk, 2001; Aleksandrov et. al., 2007; TDA, 2007	SE
	Eudendrium capillare (Allman, 1856)	Aleksandrov et. al., 2007; TDA, 2007	NA,NE
	Eudendrium vaginatum (Allman, 1863) = *Eudendrium annulatum*	Aleksandrov et. al., 2007; TDA, 2007	NA,NE

	Ferrissia wautieri (Mirolli, 1960) = *Ferrissia clessiniana* (Jickeli, 1882)	Aleksandrov et. al., 2007	Au
	Ficopomatus enigmaticus (Fauvel, 1923) = *Mercierella enigmatica* Fauvel, 1923	Dumitrescu, 1962; Pitis & Lacatusu, 1971; Micu & Micu, 2004; Surugiu, 2005; Shurova & Losovskaya, 2003; Aleksandrov et. al., 2007; TDA, 2007	SE
	Glycera capitata Oersted, 1843	Aleksandrov et. al., 2007; TDA, 2007	MS, PO
	Haliplanella luciae (Verrill 1899)	Bacescu et al., 1971; TDA, 2007	PO
exc	*Hesionides arenaria* Friedrich, 1937	Aleksandrov et. al., 2007; TDA, 2007	AO, MS
	Hypanis glabra (Ostroumoff, 1905) = *Adacna glabra* (Ostroumoff, 1905)	Nabozhenko, 2004; Aleksandrov et. al., 2007; TDA, 2007	CS
	Idyella pallidula Sars, 1905	Aleksandrov et. al., 2007; TDA, 2007	AO,PO
	Leptomesochra tenuicornis	Zagorodnyaya Yu.A., Kolesnikova E.A. (2003)	
exc	*Macrobrachium rosenbergii* (De Man, 1879)	Aleksandrov et. al., 2007; TDA, 2007	IO, PO
	Molgula manhattensis (De Kay 1843)	Bacescu et al., 1971; TDA, 2007	NA, NE

	Musculista senhousia (Benson in Cantor, 1842)	Micu, 2004 a,b; TDA, 2007	PO
	Mya arenaria (Linné, 1758)	Gomoiu, Skolka, 1996; Aleksandrov et. al., 2007; TDA, 2007	NA
	Mytilus edulis Linnaeus, 1758	Aleksandrov et. al., 2007; TDA, 2007	AO
exc	*Mytilus trossulus* Gould, 1850	Aleksandrov et. al., 2007; TDA, 2007	PO
exc	*Nannastacus euxinicus* Bacescu, 1951	Bacescu, 1951; TDA, 2007	MS
	Nephthys ciliata (Muller, 1776)	Mordukhay-Boltovskoy, 1972; Aleksandrov et. al., 2007; TDA, 2007	AO,NE,PO
	Neptunea arthritica (Bernardi, 1857) (was identified firstly as *Purpura pacifica*)	Aleksandrov et. al., 2007; TDA, 2007	PO,IO
exc	*Pachycordyle navis* = *Cordylophora inkermanica* Marfenin, sp. n.	Aleksandrov et. al., 2007; TDA, 2007	BS
	Pandalus kessleri Czerniavsky, 1878 = *P. latirostris*	Zaitsev & Öztürk, 2001; TDA, 2007	SE
	Paramphiascella vararensis (T Scott, 1903)	Aleksandrov et. al., 2007; TDA, 2007	AO, PO
	Penaeus semisulcatus De Haan, 1844	Chvorov et al., 2006	PO, IO

Perigonimus megas (Kinne, 1956) = *Bougainvillia muscus* (Van Beneden, 1844); *Bougainvillia megas* Kinne, 1956; *Bougainvillia ramosa* Less. (Hummelinck, 1936)	Simkina, 1963; Zaitsev & Ozturk, 2001; Aleksandrov et al., 2007	AO
Polydora cornuta Bosc, 1802 (was identified firstly as *Polydora limicola*)	Aleksandrov et. al., 2007; TDA, 2007	Co
Polydora websteri Hartman in Loosanoff & Engle, 1943	TDA, 2007	PO
Potamopyrgus jenkinsii (Smith, 1889); = *P. antipodarum*; *Hydrobia jenkinsi* Smith, 1889	Gomoiu, Skolka, 1996; Aleksandrov et. al., 2007; TDA, 2007	Au
Proameira simplex (Norman & T Scott, 1905) = *Ameira simplex*	Aleksandrov et. al., 2007; TDA, 2007	AO, MS, PO
Pteria hirundo (Linne, 1758)	TDA, 2007	MS
Rapana venosa (Valenciennes, 1846) = Rapana thomasiana Crosse, 1861	Grossu, 1964; Aleksandrov et. al., 2007; TDA, 2007	SE
Rhitropanopeus harrisi ridentate (Maitland, 1874)	Gomoiu, Skolka, 1996; Aleksandrov et. al., 2007; TDA, 2007	NA, NE
Robertgurneya rostrata (Gurney, 1927) = *Amphiascus rostratus*	Aleksandrov et. al., 2007; TDA, 2007	AO, PO
Ruditapes philippinarum (Adams and Reeve 1850)	Telembici A. NIMRD internal reports, Micu 2004, TDA 2007	SE
Saduria (=Mesidotea) entomon (Linnaeus, 1758)	Kvach, 2009	NE

exc	*Sigambra tentaculata* (Treadwell, 1941) = *Ancistrosyllis tentaculata* Treadwell, 1941	Aleksandrov et. al., 2007; TDA, 2007	AO
	Sinanodonta woodiana (Lea 1834) = *Anodonta woodiana* (Lea, 1834)	Aleksandrov et. al., 2007; TDA, 2007	SE
	Sirpus zariqieyi Gordon, 1953	Zaitsev & Öztürk, 2001	AO
	Sphaeroma walkeri Stebbing, 1905	TDA, 2007	PO, IO
	Streblospio shrubsolii (Buchanan, 1890)	TDA, 2007	NA, NE, MS, PO
	Streptosyllis varians Webster & Benedict, 1887	TDA, 2007	NA, NE
exc	*Teredo navalis* ((Linne, 1758)	Zaitsev & Öztürk, 2001; Aleksandrov et. al., 2007; TDA, 2007	NA, NE
	Tiaropsis multicirrata (M.Sars, 1835)	Aleksandrov et. al., 2007; TDA, 2007	NA, NE
	Tubificoides benedii (Udekem, 1855)	Aleksandrov et. al., 2007; TDA, 2007	NA
	Urnatella gracilis Leidy, 1851; = *U. dniestriensis* Zambriborsch, 1958	Bacescu, 1954; Bacescu, 1967; Aleksandrov et. al., 2007; TDA, 2007	NA
	Gyrodactylus mugili Zhukov, 1970	Aleksandrov et. al., 2007	SE
	Gyrodactylus zhukovi Ling, 1962	Aleksandrov et. al., 2007	SE

	Ligophorus kaohsianghsieni (Gussev, 1962)	Aleksandrov et. al., 2007	SE
	Pseudobacciger harengulae	Gaevskaya, 2003	
exc	*Chelon labrosus* (Risso, 1827)	Aleksandrov et. al., 2007; TDA, 2007	AO, MS
	*Gambusia holbrooki (*Girard, 1859)	Manea, 1985; Aleksandrov et. al., 2007; TDA, 2007	NA
	Gobius cruentatus Gmelin, 1789	Engin et al., 2007; Boltachev et al., 2009	AO
	Gobius xanthocephalus Heymer et Zander, 1992 (initially identified as *Cabotia schmidti* de Buen, 1930)	Boltachev et al., 2009	AO, MS
	Heniochus acuminatus (Linnaeus, 1758)	Aleksandrov et. al., 2007; TDA, 2007	IO, PO
	Lateolabrax japonicus Cuvier, 1828 = *Labrax japonicus* Cuvier, 1828	Aleksandrov et. al., 2007; TDA, 2007	PO,SE
	Lepomis gibbosus (Linnaeus, 1758) = *Perca gibbosa* Linne, *Eupomotis gibbosus* Jordan&Evermann; *L. macrochirus* (Rafinesgue, 1815)	Busnita, 1929; Aleksandrov et. al., 2007; TDA, 2007	NA
	Lithognatus mormyrus (Linne, 1758) VAGRANT	Stanciu & Ilie, 1980; TDA, 2007	AO, MS
	Micromesistius poutassou (Risso, 1827)	Aleksandrov et. al., 2007; TDA, 2007	AO, NE
	[x]*Morone saxatilis* (Walbaum, 1792) = *Roccus saxatilis*	Zaitsev & Öztürk, 2001; Aleksandrov et. al., 2007; TDA, 2007	NA
	Mugil so-iuy (Basilewski, 1855)= *Liza haematocheila* Temmnick & Schlegel, 1845	Zaitsev & Ozturk, 2001; Aleksandrov et. al., 2007; TDA, 2007	SE
	*Onchorhynchus keta**	Zaitsev & Mamaev, 1997	PO

	*Oryzias latipes**	Chikhachev & Luzhniak, 2000	
	Parablennius incognitus (Bath, 1968)	Boltachev et al., 2009	AO, MS
	Percarina demidoffii Nordmann, 1840	Otel & Banarescu, 1986; TDA, 2007	
	Plecoglossus altivelis altivelis Temminck et Schlegel, 1846	Aleksandrov et. al., 2007; TDA, 2007	SE
	Pseudorasbora parva (Temminck & Schlegel, 1846)	Banarascu, 1964; Aleksandrov et. al., 2007; TDA, 2007	SE
	Salmo salar (L. 1758)	Ustundag et al., 2000; TDA, 2007	NE
exc	*Sardinella aurita* (Valenciennes, 1847)	Aleksandrov et. al., 2007	AO,PO
	Sarpa salpa (Linnaeus, 1758) = *Boops salpa* (L , 1758.)	Boltachev & Yurakhno, 2002	AO
	Sparus aurata (Linnaeus, 1758) = *Chrysophrus aurata* (L.), *Chrysophrys aurata* Valenciennes, 1830	Boltachev & Yurakhno, 2002	AO,MS
	Sphyraena obtusata (Doinchi and Nakabo, 2005) = *Sphyraena obtusata* Cuvier, 1829; *Sphyraena chrysotaenia* non Klunzinger,1884	Aleksandrov et. al., 2007; TDA, 2007	IO, PO
exc	*Sphyraena sphyraena* (Linnaeus, 1758) NATIVE see fishbase	Boltachev, 2009	AO
	Syngnathus acus Linnaeus, 1758	Boltachev et al., 2009	AO
	Rubifrenta ruficolis Pallas, 1769	Shadrin, 2000	CS
	Vanellochettusia leucura (Lichtenstein, 1823)	Shadrin, 2000	CS

que	*Callorhinus ursinus* (Linnaeus, 1758)	Zaitsev & Öztürk, 2001	PO (northern part)
	Delphinopterus leucas (Pallas, 1776)	Zaitsev & Öztürk, 2001	Arctic
	Eumetopias jubatus (Schreber, 1776)	Zaitsev & Öztürk, 2001	PO (northern part)

Donor area*: AO: Atlantic Ocean, IO: Indian Ocean, CS: Caspian Sea, NA: North Atlantic, PO: Pacific Ocean, MS: Mediterranean Sea, Au:Australia, TO: SE: Co: BS: NE: EW

Appendix 2. . Lessepsian molluscs of the Mediterranean, Status, Distribution and Importance to Humans (Source: WWW.CIESM.ORG/ATLAS)

***This table is not completed yet (28 nov 2009).**

. Lessepsian molluscs of the Mediterranean, Status, Distribution and Importance to Humans				
	Taxon	**Status**	**Distribution in the Mediterranean**	**İmportance**
	GASTROPODA - PROSOBRANCHIA			
	Nacellidae			
1	Cellana rota (Gmelin, 1791)	Established	recorded first in 1961 from Akko, Israel (Christiaens, 1967); successively from Egypt (Giannuzzi-Savelli et al., 1994); Greece, Saronikos Gulf (Fountoulakis and Sabelli, 1999).	None
2	**Haliotidae (abalones)** Haliotis pustulata cruenta	Alien	recorded from Israel (Talmadge, 1971) and Tobruk, Libya (Giannuzzi-Savelli et al., 1994).	None
3	**Fissurellidae** (keyhole limpets) Diodora ruppellii (Sowerby, 1834)	Established	recorded first in Palestine (Haas, 1948); later on the southeast coast of Turkey, from Gulf of Iskenderun to Alanya (Engl, 1995).	None

4	**Neritidae** Smaragdia souverbiana (Montrouzier, 1863)	Established	recorded in southeastern Turkey (Buzzurro and Greppi, 1994) and Cyprus (Buzzurro and Greppi, 1997). Questionable occurrence in Rhodes (Buzzurro and Greppi, 1994).	None
5	Nerita sanguinolenta Menke, 1829	Alien	recorded in 1969 from Karpathos, Greece (Nordsieck, 1973a) as new species Nerita kinzelbachi; successively from Tobrouk, Libya, coll. Ebreo (Giannuzzi-Savelli et al., 1994).	None
6	**Trochidae (top shells)** Trochus erithraeus Brocchi, 1821	Established	recorded first in 1968 from Shiqmona, Israel (Barash and Danin, 1973); successively from Port Said, Egypt (Ghisotti, 1974a); Cyprus (Tornaritis, 1987); Lebanon (Bogi and Khairalla, 1987); Gulf of Iskenderun, Turkey (Engl, 1995); Crete, Greece (Cosenza and Fasulo, 1997).	None
7	Pseudominolia nedyma (Melvill, 1897)	Established	recorded first in 1966 from Israel, Haifa Bay and 'Atlit to Dor (Barash and Danin, 1973); later from Lebanon (Bogi and Khairallah, 1987); southeast coast of Turkey, from Mersina to Tasuçu (Engl, 1995).	None
8	Stomatella impertusa (Burrow, 1815)	Alien	recorded only in 1999 from Gönyük near Kemer, southeastern Turkey (Schniebs, 2000).	None

9	**CERITHIIDAE** Cerithium nesioticum Pilsbry and Vanatta, 1906	Alien	recorded in 1971 from Shiqmona, Israel (one shell: Mienis, 1977) then from Ayia Napa, Cyprus (Bogi et al., 1989).	None
10	Cerithium scabridum Philippi, 1848	Established	recorded first from Port Said, Egypt (Keller, 1883); successively from Israel (Haas, 1937); Syria (Pallary, 1938); Lebanon (Pallary, 1938); Italy: Sicily (Di Natale, 1978a), Naples (Mienis, 1985); southern Turkey (Enzenross et al., 1990); Cyprus (Cecalupo and Quadri, 1996), southern Tunisia (Enzenross and Enzenross, 2001); Imbros Island, NE Aegean (Albayrak, 2001). The species from Cyprus illustrated as C. scabridum by Tornaritis (1987) is however the native C. lividulum Risso, 1826.	None
11	Cerithium egenum Gould, 1849	Alien	four different records from Israel from 1971 to 1993: Haifa 1971, dredged at 55 m depth by L. Fishelson (Mienis, 2001a).	None
12	Rhinoclavis kochi (Philippi, 1848)	Established	recorded first in 1963 from Israel (Barash and Danin, 1973); successively from Cyprus (Demetropoulos and Hadjichristophorou,	None

			1976); Lebanon (Bogi and Khairalla, 1987); Turkey, from Gulf of Iskenderun to Alanya (Enzenross et al., 1990).	
13	Clypeomorus bifasciatus (Sowerby G.B. II, 1855)	Alien	recorded first in 1983 in Akhziv, Israel (Mienis, 1985a); later in Port Said, Egypt (Giannuzzi-Savelli et al., 1997); and Tobruk, Libya (ibid., as Cerithium caeruleum, fig. 63).	None
14	**Planaxidae** Angiola punctostriata (Smith E.A., 1872)	Alien	only one record in 1950 near Dor, Israel (Mienis, 1980a).	None
15	Planaxis griseus (Brocchi, 1821)	Alien	recorded as common in Port Said, Egypt by Tillier and Bavay (1905) but this occurrence was disputed by Moazzo (1939). The next record from Haifa, Israel (Giannuzzi-Savelli et al., 1997, misidentified as P. punctostriatus), is doubtful.	None
16	**Litiopidae** Gibborissoa virgata (Philippi, 1849)	Established	recorded first in 1970 as Gibborissoa mirabilis from Israel (van Aartsen et al., 1989); then at Kizkalezi, southeastern Turkey in 1997 (van Aartsen, 2002).	None
17	**Obtortionidae** Finella pupoides Adams A., 1860	Established	recorded first in 1958 from Israel, Haifa Bay, (Barash and Danin, 1977); successively at Jounieh, Lebanon (Bogi and Khairallah, 1987); southeast coast of Turkey, from Gulf of Iskenderun to Tasuçu (Tringali and Villa,	None

			1990); Cyprus (Cecalupo and Quadri, 1996).	
18	Clathrofenella ferruginea (Adams, 1860)	Established	recorded first in 1970 from Israel, Haifa, as Clathrofenella reticulata (Barash and Danin, 1977); successively from southeast coast of Turkey, Mersina to Tasuçu, as Clathrofenella fusca (Engl, 1995) and Cyprus, as C. fusca (Cecalupo and Quadri, 1995).	None
19	**Dialidae** Diala varia Adams A., 1860	Established	collected by Haas in 1935, between Yaffo and Bet Yam, Israel (Mienis, 1984a); successively recorded from Bardawil lagoon, Egypt (Barash and Danin, 1977) and Tripoli, Lebanon (Bogi and Khairalla, 1987).	None
20	**Cerithiopsidae** Cerithiopsis pulvis (Issel, 1869)	Established	recorded first in 1978 from Dor, Israel (Mienis 1992); successively from Lebanon (Bogi and Khairallah, 1987); Cyprus (Bogi et al., 1989) and southeast coast of Turkey, Mersina and Antalya areas (Tringali and Villa, 1990).	None
21	Cerithiopsis tenthrenois (Melvill, 1896)	Established	recorded first in 1982 from Israel, Shiqmona and Haifa Bay (van Aartsen et al., 1989); then from southeast coast of Turkey, Mersina area (Tringali and Villa, 1990), and Cyprus (Buzzurro and Greppi, 1997).	None

22	**Triphoridae** Metaxia bacillum (Issel, 1869	Established	recorded from Israel, first in 1978 as Metaxia bacilla (Mienis, 1985b); later as Cerithiopsis bacillum (van Aartsen et al., 1989); successively from southern Turkey, from Gulf of Iskenderun to Tasuçu (Cecalupo and Quadri, 1995) and Cyprus (Cecalupo and Quadri, 1995).	None
23	Rissoina spirata Sowerby, 1825	Alien	a spurious record in 1974 from the Tyrrhenian Sea (Bogi et al., 1984) not further documented and possibly based on a displaced specimen. The records from Haifa, Israel seem more likely (Giannuzzi-Savelli et al., 1997).	None
24	Alvania dorbignyi (Audouin, 1826)	Established	recorded first from Israel in 1958 (van Aartsen, 1982; Nordsieck, 1972b); later from Cyprus (Cecalupo and Quadri, 1996).	None
25	Voorwindia tiberiana (Issel, 1869)	Alien	first stated as a probable immigrant in the Mediterranean by Nordsieck (1972b) and therefore included in the list of Mediterranean molluscs by Piani (1980-83); first records based on actual specimens are from Port Said, Egypt (Giannuzzi-Savelli et al., 1997) as Setia tiberiana and Haifa, Israel (Bogi and Galil, 1999).	None

26	**STROMBIDAE** (conchs) Strombus persicus Swainson, 1821	Established	recorded first from southern Turkey in 1978 (Nicolay, 1986) as Strombus (Conomurex) decorus raybaudii; successively from Israel (Mienis, 1984); Greece, Rhodes (Verhecken, 1984); Cyprus (Bazzocchi, 1985); Syria (Gosselck et al., 1986); Lebanon (Bogi and Khairallah, 1987); southern Turkey (Crucitti and Rotella, 1991); Greece, south Peloponnese (collected by Enzenross and Enzenross), Argolikos (Zenetos et al., 2002b). An accidental introduction in the Northern Adriatic (De Min and Vio, 1998) is unlikely to establish due to the cold winter conditions.	None
27	Strombus mutabilis Swainson, 1821	Alien	Israel, one shell collected in 1991 at Habonin, Israel and two juveniles collected at Shiqmona in 1998 (Mienis, 2001b).	None
28	**Hipponicidae** Sabia conica (Schumacher, 1817)	Alien	recorded in 1980 from Dor, Israel as Hipponyx conicus, record based on a single shell (Barash and Danin, 1986); later one spurious locality in Sicily (Giannuzzi-Savelli	None

			et al., 1997).	
30	Crepidula fornicata (Linnaeus, 1758	Established	record mostly limited to lagoons where marine farming is active; France : collected first in 1957 La Seyne-sur-mer, (Zibrowius, 1992), Salses-Leucate (Clanzig, 1989), Thau (Zibrowius, pers. comm.); Malta: Marsamxett harbour and Marsaxlokk Bay (Cachia, 1981); Italy: lagoon of Faro, Sicily (Di Natale, 1982) and Caprolacce Lagoon (Bini, 1983); Greece: Saronikos Gulf, Evvoikos (Delamotte and Vardala-Theodorou, 1994). On the French coast, the species is occasionally found offshore, in the Rhone delta area.	None
31	**Cypraeidae (cowries)** Erosaria turdus (Lamarck, 1810)	Alien	recorded first in 1980 from Dor, Israel (Barash and Danin, 1986); later from Port Said, Egypt (illustrated by Giannuzzi-Savelli et al., 1997).	None
32	Purpuradusta gracilis notata (Gill, 1858)	Established	recorded first from Israel in 1981 (Mienis and Singer, 1983) as Cypraea gracilis;	None

			successively from southern Turkey (Blöcher, 1983); Lebanon (Bitar and Kouli-Bitar, 1999); Cyprus, Xylophagou area: in May 2000 two live specimens of 16 mm and 14 mm on rocks at low water mark, almost out of the water (J. Varnavas, pers. comm.).	
33	Palmadusta lentiginosa (Gray, 1825)	Alien	known from a few findings from Israel: recorded first in 1989 from Tel Aviv as Cypraea lentiginosa (Mienis, 1990).	None
34	**NATICIDAE** moon shells Natica gualteriana Récluz, 1844	Established	recorded first in 1966 from Israel (Mienis, 2000b); later from Egypt (Giannuzzi-Savelli et al., 1997). There are few published records, but specimens supposed to come from Israel have been seen in amateur shell shows.	None
35	**EPITONIIDAE** wentletraps Cycloscala hyalina (Sowerby, 1844)	Established	known from the first record in 1992 in Cyprus (Cecalupo and Quadri, 1994) and from Adana and Yumurtalik, southern Turkey (Engl and Çeviker, 1999).	None
36	**EULIMIDAE** Sticteulima cf. lentiginosa (Adams A., 1861)	Alien	recorded first from Aydincik, southern Turkey in 1989 (Tringali, 1994); later from Cyprus (Buzzurro and Greppi, 1997).	None

37	**MURICIDAE** murex shells Ergalatax obscura Houart, 1996	Established	recorded from Mersin to Tasuçu, on the southern Turkish coast (Engl, 1995 as Ergalatax martensi and Giunchi and Tisselli, 1995 as Cronia cf. konkanensis); Cyprus (Buzzurro and Greppi, 1997).	None
38	Thais lacera (Born, 1778)	Established	recorded first from Jaffa, Israel as Thais carinifera in 1928 (Mienis, 1977); successively from Egypt (Moazzo, 1939); southern Turkey (Engl, 1995). A punctual record, without follow-up, in Caprolace lagoon, Italy (Bini, 1983).	Potentially an edible species, also used as bait for angling.
39	Thais sacellum (Gmelin, 1791)	Established	observed first in 2000, in Beyrouth, Lebanon (Zibrowius and Bitar, 2003); its distribution seems limited to Lebanon.	None
40	Rapana venosa (Valenciennes, 1846)	Established	recorded first in 1974 in the northern Adriatic (Ghisotti, 1974b); successively from northern Aegean Sea (Koutsoubas and Voultsiadou-Koukoura, 1991); Slovenia (De Min and Vio, 1997). A single record from Elba by Terreni (1980) without follow-up.	Active predator of epifaunal bivalves, its proliferation is a serious limitation to natural and cultivated populations of oysters and mussels. In Japan, sold as seafood on fish markets.

41	Murex forskoehli Röding, 1798	Established	recorded first in Egypt, Port Said (Tillier and Bavay, 1905); later, from Lebanon (Pallary, 1938) and from Israel (Settepassi, 1967-70) [1932]. The record from Saronikos Gulf, Greece (Settepassi, 1967) is questionnable.	None
42	**NASSARIIDAE** Nassarius arcularia plicatus (Röding, 1798)	Alien	only known from one shell from Haifa collected in 1968 and three shells from Bardawil, Egypt, collected in 1974 (Barash and Danin, 1977a).	None
43	**FASCIOLARIIDAE** spindle shells Fusinus verrucosus (Gmelin, 1791)	Alien	recorded first from Port Said, Egypt, as Fusus marmoratus (Tillier and Bavay, 1905), later from Israel (Haas, 1937).	Moazzo (1939) reported that this species is used as seafood along the Suez Canal.
44	**COLUMBELLIDAE** dove shells Zafra savignyi (Moazzo, 1939)	Established	recorded first in 1954, in Israel as Columbella savignyi (Mienis, 1972, with illustration; 1976d); then recorded from Lebanon (Bogi and Khairallah, 1987); south Turkey (Palazzi, 1993, as Anachis cfr. melitoma); Cyprus (Buzzurro and Greppi, 1997).	None

45	Zafra selasphora (Melvill and Standen, 1901)	Established	recorded first from Israel in 1980 (van Aartsen, 1997); successively from south Turkey, as Anachis troglodytes (van Aartsen, 1997); Cyprus (Buzzurro and Greppi, 1997).	None
46	**CONIDAE** cone shells Conus fumigatus Hwass in Bruguière, 1792	Alien	only from Marsa el Brega, Libya (Röckel, 1986)	None
47	**GASTROPODA - HETEROBRANCHIA** **Anisocyclidae** Murchisonella columna (Hedley, 1907)	Alien	recorded first along the Turkish coasts (Bogi et al., 1995); subsequently in Haifa, Israel (Bogi and Galil, 1999).	None
48	**PYRAMIDELLIDAE** Chrysallida fischeri (Hornung and Mermod, 1925)	Established	records are based only on shell findings from Israel, Haifa Bay in 1974 (van Aartsen and Carrozza, 1979) and Turkey, Gulf of Iskenderun (Micali and Palazzi, 1992) and Tasuçu (Buzzurro and Greppi, 1995).	None
49	Chrysallida maiae (Hornung and Mermod, 1924)	Established	recorded first from Israel in 1935, Atlit (van der Linden and Eikenboom, 1992); successively from Syria, Lattakia (Barash and Danin, 1992); Lebanon (Bogi and Khairallah, 1987); south Turkey (Tringali and Villa, 1990); Egypt, Bardawil (Barash and Danin, 1992); Cyprus (Buzzurro and Greppi, 1996).	None

50	Chrysallida pirintella (Melvill, 1910)	Established	recorded first in 1984 from Israel, Shiqmona and Haifa Bay (van Aartsen et al., 1989); subsequently from Tabuçu, southern Turkey (Micali and Palazzi, 1992).	None
51	Adelactaeon fulvus (Adams A., 1851)	Established	recorded first in 1967 from Israel, Haifa Bay, Atlit-Dor, as Kleinella (Acteopyramis) fulva (Adams A., 1851) (Lavaleye and Barash, 1981); subsequently from Egypt (Mienis, 1984c).	None
52	Adelactaeon amoenus (Adams A., 1851)	Established	recorded first in 1978 from Israel, Atlit-Dor as Kleinella amoena (Mienis, 1985b); successively from southern Turkey (Micali and Palazzi, 1992); Cyprus (Cecalupo and Quadri, 1996), (Buzzurro and Greppi, 1997).	None
53	Styloptygma beatrix Melvill, 1911	Established	recorded first in 1988-89 from southern Turkey (Micali and Palazzi, 1992); subsequently from Israel (Bogi and Galil, 1997).	None
54	Cingulina isseli (Tryon, 1886)	Established	recorded first in 1980 from Israel, Haifa Bay (van Aartsen and Carrozza, 1983); successively from Lebanon, Jounieh Bay (Bogi and Khairallah, 1987); Turkey, Mersin (van Aartsen et al., 1989); Cyprus, Kyrenia harbour, collected by H. Zibrowius in 1998 (identification confirmed by S. Gofas).	None

55	Turbonilla edgarii (Melvill, 1896)	Established	recorded first in 1984 from Israel, Haifa Bay and Shiqmona (van Aartsen et al., 1989); successively from southern Turkey (Micali and Palazzi, 1992); Cyprus (Cecalupo and Quadri, 1996) , (Buzzurro and Greppi, 1997).	None
56	Syrnola fasciata (Jickeli, 1882)	Established	recorded first in 1958 from Haifa, Israel (van Aartsen et al., 1989); successively from Jounieh Bay, Lebanon (Bogi and Khairallah, 1987); southern Turkey (van Aartsen et al., 1989); Cyprus (Nofroni and Tringali, 1995).	None
57	Syrnola cinctella Adams A., 1860	Alien	recorded only from Yumurtalik harbour, southeastern Turkey in 1994 (van Aartsen and Recevik, 1998).	None
58	Odostomia (Megastomia) lorioli (Hornung and Mermod, 1924)	Alien	recorded first from Haifa, Israel in 1974 (van Aartsen, 1987).	None
59	Oscilla jocosa Melvill, 1904	Alien	only known from Israel recorded in 1984 in Haifa Bay (van Aartsen et al., 1989).	None
60	Iolaea neofelixoides (Nomura, 1936)	Alien	only known from Yumurtalik harbour, southeastern Turkey, 1994 (van Aartsen and Recevik, 1998).	None
61	Hinemoa cylindrica (de Folin, 1879)	Alien	only known from specimens collected in 1992-93-95 in southeasthern Turkey	None

			(Buzzurro et al., 2001).	
62	Leucotina cf. eva Thiele, 1925	Alien	only known from southeasthern Turkey, 1995 (Giunchi et al., 2001).	None
63	**GASTROPODA - OPISTHOBRANCHIA** **CYLICHNIDAE** Acteocina mucronata (Philippi, 1849)	Established	recorded first in 1986 from Israel and southern Turkish coast (van Aartsen et al., 1990); successive records from Lebanon (Bogi and Giannini, 1990); Cyprus (Celalupo and Quadri, 1994); Greece (Storsberg, 1997). A record of Utriculastra knockeri in Tunisia (Hoenselaar and Gulden, 1991) might be Acteocina mucronata.	None
64	**RETUSIDAE** Cylichnina girardi (Audouin, 1826)	Established	recorded first in 1974 from Bardawil lagoon, Egypt (Mienis, 1976e); successive records from Lebanon (Bogi and Khairallah, 1987); southern Turkey (Tringali and Villa, 1990); Aegean coast of Turkey (Buzzurro and Greppi, 1996); Cyprus (Cecalupo and Quadri, 1996); Crete (Cosenza and Fasulo, 1997).	None
65	Pyrunculus fourierii (Audouin, 1826)	Established	recorded first from Jounieh Bay, Lebanon (Bogi and Khairallah, 1987); successive records from Israel and southern Turkey (van Aartsen et. al., 1989); Cyprus (Buzzurro and Greppi, 1997).	None

66	**BULLIDAE** bubble shells Bulla ampulla Linnaeus, 1758	Established	recorded first in 1978 from Tel Aviv, Israel (Barash and Danin, 1982b); successive records from Greece, Elefsis Bay (Vardala-Theodorou, 1999; also seen in Turkey (van Aartsen, pers. comm.) and Cyprus (J. Varnavas, pers. comm., sighted August 2000).	None
67	**HAMINOEIDAE** Haminoea callidegenita Gibson and Chia, 1989	Established	only known from the Venice Lagoon (Alvarez et al., 1993).	None
68	Haminoea cyanomarginata Heller and Thompson, 1983	Alien	found in 2001 from Porto Germeno, Korinthiakos, Greece (E. Mollo, identification confirmed by J. Templado) and from Izmir and Antalya, Turkey (photos by N. Kural and A. Buyuk respectively, Rudman, 2003).	None
69	**AGLAJIDAE** Chelidonura fulvipunctata Baba, 1938	Established	recorded first in 1959 from Selimiye harbour, Antalaya, Turkey, as Chelidonura mediterranea new species (Swennen, 1961); successive records from Israel (Mienis and Gat, 1987) and Malta (Perrone and Sammut, 1997).	None
70	**APLYSIIDAE** sea hares Bursatella leachi De Blainville, 1817	Established	recorded first from Palestine (O'Donoghue and White, 1940); successively recorded in Turkey (Swennen, 1961); Malta (Bebbington, 1970); Israel (Eales, 1970); Sicily (Piani, 1980); Tunisia (several records from the Gulf	None

			of Gabès since 1982, Enzenross and Enzenross, 2001); Italy (Fasulo et al., 1984 as B. leachii and B. l. savignyana); Slovenia (Jaklin and Vio, 1989); Greece (Koutsoubas, 1992); Lebanon (collected by G. Bitar and H. Zibrowius, identification confirmed by J. Templado); Sardinia (collected by A. Olita, identification confirmed by J. Templado).	
71	**PLEUROBRANCHIDAE** Pleurobranchus forskalii Rüppell and Leuckart, 1828	Alien	a single record in 1975 from Haifa Bay, Israel (Barash and Danin, 1977a).	None
72	**POLYCERIDAE** Polycerella emertoni Verrill, 1881	Established	recorded first in 1964 from Lago Fusaro (Schmekel, 1965); successively from Toscany coasts (Cattaneo-Vietti et al., 1990); Malta (Sammut and Perrone, 1998) and Greece (Koutsoubas et al., 2000).	None
73	Polycera hedgpethi Marcus, Er. 1964	Alien	only known from Fusaro lagoon, Naples, Italy in 1986 (Cervera et al., 1991).	None

74	**TRIOPHIDAE** Plocamopherus ocellatus Rüppell and Leuckart, 1830	Established	one specimen was recorded in 1977 from Nizzanim, Israel (Barash and Danin, 1982b); another one in Turkey in 1998 (photographed by Ferda Buyukbayal; Rudman, 2002), and three specimens found in Lebanon (collected by G. Bitar and H. Zibrowius; Valdés and Templado, 2002).	None
75	**DISCODORIDIDAE** Discodoris lilacina (Gould, 1852)	Established	recorded first in 1974 from Haifa Bay, Israel as Discodoris concinna Barash and Danin, 1977a); later in Lebanon (collected by G. Bitar and H. Zibrowius, Valdés and Templado, 2002).	None
76	**CHROMODORIDIDAE** Hypselodoris infucata (Rüppell and Leuckart, 1830)	Established	recorded first in 1965 from Caesarea, Israel as Glossodoris runcinata (Barash and Danin, 1977a); later in Turkey (Çevik and Öztürk, 2001), and Lebanon (collected by G. Bitar and H. Zibrowius, Valdés and Templado, 2002).	None
77	Chromodoris quadricolor (Rüppell and Leuckart, 1830)	Alien	only known from one specimen collected in 1982 in Capo Martola, Imperia, Ligurian Sea, Italy (Cattaneo Vietti, 1986).	None
78	**DENDRODORIDIDAE** Dendrodoris fumata (Rüppell and Leuckart, 1830)	Established	a single record in 1980 from the vicinity of Dor, Israel as Dendrodoris nigra (Barash and Danin, 1986).	None

79	**TETHYIDAE** Melibe fimbriata Alder and Hancock, 1864	Established	recorded first in 1970 in Cephalonia Island, Greece (Mooseleitner, 1986); successive records from Korinthiakos Gulf, Greece (Moosleitner, 1986); Strait of Messina (Mojetta, 1998); Calabria, south western Italy (G. Villani, identification confirmed by J. Templado) and Croatia, middle Adriatic (Despalatovic et al., 2002).	None
80	**TERGIPEDIDAE** Cuthona perca (Marcus, 1958)	Alien	recorded only in the Gulf of Venice in 1976-77 (Perrone, 1995).	None
81	**FLABELLINIDAE** Flabellina rubrolineata (O'Donoghue, 1929)	Established	recorded in 1988 off Ashqelon, Israel (Gat, 1993); successively from Antalya, Turkey (Erwin Köhler, pers. comm., identification confirmed by J. Templado).	None
82	**FACELINIDAE** Caloria indica (Bergh, 1896)	Alien	only known as Phidiana indica for a couple of specimens found in 1986 off Ashqelon, Israel (Gat, 1993).	None
83	**AEOLIDIIDAE** Aeolidiella indica (Bergh, 1888)	Alien	recorded first in 1968 from Capo Miseno, Naples, Italy as Aeolidiella takanosimensis (Schmekel, 1968), and later in Malta (Sammut and Perrone, 1998).	None

84	**GASTROPODA PULMONATA** **Siphonaridae** Siphonaria crenata Blainville, 1827 SIPHONARIIDAE	Established	recorded first in 1965, as Siphonaria kurracheensis, from Shiqmona, Israel (Barash and Danin, 1973); successively from southeastern Turkey (Albayrak and Çeviker, 2001).	None
85	**ARCIDAE** arc clams Acar plicata (Dillwyn, 1817)	Alien	a single record from Israel, in 1978, as Barbatia plicata (Barash and Danin, 1986).	None
86	Anadara demiri (Piani, 1981)	Established	recorded first in 1972 from Izmir, Turkey as Arca amygdalum (Demir, 1977); successively found in 1992 in Greece, Thessaloniki Gulf (Zenetos, 1994) and Italy, Adriatic Sea (Morello and Solustri, 2001).	None
87	Anadara inaequivalvis (Bruguière, 1789)	Established	reported first in 1969 as Scapharca cfr. cornea from the Adriatic Sea, near Ravenna, Italy (Ghisotti, 1973) from where it rapidly spread.	None
88	Anadara natalensis (Krauss, 1848)	Established	recorded first in 1935 from Gaza, Palestine (Haas, 1937); successively from Port Said and Port Fouad, Egypt (Moazzo, 1939); Iskenderun and Mersin gulfs (Enzenross et al., 1990).	None in the Mediterranean but similar species are consumed and commercially fished in southeastern Asia.

89	**GLYCYMERIDIDAE** (bittersweet clams) Glycymeris arabicus (Adams H., 1871)	Alien	a single record in 1966 from Dor, Israel (Barash and Danin, 1977a).	None
90	**LIMOPSIDAE** Limopsis multistriata (Forsskål, 1775)	Alien	a single record in 1965 from Dor, Israel (Barash and Danin, 1977a).	None
91	**MYTILIDAE** (mussels) Musculista perfragilis (Dunker, 1857)	Established	recorded first in 1960 as Modiolus glabberrimus from Bat Yam, Israel (Barash and Danin, 1973); successively from Bardawil Lagoon, Egypt (Barash and Danin, 1971) and Port Said.	None
92	Musculista senhousia (Benson in Cantor, 1842)	Established	recorded first in 1960 as Modiola arcuatula from Tel Aviv, Israel (Barash and Danin, 1971); successively from Bardawil lagoon, Egypt (Barash and Danin, 1971a); France, Etang de Thau (Hoenselaar and Hoenselaar, 1989); Italy, Ravenna lagoon, Adriatic Sea (Lazzari and Rinaldi, 1994); Slovenia (De Min and Vio, 1997).	May have an adverse impact on biodiversity as it reaches high densities that can exclude other infaunal species.

93	Modiolus auriculatus (Krauss, 1848)	Alien	recorded from Palestine (Haas, 1937).	Can be used as a biological indicator to monitor chemical contaminants in a tropical marine ecosystem (Bourdelin, 1996).
94	Xenostrobus securis (Lamarck, 1819)	Established	recorded first in 1992 in Ravenna lagoon, Italy, Adriatic Sea (Lazzari and Rinaldi, 1994); successive reports in Italy from Venice lagoon as Xenostrobus sp. (Sabelli and Speranza, 1994), Porto Buso (De Min and Vio, 1997), delta of the river Po (Russo, 2001). In French Mediterranean lagoons, massive presence in the canal between Etang du Vidourle and the sea, at Le Grau du Roi (Pelorce, identification confirmed by S. Gofas on the basis of material).	May have a negative impact on lagoonal ecosystems when it becomes invasive, covering soft sediments and smothering the infauna.

95	Brachidontes pharaonis (Fischer P., 1870)	Established	first record from Port Said, Egypt in 1876 (Fuchs, 1878); successively from Lebanon (Gruvel and Moazzo, 1931); Israel (Haas, 1937); Sicily (Di Geronimo, 1971); Greece, Chalkida, Evvoikos (Koroneos), 1979; Syria (Kinzelbach, 1985); southern Turkey (Kinzelbach, 1985); Greece, Rhodes (Tenekides, 1989); Cyprus (Cecalupo and Quadri, 1996); Croatia, northern Adriatic (De Min and Vio, 1997).	None
96	Septifer forskali Dunker, 1855	Alien	recorded only from southern Turkey: a first record in 2001 in Yumurtalik (Albayrak and Çeviker, 2001), then in the Iskenderun area at a depth 5-7 m (Çeviker, identification confirmed by A. Zenetos on the basis of photo).	None
97	**OSTREIDAE** (oysters) Crassostrea gigas (Thunberg, 1793)	Established	imported in Etang de Thau, France, (Raimbault, 1964) and in Adriatic lagoons (Venice, Grado, Varano, Foggia) (Matta, 1969). Successively recorded from Malta (Agius et al., 1978); Spain (Poutiers, 1987); Tunisia, Ichkeul (Madhioub and Zaouali, 1988); Ionian Sea-Tyrrhenian Sea (Minelli et al., 1995); now widely established in the	Edible. Importation of Japanese oysters into France has permitted the oyster industry to remain in existence; the overall economic

			northern Adriatic (De Min and Vio, 1997). Suspected records in Greece: Patraikos, Korinthiakos (Dimitrakis, 1989) and Yurkey (Çevik et al., 2001).	impact has been positive.
98	Saccostrea cucullata (Born, 1778)	Established	recorded first in 1999 from Turkey at Erdemli (Kideys, identification confirmed by S. Gofas) and Yumurtalik, Tasuçu as Saccostrea commercialis (Çevik et al., 2001); successively from Egypt (El-Faham, identification confirmed by A. Zenetos).	Edible, its cultivation is very popular in many parts of the world (Thailand, Australia).
99	Saccostrea commercialis (Iredale and Roughley, 1933)	Alien	imported in 1984 in the Venice lagoon, Adriatic (Cesari and Pelizzato, 1985b) from where it expanded northwards (St Erasmo Island).	Edible, its cultivation is very popular in Australia and New Zealand.
100	Dendrostrea frons (Linnaeus, 1758)	Established	known only from the Iskenderun area, Southeastern Turkey (Çeviker, 2001).	None

101	**PTERIIDAE** (pearl oysters) Pinctada margaritifera (Linnaeus, 1758)	Established	an old record from Calabria, Italy (Bellet, 1899) but no recent records; later record from Alexandria, Egypt (Hasan, 1974).	The best pearls are produced by the tropical P. margaritifera.
102	Pinctada radiata (Leach, 1814)	Established	recorded first in 1874 as Meleagrina sp. from Egypt (Monterosato, 1878); then from Tunisia (Dautzenberg, 1895); Cyprus (Monterosato, 1899); Israel (mentioned in Monterosato, 1899); Malta (Pallary, 1912); Greece: Saronikos (Serbatis, 1963), Karpathos (Nordsieck, 1969); Lebanon (Christensen, 1972); Libya (reference in Barash and Danin, 1973); France (Zibrowius, 1979); Sicily (Di Natale, 1982); southern Turkey (Kinzelbach, 1985); Syria (Kinzelbach, 1985); W. Peloponnese (Enzenross and Enzenross, identification confirmed by A. Zenetos); Adriatic (Vio and De Min, 1996).	Pearls. It is overcollected in search of its pearls which are of no commercial value. Used as bioindicator in polluted ecosystems

103	**MALLEIDAE** (hammer oysters) Malvufundus regulus (Forsskål, 1775)	Established	recorded first from Israel and Lebanon (Moazzo, 1931); successively from Palestine (Haas, 1937); Kyrenia, Cyprus (Demetropoulos, 1971); southern Turkey (Falchi, 1974); Egypt (Barash and Danin, 1977a); Libya (Giannuzzi-Savelli et al., 2001); Simi, Greece (Giannuzzi-Savelli et al., 2001).	None
104	**SPONDYLIDAE** (spiny oysters) Spondylus spinosus Schreibers, 1793	Established	records first in 1988 off Israel (Mienis et al., 1993a); successively from Iskenderun, Turkey (Engl and Çeviker, 1999); Lebanon (Bitar and Zibrowius, pers. comm.).	The species is collected by diving and is served in restaurants in Jbail, Lebanon (Zibrowius, pers. comm.).
105	Spondylus groschi Lamprell and Kilburn, 1995	Q	recorded from Israel (Lamprell, 1998); its exact distribution is unknown.	None

106	Spondylus cf. multisetosus Reeve, 1856	Q	reported in 1992 from Turkey (Çeviker, 2001) near Tasuçu.	Edible.
107	**BIVALVIA - HETERODONTA LUCINIDAE** (lucina clams)	Established	reported first from Israel in 1956 as Divaricella angulifera (Barash and Danin, 1986) and in 1976 (Mienis, 1979); later in Egypt, off Bardawil (Barash and Danin, 1986).	None
108	**TRAPEZIIDAE** Trapezium oblongum (Linnaeus, 1758)	Alien	reported in 1980 only from Yamit, Israel (Mienis, 1980c).	None
109	**UNGULINIDAE** Diplodonta cf. subrotunda Issel, 1869*	Alien	recorded only from Israel coasts (Bogi and Galil, 1999).	None
110	**CHAMIDAE** (jewel boxes) Chama pacifica Broderip, 1834	Established	recorded first as C. broderipi from Alexandria, Egypt (Tillier and Bavay, 1905); successively from Israel (Mienis et al., 1993b); Lebanon (Bitar G. and H. Zibrowius, pers. comm.); southern Turkey (Çeviker, 2001); Cyprus (coll. H. Zibrowius, identification confirmed by S. Gofas on the basis of material).	Some members of the family, known for their decorative shells, have been adequately studied from the perspective of aquaculture.

111	Pseudochama corbieri (Jonas, 1846)	Alien	successive reports from Greece, Attiki (Ralli-Tzelepi, 1946) and Israel, Yafo (Barash and Danin, 1973) as Pseudochama cornucopiae.	None
112	**CARDIIDAE** (cockles) Fulvia australis (Sowerby G.B., 1834)	Established	reported first from Gaza, Palestine (Haas, 1948); subsequently from Israel (Haas, 1948).	None
113	Fulvia fragilis (Forsskål in Niehbur, 1775)	Established	recorded first in 1955 as Papyridea papyracea from Israel (Barash and Danin, 1973); successively from southern Turkey (Lindner, 1988); Tunisia (Passamonti, 1996); Greece (Vardala-Theodorou, 1999); Spain (Emilio Rolán, pers. comm., identification confirmed by S. Gofas on the basis of the material).	None
114	Afrocardium richardi (Audoin, 1826)	Established	reported first as Cardium richardi from Haifa, Israel (Bogi and Galil, 1999); later from southeastern Turkey (van Aartsen and Goud, 2000).	None
115	**TELLINIDAE** (tellins) Tellina valtonis	Established	recorded first in 1970 from Bardawil lagoon, Egypt (Barash and Danin, 1977a); recently	None

	Hanley, 1844		from southeastern Turkey near Yumurtalik (Giunchi et al., 2001).	
116	Psammotreta praerupta (Salisbury, 1934)	Alien	only one record in 1992, off Adana, southern Turkey (Engl and Çeviker, 1999).	None
117	**PSAMMOBIIDAE** (sanguin clams) Hiatula ruppelliana (Reeve, 1857)	Established	reported first in Egypt, Port Said (Tillier and Bavay, 1905) as Psammobia ruppelliana; more recently in Bardawil lagoon (Mienis, 1980b).	None
118	**MACTRIDAE** (surf clams) Mactra olorina Philippi, 1846	Established	recorded first from Egypt, Port Said (Carus, 1889-93); successive reports from Lebanon (Gruvel and Moazzo, 1931); Israel (Barash and Danin, 1973).	Edible but not of high economic interest. Locally common in Bardawil.
119	Mactra lilacea Lamarck, 1818	Established	recorded first in 1972, in Bardawil, Egypt (Mienis, 2000c); recently from Israel coast (Mienis, 2002b).	None
120	**MESODESMATIDAE** Atactodea glabrata (Gmelin, 1791)	Alien	reported only in 1973 as Atactodea striata from Netanya, Israel (Barash and Danin, 1977a).	None

121	**VENERIDAE** (venus clams) Gafrarium pectinatum (Linnaeus, 1758)	Established	recorded first from Port Said, Egypt (Tillier and Bavay, 1905); Sinai (Barash and Danin, 1973); southern Turkey (Lindner, 1987); Israel (Mienis, 1999d); Lebanon (Bitar and Kouli-Bitar, 1999).	Sold in the market at Alexandria (Pallary, 1912).
122	Circenita callipyga (von Born, 1778)	Alien	recorded only from Israel coasts, first in 1972 (Mienis, 2000d), then in 1980, as Gafrarium callipygum (Barash and Danin, 1986).	Unknown.
123	Clementia papyracea (Gray, 1825)	Established	successive records from Gaza, Palestine (Haas, 1948); Israel (Barash and Danin, 1973); southeastern Turkey from Gulf of Iskenderun to Alanya (Enzenross et al., 1990).	None
124	Paphia textile (Gmelin, 1791)	Established	recorded in Palestine (Haas, 1948); southern Turkey (Niederhöfer et al., 1991) and Syria (Kucheruk and Basin, 1999).	None
125	Ruditapes philippinarum (Adams and Reeve, 1850)	Established	introduced first in 1980 in France (Bodoy et al., 1981); in 1983 in the Venice lagoons for experimental aquaculture (Cesari and Pellizzato, 1985; Breber, 1985 as Tapes semidecussatus): now found on the coasts of Romagna and Sardinia. A recent record in the Turkish North Aegean Sea, difficult to explain, is until further evidence considered	Edible. Clam farming.

			accidental (Albayrak et al., 2001).	
126	Antigona lamellaris Schumacher, 1817	Alien	reported only from Iskenderun, southern Turkey in 1988 (Engl and Çeviker, 1999).	None
127	Dosinia erythraea Römer, 1860	Alien	only known from the original record in Port Said, Egypt (Tillier and Bavay, 1905).	Edible.
128	Timoclea roemeriana (Issel, 1869)	Established	only known from Israel: recorded first in 1997 as Venus roemeriana Issel, Haifa (Bogi and Galil, 1999).	None
129	MYIDAE (soft-shell clams) Sphenia rueppelli Adams A., 1850	Alien	only from Israel, Netanya, in 1978 (Barash and Danin, 1986).	None
130	**GASTROCHAENIDAE** (rock-borer clams) Gastrochaena cymbium (Spengler, 1783)	Established	recorded first in 1954 from Israel (Barash and Danin, 1973); successively from Greece, Saronikos (Tenekidis, 1989); southeastern Turkey (Niederhöfer et al., 1991).	None

131	**BIVALVIA - ANOMALODESMATA** LATERNULIDAE (lantern clams) Laternula anatina (Linnaeus, 1758)	Established	successive records from Egypt as Anatina labiata (Tillier and Bavay, 1905); Israel (Barash and Danin, 1973); Lebanon (Bogi and Khairallah, 1987) and southern Turkey (Engl, 1995).	None
132	**POLYPLACOPHORA** CHITONIDAE (chitons) Chiton hululensis (Smith E.A. in Gardiner, 1903)	Alien	recorded only from Israel in 1934, as Chiton platei (Barash, 1974).	None
133	Petricola hemprichi Issel, 1869	Alien	Seven specimens were found under the spines of the bivalve Spondylus spinosus Schreibers, 1793 from 25 m depth at Yumurtalık (36o46’17” N, 35o49’57” E) on 12 January 2000.	Undefined
134	Cardites akabana (Sturany, 1899)	Alien	Three specimens were found on muddy-sand bottom from 10 m depth at Dortyol (36o53’50” N, 36o04’34” E) and Kale (36o19’31” N, 35o46’49” E) on 11 November 2005.	Undefined

135	Amathina tricarinata	(Linnaeus, 1767)	Alien	Eleven specimens were found in holes on the shells of Spondylus spinosus from 7 m depth at Karatas (36o34’12” N, 35o34’30” E) on 11 August 1999.	is a commensal/ parasite of large bivalves, particularly Pinna and oysters, and could become a pest of cultivated bivalves (Ponder 1987).

* Only those exotic species of Indo-Pacific origin that were recorded after 1920 and of Atlantic origin that were recorded after 1960 are considered. The data base of Exotic Molluscs in the Mediterranean Sea was developed by a CIESM 2003-2005.

Website adresses: www.ciesm.org,www.journals.tubitak.gov.tr, WWW.MARINESPECIES.ORG

Appendix 3. Alien crustacean species in the Mediterranean Sea. (Source: WWW.CIESM.ORG) *This table is not completed (28 Nov 2009)

SPECIES	Turkey	Marmara Sea	Israel	Lebanon	Egypt	Cyprus	Palestine	Syria	Greece	Italy	Sicily	Ionian Sea	Tunisia	France
Marsupenaeus japonicus (Bate,1888)	+	+	+	+	+	+	–	+	+	+	–	+	–	+
Melicertus hathor (Burkenroad, 1959)	+	–	+	–	–	–	–	–	+	–	–	–	–	–
Metapenaeopsis aegyptia Galil & Golani, 1990	–	–	+	–	–	–	–	–	+	–	–	–	–	–
Metapenaeopsis mogiensis consobrina (Nobili, 1904)	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Metapenaeus monoceros (Fabricius, 1798)	+	–	+	+	+	+	–	+	–	–	–	–	+	–
Metapenaeus stebbingi Nobili, 1904	+	–	+	+	+	–	–	+	–	–	–	–	–	–
Penaeus semisulcatus DE HAAN, 1844	+	–	+	+	+	–	–	–	–	–	–	–	–	–
Trachysalambria palaestinensis Steinitz, 1932	+	–	–	–	+	–	+	–	+	–	–	–	+	–
Solenocera crassicornis (H. Milne Edwards, 1837)	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Lucifer hanseni Nobili 1905	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Leptochela pugnax De Man, 1916	+	–	+	–	–	–	–	–	–	–	–	–	–	–

Palaemonella rotumana (Borradaile, 1898)	+	–	+	–	–	–	–	–	–	–	–	–	–	–
Periclimenes calmani Tattersal, 1921	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Alpheus audouini Coutière, 1905	–	–	+	–	+	–	–	–	–	–	–	–	–	–
Alpheus inopinatus (Holthuis & Gottlieb,. 1958	+	–	+	–	+	–	–	–	–	–	–	–	+	–
Alpheus migrans Lewinsohn & Holthuis, 1978	+	–	+	–	+	–	–	–	–	–	–	–	–	–
Alpheus rapacida De Man, 1908	+	–	+	–	–	–	–	–	–	–	–	–	–	–
Ogyrides mjoebergi (Balss, 1921)	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Panulirus ornatus (Fabricius, 1798)	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Notopus dorsipes (Linnaeus, 1758)	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Ixa monody (Holthuis and Gottlieb, 1956)	+	–	+	–	–	–	–	–	+	–	–	–	–	–
Leucosia signata Paulson, 1875	+	+	+	+	+	–		–	–	–	–	–	–	–
Myra subgranulata Kossmann, 1877	+	–	–	+	+	–	+	–	–	–	–	–	–	–
Ashtoret lunaris	–	–	+	–	–	–	–	–	–	–	–	–	–	–

(Forsskål, 1775)														
Hyastenus hilgendorfi De Man, 1887	–	–	+	–	+	–	–	–	–	–	–	–	–	–
Charybdis (Charybdis) hellerii (A. Milne Edwards, 1867)	+	–	–	+	+	+	+	+	–	–	–	–	–	–
Charybdis (Goniohellenus) hellerii (Milne Edwards, 1867)	+	–	+	+	+	+	–	–	+	–	–	–	–	–
Portunus pelagicus (Linnaeus, 1758)	+	–	–	+	+	+	+	+	–	+	+	–	–	–
Thalamita poissonii (Audouin, 1826)	+	–	+	+	–	+	–	–	+	–	–	–	–	–
Halimede tyche (Herbst, 1801)	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Heteropanope laevis (Dana, 1852)	–	–	–	–	+	–	–	–	–	+	–	–	–	–
Pilumnopeus vauquelini (Audouin, 1826)	+	–	+	–	+	–	–	–	–	–	–	–	–	–
Pilumnus hirsutus Stimpson, 1858	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Atergatis roseus (Riippell, 1830)	+	–	+	+	–	–	–	–	–	–	–	–	–	–
Daira perlata (Herbst, 1790)	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Sphaerozius nitidus Stimpson, 1858	–	–	–	–	+	–	–	–	–	–	–	–	–	–

Eucrate crenata De Haan, 1835	+	–	+	–	+	–	–	–	–	–	–	–	+	–
Plagusia tuberculata Lamarck, 1818	–	–	–	+	–	–	–	–	–	–	–	–	–	–
Macrophthalmus graeffei A. Milne-Edwards, 1873	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Erugosquilla massavensis (Kossmann, 1880)	+	–	–	+	+	+	+	–	+	–	–	–	–	–

Appendix 4. Lessepsian fish species (Sources: WWW.CIESM.ORG, WWW.FISHBASE.COM, WWW.TUBITAK.GOV.TR) *This table is not completed (28 Nov 2009).

Species	Origin	Mediterranean	Aegean	Marmara	Black Sea	Israel	Lebanon	Egypt	Algerian	Cyprus	Palestine	Libya	Syria	Crete	Albania	Aegean Sea	Greece	Rhodes	Dodecanese Islands	Saronikos Gulf	Italy	Trieste	Sicily	Thyrreanean	Sardinia	Adriatic	Gulf of Naples	Malta	Ionian Sea	Tunisia	Lempedusa island	Ligurian sea	Marseille	Messiniakos
Abudefduf vaigensis (Quoy ann Gaimard, 1825)	IP	+				+																					+					+		
Alepes djedaba (Forsskal,1775)	IP	+	+					+			+					+																		
Apogon nigripinnis Cuvier, 1882	IP	+								+	+																							
Apogon pharaonis Bellotti, 1874	IP	+	+																															
Apogon queketti Gilchrist, 1903	IP	+																																
Apogon smithi (Kotthaus, 1970)	IP	+																																
Atherinomorus lacunosus (Forster in Bloch and Schneider, 1861)	IP	+	+			+	+	+				+							+											+				
Callionymus filamentosus Valenciennes, 1837	IP	+				+	+	+										+																
Cyclichthys spilostylus (Leis and Randall, 1982)	IP					+																												
Coryogalops ochetica (Norman, 1927)	IP							+																										
Crenidens crenidens (Forsskal,1775)	IP					+		+				+																						
Cynoglossus sinusarabici (Chabanaud, 1931)	IP	+				+		+																										
Decapterus russelli (Rüppell, 1830)	IP																																	
Dussumieria acuta Valenciennes, 1847	IP	+																																

Dussumieria elopsoides Bleeker, 1849	IP	+				+		+																										
Epinephelus coioides (Hamilton, 1822)	IP					+															+	+				+								
Epinephelus malabaricus (Bloch and Schneider, 1801)	IP					+																												
Etrumeus teres (Dekay, 1842)	IP	+	+			+		+		+				+				+																
Fistularia commersonii Rüppell, 1835	IP	+	+			+			+							+		+			+		+	+	+	+				+	+			+
Hemiramphus far (Forsskal,1775)	IP	+					+	+			+		+					+								+								
Heniochus intermedius Steindachner, 1893	IP	+																																
Herklotsichthys punctatus (Rüppell, 1837)	IP	+					+				+																							
Himantura uarnak (Forsskal,1775)	IP	+				+	+	+																										
Hippocampus fuscus Rüppell, 1838	IP	+				+																												
Hyporhamphus affinis (Günther, 1866)	IP	+					+																											
Iniistius pavo (Valenciennes, 1840)	IP																	+																
Lagocephalus sceleratus (Gmelin, 1789)	IP		+																															
Lagocephalus spadiceus (Linnaeus, 1758)	IP	+	+	+		+											+		+															
Lagocephalus suezensis Clark and Gohar, 1953	IP	+	+			+	+											+																
Equulites klunzingeri (Steindachner, 1898)	IP	+				+		+					+				+	+	+							+					+			
Liza carinata (Valenciennes, 1836)	IP	+						+																										
Lutjanus argentimaculatus(Forsskal,1775)	IP						+																											
Mugil soiuy Basilewsky, 1855	IP		+	+	+																													
Muraenesox cinereus (Forsskal,1775)	IP					+																												
Nemipterus japonicus (Bloch, 1791)	IP					+																												
Nemipterus randalli Russell, 1986	IP	+																																
Omobranchus punctatus (Valenciennes, 1836)	IP																																	

Oxyurichthys papuensis (Valenciennes, 1837)	IP	+	+			+		+					+																					
Pampus argenteus (Euphrasen, 1788)																																		
Papilloculipes longiceps (Ehrenberg in Valenciennes, 1829)	IP					+																												
Parexocoetus mento (Valenciennes, 1846)	IP	+	+								+	+			+			+	+							+				+				
Pelates quadrilineatus (Bloch, 1790)	IP	+					+	+																										
Pempheris vanicolensis Cuvier, 1831	IP	+	+			+	+												+											+				
Petroscirtes ancylodon Rüppell, 1838	IP	+				+												+																
Platax teira (Forsskål, 1775)	IP																																	
Platycephalus indicus (Linnaeus, 1758)	IP					+	+	+													+													
Plotosus lineatus (Thunberg, 1787)	IP																																	
Pomadasys stridens (Forsskal,1775)	IP	+					+	+													+													
Pteragogus pelycus Randall, 1981	IP		+			+				+								+																
Pterois miles (Bennet, 1803)	IP					+																												
Rastrelliger kanagurta (Cuvier, 1816)	IP					+																												
Rhabdosargus haffara (Forsskal,1775)	IP					+																												
Rhynchoconger trewavasae BenTuvia, 1993	IP					+												+																
Sargocentron praslin (Lacepède, 1802)	IP																																	
Sargocentron rubrum (Forsskal,1775)	IP	+	+			+	+			+		+						+																
Saurida undosquamis (Richardson, 1848)	IP	+	+			+		+		+		+		+	+		+		+		+					+								
Scarus ghobban Forsskål, 1775	IP					+	+																											
Scomberomorus commerson (Lacapede, 1800)	IP	+	+				+	+			+							+	+															
Scorpaenopsis ramaraoi Randall & Eschmeyer, 2001	IP																																	

Siganus luridus (Rüppell, 1828)	IP	+	+			+	+			+	+	+					+		+		+		+						+	+			+	+
*Siganus rivulatus*Forsskal,1775	IP	+	+							+	+	+	+			+					+								+	+				+
Silhouetta aegyptia (Chabanaud, 1933)	IP					+		+																										
Sillago sihama (Forsskal,1775)	IP	+				+	+	+																										
Sorsogona prionota (Sauvage, 1873)	IP					+																												
Sphyraena chrysotaenia Klunzinger, 1884	IP	+					+				+	+									+					+		+						
Sphyraena flavicauda Rüppell, 1838	IP	+				+												+																
Sphyraena obtusata Cuvier, 1829	IP	+			+																													
Sphyraena pinguis Günther, 1874	IP	+	+		+		+																											
Spratelloides delicatulus (Bennett, 1831)	IP					+																												
Stephanolepis diaspros Frase Brunner,1940	IP	+	+							+	+		+	+				+	+	+	+		+			+				+				
Terapon puta (Cuvier, 1892)	IP						+	+																										
Tetrosomus gibbosus (Linnaeus, 1758)	IP					+																												
Torquigener flavimaculosus Hardyand Randall, 1983	IP	+				+																												
Tylerius spinosissimus (Regan, 1908)	IP																	+																
Tylosurus choram (Rüppell, 1837)	IP					+																												
Upeneus asymmetricus Lachner, 1954	IP	+																																
Upeneus moluccensis (Bleeker, 1855)	IP	+	+					+		+		+						+																
Upeneus pori BenTuvia and Golani, 1989	IP	+	+			+		+										+												+				