JELLYFISH OF THE BLACK SEA AND EASTERN MEDITERRANEAN WATERS

Bayram ÖZTÜRK
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Fax: 0 (216) 424 07 71
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PREFACE

Jellyfish are important sea animals, and public awareness of them has increased in the last 40 years due to outbreaks of *Pelagica noctiluca* in the Mediterranean Sea and later *Mnemiopsis* in the Black Sea. In the Black Sea, *Mnemiopsis* is an alien ctenophore that has caused substantive damage to the fisheries industry in the region.

Although *Mnemiopsis leidyi* blooms have decreased in recent years, another alien species of Indo–Pacific Origin, *Rhopilema nomadica,* has now appeared in the Mediterranean Sea causing impacts on biodiversity, tourism and fisheries of the native people of the coastal areas. Fortunately, *R. nomadica* has not yet been found in the Black Sea and the Sea of Marmara. Why have these jellyfish species spread so easily in these areas? Which person, entity or state is responsible? Who is responsible for compensating the local people? Which mechanism, entity or international agreement can protect us from the invasion and damage to our lovely, unique ecosystems? Unfortunately, we have no proper answers to these questions.

The introduction of *M. leidyi* occurred through ship ballast water with the shipping industry as a vector. *R. nomadica* entered the Mediterranean Sea through the Suez Canal, which now poses a greater risk for the entire Mediterranean and Black Sea is due to repeated increases in size.

Nowadays, from the Gibraltar to the Levant Sea, massive and long-standing jellyfish blooms are regular phenomena. Due to the direct influence of jellyfish swarms on the tourism industry, some holiday resorts have already taken measures with nets or fences to exclude them from their beaches. These measures were not necessary in the Mediterranean Sea in earlier decades, such as the sixties. It is obvious that the sea is changing, and we are in the position of trying to predict scientifically what will happen in this new stage. I hope that we will learn from the messages nature is giving us.

We must now take actions to understand what is happening and to prevent further damage. One step has been establishing an awareness program for invasive alien species using posters and booklets. We have already printed some posters both in Turkish and in English and have distributed them in several coastal villages and ports. But this is not enough. Actions are needed to address overfishing, pollution, and global climate change, which are likely to cause increases in jellyfish blooms in the near future. Secondly, we have started to monitor the abundance and population density of jellyfish species in the sea around us.

Finally, this publication is a part of the results of selected species for raising public awareness and our monitoring program. This is for the education of divers, diving guides, sailors, nature lovers, and amateur and professional fishermen. Luckily, citizen science activities are increasing around the Black Sea and Mediterranean Sea, and we now know much more about jellyfish locations and abundance. I sincerely thank all of the contributors to this publication and the people who have provided pictures for this book. Needless to say, I am grateful to the Turkish Underwater Sports Federation for financing this book and to Drs. Elizabeth Hemond and Ayaka Amaha Öztürk for helping the English editing.

Prof. Bayram ÖZTÜRK
Head of Turkish Marine Research Foundation

PART 1. INTRODUCTION TO THE JELLYFISH WORLD

Jellyfish are complex animals that have lived for at least 500 million years on our planet. In the water they are beautiful, with incredible colours, but they are also dangerous. Despite being found in all oceans, even under the ice in Antarctica, they have been the subject of very little study and their taxonomy is not yet completed. These animals are being seen more in our lives, even in the cinema. At the Cannes film festival in 2003, I remember seeing jellyfish in the film "Bright Future" directed by Kiyoshi Kurosawa. I also remember fabulous work of Philippe Cury and Yves Miserey in "Un Mer Sans Poissons" published in 2008. Finally, I was very impressed by "Stung!" written by Lisa-Ann Gershwin in 2013 about jellyfish blooms and the future of the ocean, which showed the large impact of these sometimes tiny animals. How incredible that we are swimming, diving or fishing around these fabulous animals. Jellyfish have also been on menus of Chinese and Japanese cuisine for many centuries because of their low calorie and high protein content, and some jellyfish species are even used for health cure. However, none of the jellyfish species in the Mediterranean and Black Sea is edible. Recently, the European regulation on novel foods (EC 2015/2283) has given an opportunity for edible jellyfish in the diet and this can be a new opportunity for local fishermen.

Jellyfishes have become very well-known marine animals over the past 40 years, since *Pelagia noctiluca* (Cnidaria, Scyphozoa) blooms became common in the Mediterranean Sea during the years 1978-1981. Following these events, the first international workshop on jellyfish blooms was held in Athens by UNEP in 1983 and 1987, with papers published in 1984 and 1991. As an outcome of these workshops, the most significant recommendation was to establish a monitoring program in the Mediterranean countries impacted by the phenomenon. Later there were massive outbreaks of the ctenophore *Mnemiopsis* in the Black Sea, which lasted for a long time and caused substantive damage to the fisheries industry. Because this species is a predator on small pelagic fish eggs and larvae, it can significantly decrease the number of fish that reach maturity. In addition, by feeding zooplankton, which is a primary source of food for adult fish, *Mnemiopsis* outbreaks can cause starvation and accelerate ongoing ecological impacts experienced by fish stocks due to eutrophication. The combined effects related to this new predator have resulted in a drastic decrease of fish production – 4–5 times for Black Sea shad and over 10 times for anchovy, along with a corresponding decline in the biomass of both populations. The regular occurrence of large outbreaks 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. Some jellyfish species, mostly scyphozoans, have been increasingly considered as nuisance species around the Black and Mediterranean Seas because they form very large aggregations with significant ecological and economic impacts. Aggregations, blooms, and swarms can adversely affect important fisheries, sting and injure swimmers, clog the water intakes of power plants, and invade ecosystems in both Black and Mediterranean Seas. The proliferation of jellyfish has caused problems for desalination and seaside power plants that require intake of large volumes of seawater. Even ships can be affected, such as in Australia in 2006 when the USS Ronald Reagan encountered a problem caused by acute fouling in the giant vessel‘s cooling system. The ecological and economic effects of jellyfish outbreaks continue when the jellyfish die and large numbers of jellyfish carcasses are deposited on the shores.

The underlying causes of mass jellyfish outbreaks in the Mediterranean and Black Seas remain poorly understood, in part because of the lack of a monitoring program, difficulty in identifying species, and a lack of knowledge about the ecology of these organisms. According to our research, jellyfish outbreaks are due in part to changing seasonal climate conditions. According to our data (www.tudav.org), warm late springs in the Marmara and Aegean Sea stimulate *Aurelia aurita* blooms, and warm winter (September) waters in the Black Sea have supported *Rhizostoma pulmo* blooms over the past ten years. Other impacts affecting outbreaks are likely to involve changes in food web, pollution and overfishing.

About 100 cnidarian species are known to be harmful to humans. The most toxic species is *Chironex fleckeri,* a box jellyfish species with serious envenomation found around Australia.Fortunately, *C. fleckeri* has not yet reached to the Mediterranean Sea; however, *R. nomadica,* a recent alien invasive species in the Mediterranean Sea, has already caused some cases of hospitalization. This means that public health also must be considered as a serious issue regarding alien invasive jellyfish species. In Europe, hundreds of people were stung in Torremolinos, Spain, in just one day. 19,000 people were treated for sting in summer 2016 by the Spanish Red Cross. Besides, beaches near Malaga were closed. In addition, on the Italian Riviera and the Cote d'Azur in France, some jellyfish stungs were also reported (www.telegraph.co.uk).

Craspedacusta sowerbii is a freshwater jellyfish that is used in biological control of mosquitos, as an alternative to insecticide. The jellyfish is also a matter of Nobel Prize and two prizes have been given already to jellyfish studies.

Finally, some fossil jellyfish species have been discovered mainly in Australia.

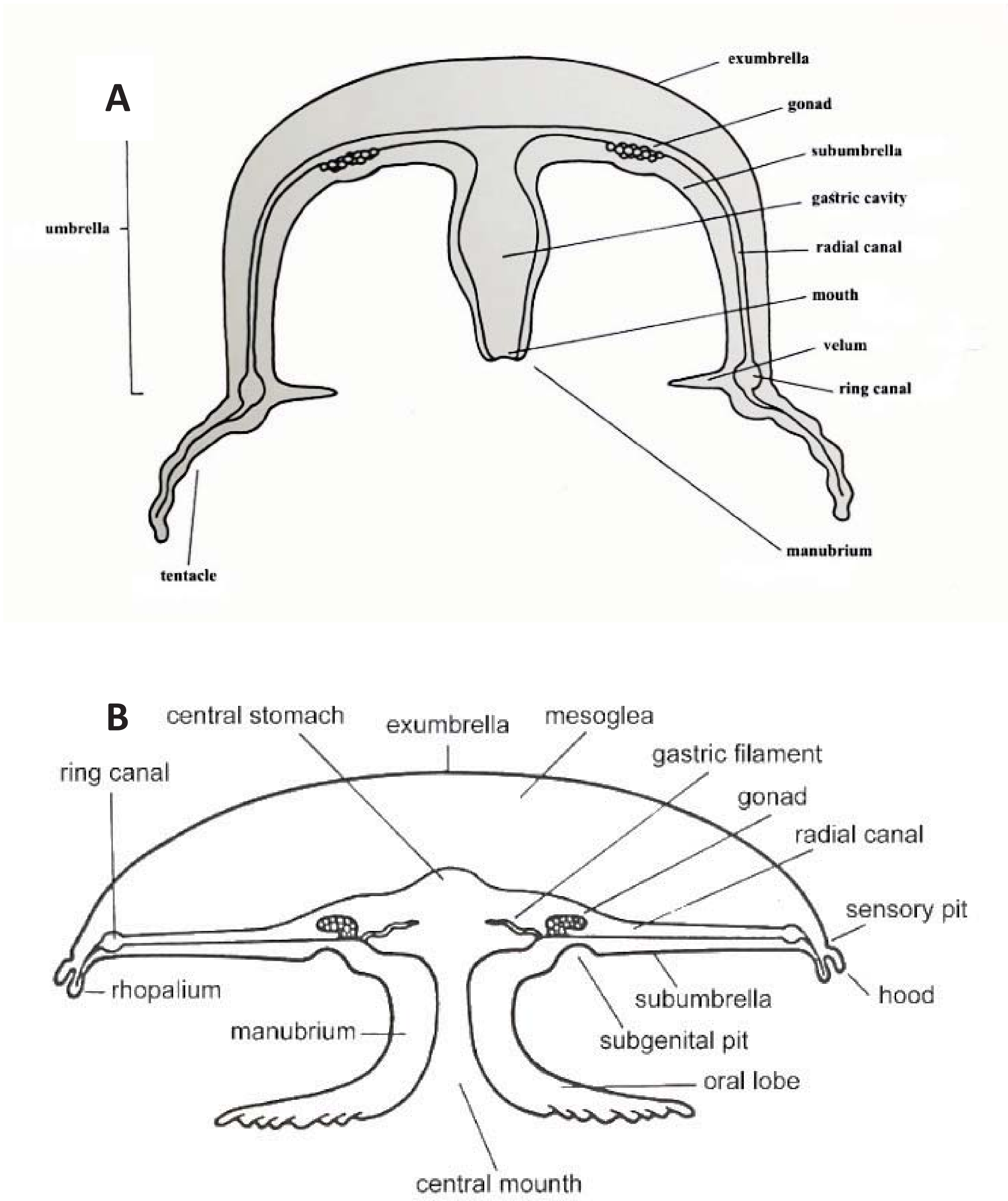


Figure 1. General body plan of Hydrozoa (A) and Scyphozoa, (B) after Stachowitsch (1992)

PART 2. JELLYFISH AND THEIR ROLES IN THE ECOSYSTEM

The jellyfish has important roles in the marine ecosystem and is a crucial part of the marine food web. While most jellyfish are carnivorous and feed on zooplankton, some jellyfish species feed on large crustaceans and other marine creatures. As prey, jellyfish are consumed by sunfish, sea turtles and mackerels in the Black and Mediterranean Seas.

The increase in reports of high jellyfish abundance in recent years can be related to overfishing and fisheries collapses occurring all over the world. According to the GFCM assessment (2016), about 85% of the Black Sea and Mediterranean fish stocks are fished at biologically unsustainable level. Many natural predators of jellyfish, such as *Mola mola, Thunnus thynnus, Caretta caretta, Chelonia mydas,* have experienced population declines in the Mediterranean Sea. When fish populations are diminished, predation on jellyfish also decreases. When this happens, jellyfish populations become dominant in the water column. It has been show that the frequency of jellyfish blooms has an increasing trend yearly for most of the species.

Jellyfish eats zooplankton species such as copepods

Sea turtles feed on jellyfish species.

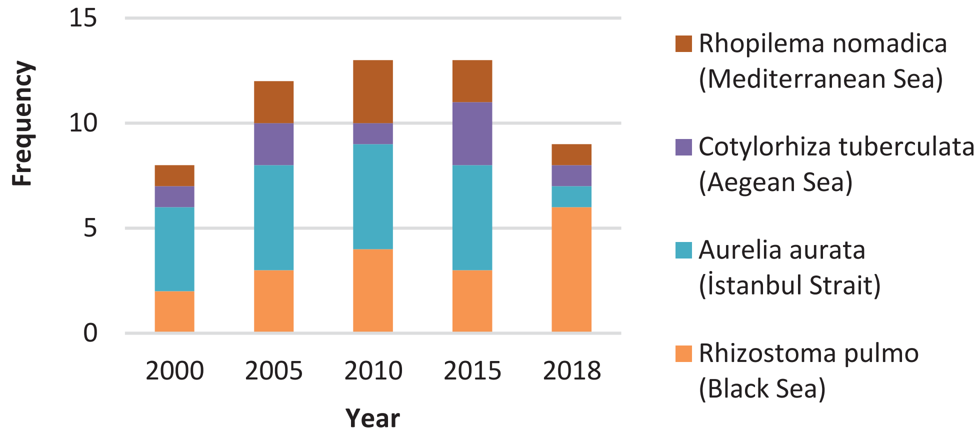


Figure 2. Blooms of the four jellyfish species between 2000 and 2018 around Turkey.

To reduce the occurrence and impacts of jellyfish outbreaks, we must manage the seas to restore their health and equilibrium. It is essential that we enact better management of fisheries, mitigate eutrophication and other forms of pollution and reduce our impact on the climate.

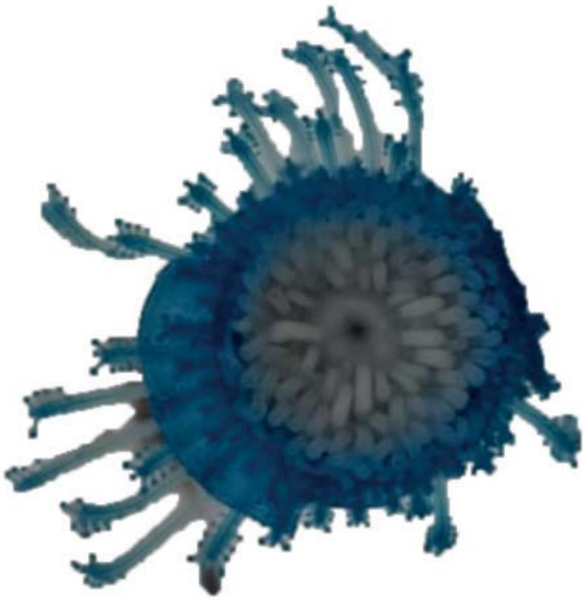
Protection of marine biodiversity is essential for the equilibrium of the seas. Ultimately, control of jellyfish populations requires healthy populations of their predators, like sun fish, sea turtles as and others. We also know that some alien jellyfish species easily adapted to the Mediterranean Sea due to lack of predators.

PART 3. SELECTED JELLYFISH SPECIES

HYDROZOA

Porpita porpita (Linnaeus, 1758)

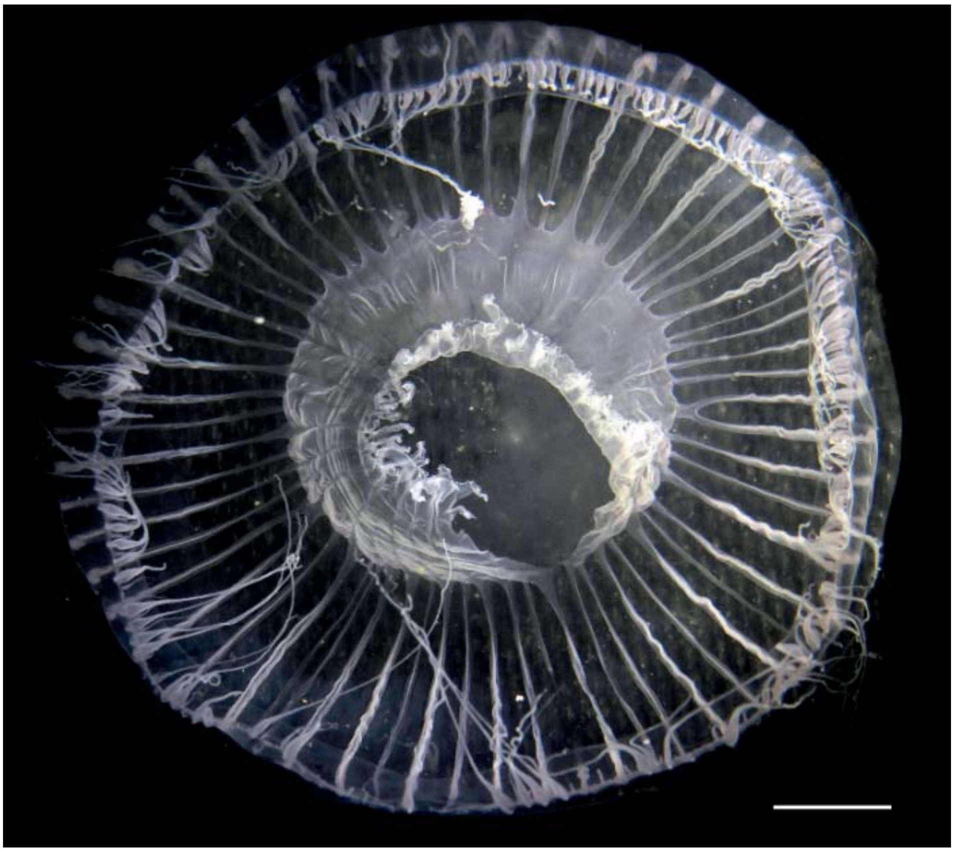
Classification
- Animalia (Kingdom)
  - Cnidaria (Phylum)
    - Hydrozoa (Class)
      - Hydroidolina (Subclass)
        - Anthoathecata (Order)
          - Porpitidae (Family)
            - *Porpita* (Genus)
              - *P. porpita* (Species)



Porpita porpita, usually known from its bright blue color, is from the family Porpitidae within the class Hydrozoa (Saygın 2017). The specimens are easily carried to shore by wind and water currents. The venom of *P. porpita* may cause mild irritation to human skin. Very mild stinger.

Aequorea vitrina Gosse, 1853

Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Hydrozoa (Class)
Hydroidolina (Subclass)
Leptothecata (Order)
Aequoreidae (Family)
Aequorea (Genus)
A. vitrina (Species)

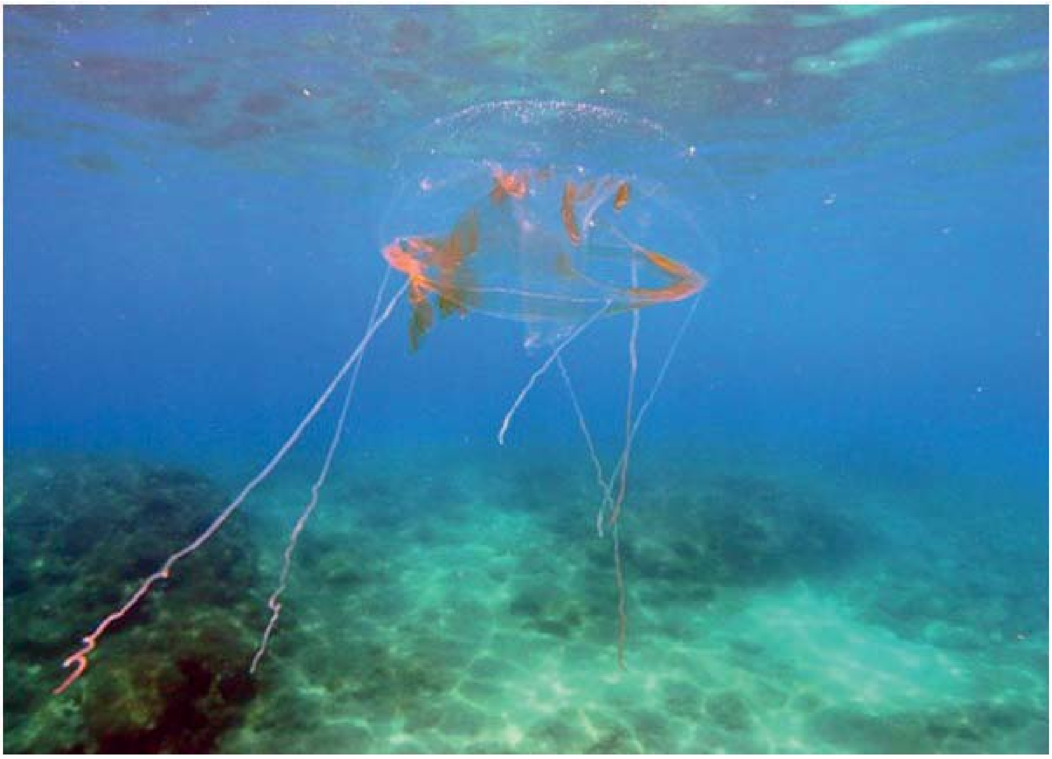


Aequorea vitrina from the Marmara Sea (Yılmaz *et al.* 2017)

Aequorea vitrina is a temperate north-eastern Atlantic Ocean species with profound impacts on the food webs. This species was first reported from the Turkish marine waters in the Istanbul Strait by Yılmaz *et al.* (2017).

Geryonia proboscidalis (Forsskål, 1775)

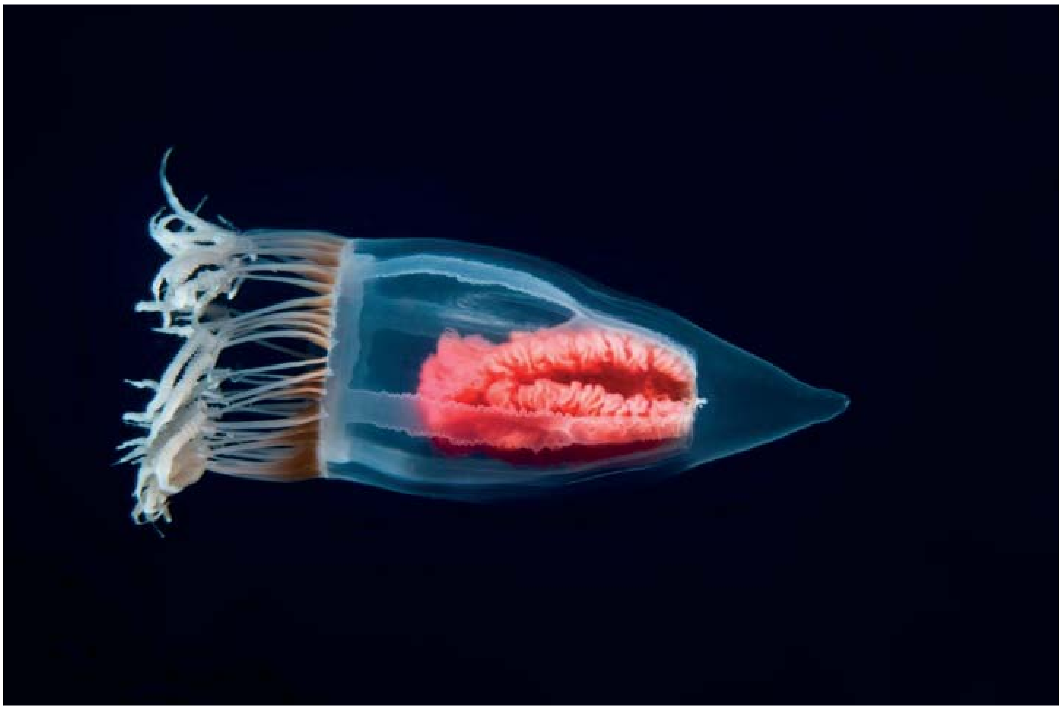
Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Hydrozoa (Class)
Trachymedusae (Order)
Geryoniidae (Family)
Geryonia (Genus)
G. proboscidalis (Species)



Geryonia proboscidalis was first reported from the Turkish marine waters by Gülşahin *et al.* (2013) and later by Ergüden *et al.* (2014).

Neoturris pileata (Forsskål, 1775)

Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Hydrozoa (Class)
Anthoathecata (Order)
Pandeidae (Family)
Neoturris (Genus)
N. pileata (Species)



Neoturris pileata is a neritic species with a wide distribution in the northern North Sea, North Atlantic Ocean, Mediterranean Sea, Eastern and Western South Atlantic Ocean, and Indo-Pacific Ocean. This species was also reported from the Turkish coastal waters in the central part of the Marmara Sea and at the entrance of the Istanbul Strait by Isinibilir *et al.* (2010).

Olindias muelleri Haeckel, 1879

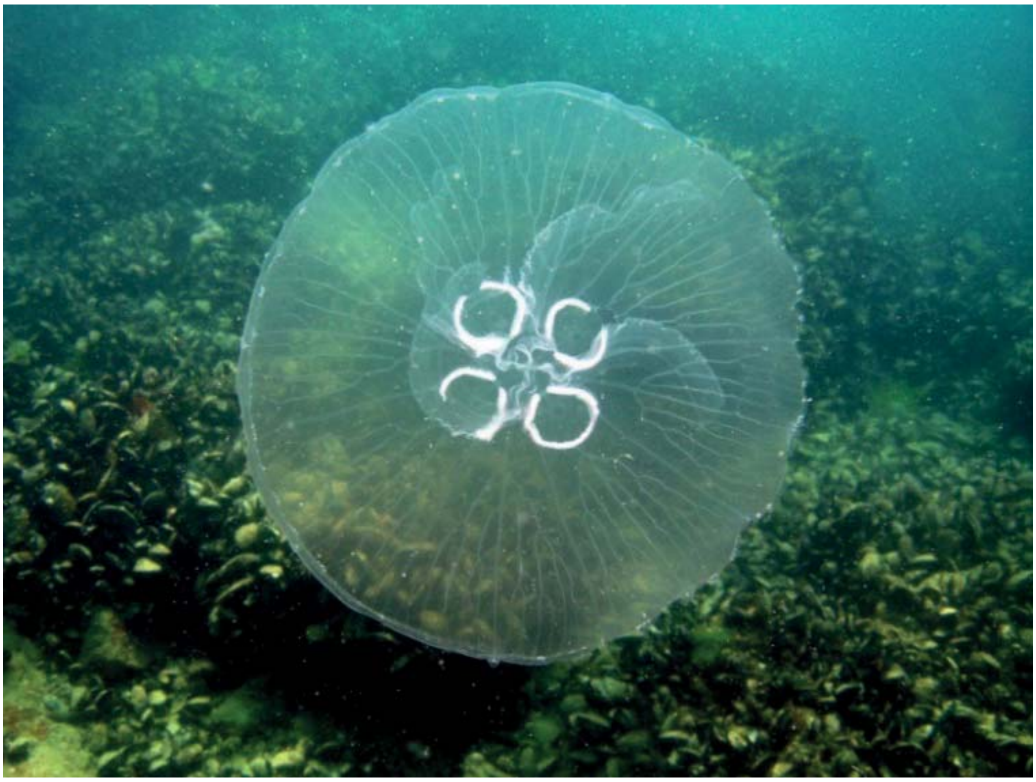
Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Hydrozoa (Class)
Limnomedusae (Order)
Olindiidae (Family)
Olindias (Genus)
O. muelleri (Species)

Olindias muelleri (as invalid name *O. phosphorica*) was reported by Eleftheriou *et al.* (2011) from the Aegean part of Turkey. This species has a mild sting.

SCHPHOZOA

Aurelia aurita (Linnaeus, 1758)

Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Scyphozoa (Class)
Discomedusae (Subclass)
Semaeostomeae (Order)
Ulmaridae (Family)
Aurelia (Genus)
A. aurita (Species)



Aurelia aurita, the moon jellyfish, is carnivorous and feeds mostly on planktonic species (i.e. planktonic crustacea and mollusca species, including the planktonic stages of benthic species). *A. aurita* is common in all seas globally. Population of *A. aurita* depend on various environmental factors. The abundance of plankton is the most important factor determining *A. aurita* populations, but increasing sea water temperature is another important factor (Öztürk *et al.* 2004).

Although *A. aurita* is generally considered harmless to humans, they may negatively affect tourism and fisheries during periods of over-proliferation. Increases in numbers of *A. aurita* are predicted in the future, meaning coastal areas will be more heavily impacted by this species (Mills 2001). The nematocysts of *A. aurita* contain a weak and non-irritating poison; however, in case of contact with sensitive skin and mucous membranes (lips, eyes, etc.) they can cause discomfort and itching (Isinibilir *et al.* 2017). This species can be called a very mild stinger (Isinibilir *et al.* 2017).

Bloom of *A. aurita*

A. aurita is a dominant species involved in jellyfish blooms in the Istanbul Strait (Bingel 1987). Blooms start in March and continue until the end of the October in the Black Sea and Sea of Marmara. Blooms of *A. aurita* impact fisheries and can clog and damage fishing nets. In the Eastern Mediterranean Sea blooms of *A. aurita* last only for a short period of time.

Bloom of *A.aurita* in the Istanbul Strait.

A. aurita

A. aurita in a fishing net.

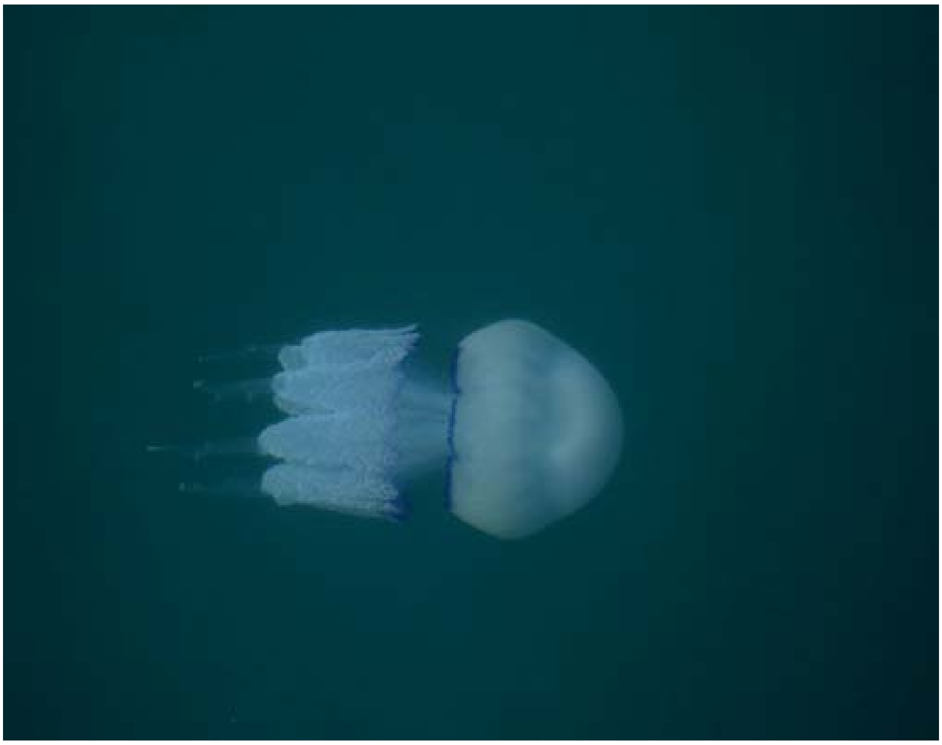
Stranded *A. aurita*.

Rhizostoma pulmo (Macri, 1778)

Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Scyphozoa (Class)
Discomedusae (Subclass)
Rhizostomeae (Order)
Rhizostomatidae (Family)
Rhizostoma (Genus)
R. pulmo (Species)

Rhizostoma pulmo is usually known as barrel jellyfish. The surface color of its umbrella is typically pale grey and colourless. The marginal lappets are narrowly edged with an ultramarine blue, violet, or brown line of dense colour. The mature medusae are observed mostly in late summer through the winter season. This species is common and easily observed in all the seas of Turkey (Öztürk *et al*. 2004; Çınar *et al*. 2014).

Blooms occur often in the Black Sea between September and November, which is the season of high bonito and bluefish abundance. This species is a very mild stinger (Isinibilir *et al.* 2017).

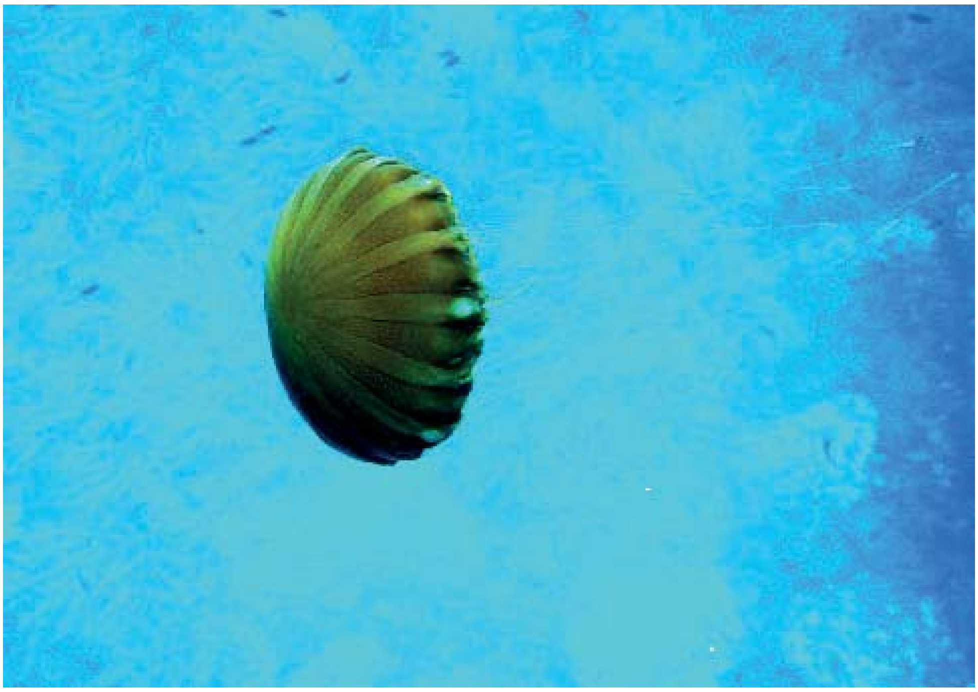


R.pulmo blooms in the Black Sea

R. pulmo among bonito catch

Chrysaora hysoscella (Linnaeus, 1767)

Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Scyphozoa (Class)
Discomedusae (Subclass)
Semaeostomeae (Order)
Pelagiidae (Family)
Chrysaora (Genus)
C. hysoscella (Species)



Chrysaora hysoscella, compass jellyfish, has 16 V-shaped yellow-brown bands extending from the top of the hemispherical body structure to the edge. *C. hysoscella*, commonly found in the Mediterranean, was reported from the Turkish coasts of the Mediterranean by Bingel *et al.* (1991). Due to a sudden increase in abundance of this species in the Sea of Marmara, this species has caused many hospital cases in previous years (Isinibilir and Yılmaz 2017). This species is a very mild stinger.

Cassiopea andromeda (Forsskål, 1775)

Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Scyphozoa (Class)
Discomedusae (Subclass)
Rhizostomeae (Order)
Cassiopeidae (Family)
Cassiopea (Genus)
C. andromeda (Species)

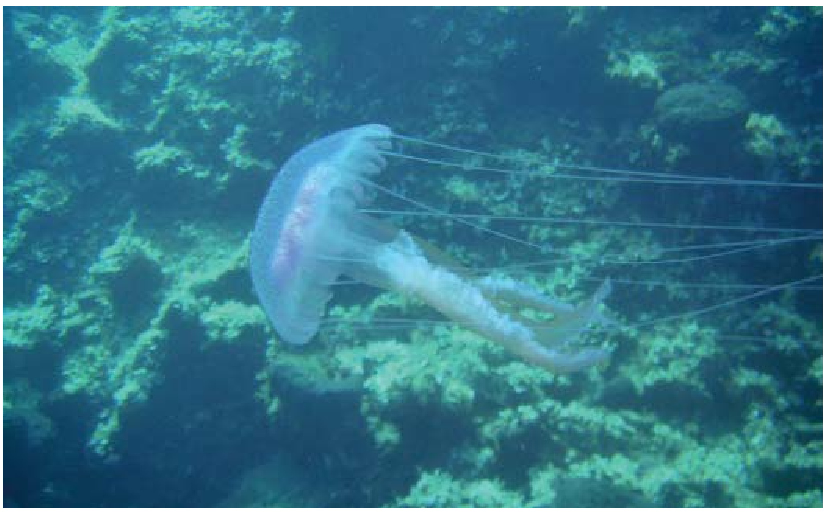
Cassiopea andromeda is a Lessepsian species which entered into the Eastern Mediterranean Sea through the Suez Canal (Galil *et al.* 1990; Bilecenoglu 2002; Özbek and Öztürk 2015). The colour is typically brown and they are usually at the sea bottom, upside down, with tentacles pointing upwards. Very mild stinger (Isinibilir and Yılmaz 2017).

Pelagia noctiluca (Forsskål, 1775)

Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Scyphozoa (Class)
Discomedusae (Subclass)
Semaeostomeae (Order)
Pelagiidae (Family)
Pelagia (Genus)
P. noctiluca (Species)

Pelagia noctiluca is one of the most common jellyfish species in the Mediterranean Sea. It has been reported from Gökçeada Island in the North Aegean Sea (Öztürk and Topaloğlu 2011).

P. noctiluca is one of the most dangerous Mediterranean jellyfish and its venom can produce redness, swelling and blisters as well as persisting pain at the site of the sting (Isinibilir *et al.* 2017). Blooms have been very common since 1978 in the Mediterranean Sea and since 1988 in the Turkish part of the Mediterranean Sea. This species can severely impact aquaculture and caused the death of more than 100,000 salmon in a salmon farm in Ireland in 2007 (Doyle *et al*. 2008). But, there has been no record for the sea bass or sea bream cages in the Mediterranean Sea.

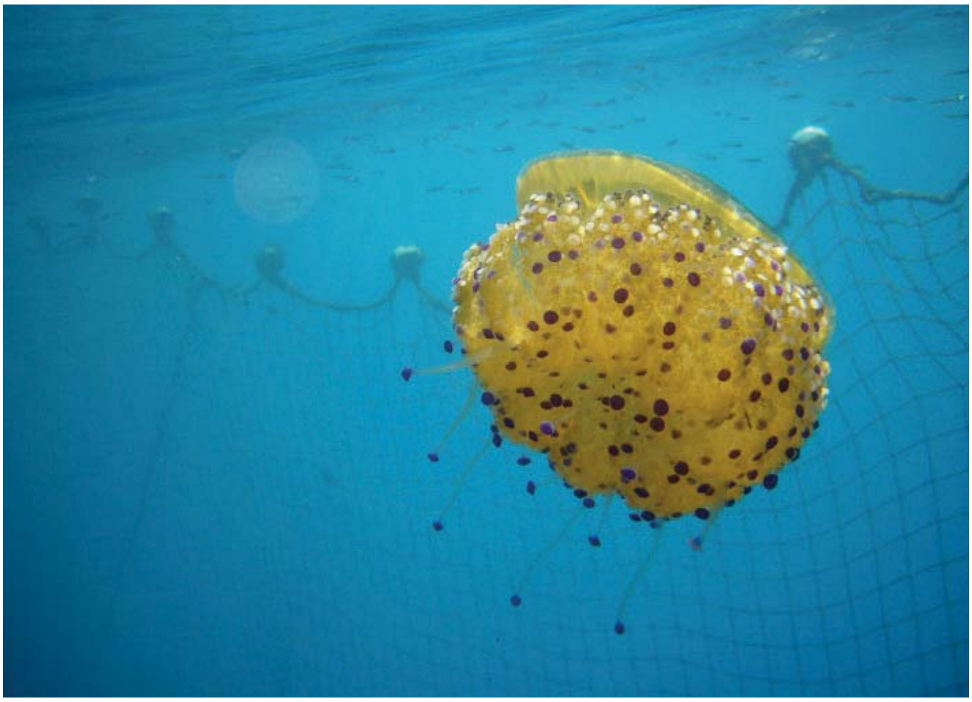


Cotylorhiza tuberculata (Macri, 1778)

Classification
- Animalia (Kingdom)
  - Cnidaria (Phylum)
    - Scyphozoa (Class)
      - Discomedusae (Subclass)
        - Rhizostomeae (Order)
          - Cepheidae (Family)
            - *Cotylorhiza* (Genus)
              - *C. tuberculata* (Species)

Cotylorhiza tuberculata is one of the native jellyfish species in the Mediterranean Sea. The common name for this species is “Fried Egg Jellyfish” due to having a dome on the central part of the umbrella which looks like a fried egg.

Although *C. tuberculata* is not a strong stinger, it can cause discomfort by creating mild itching in case of contact with sensitive skin and mucous membranes (Isinibilir *et al.* 2017). Some fishes such as *Salpa salpa* and *Trachurus trachurus* use the tentacles of this species as temporary habitat. Blooms of *C. tuberculata* occur in the central Aegean Sea (Gülşahin and Tarkan 2011). In 2018, some blooms were also reported in the Aegean Sea by aerial survey.



Beach net against *C. tuberculata*

Rhopilema nomadica Galil, Spanier&Ferguson, 1990

Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Scyphozoa (Class)
Discomedusae (Subclass)
Rhizostomeae (Order)
Rhizostomatidae (Family)
Rhopilema (Genus)
R. nomadica (Species)

Rhopilema nomadica has a nearly spherical icy-blue-colored umbrella with long oral lobes and large scapulets with long filaments. *R. nomadica* is a Lessepsian species that migrated to Mediterranean Sea from the Red Sea via the Suez Canal. *R. nomadica* first appeared along the coast of Turkey in Mersin Bay in 1995 (Kideys and Gücü 1995). Gülşahin and Tarkan

(2011) later reported this species from the southern Aegean coast of Turkey.

Massive swarms of this stinging nomadic jellyfish have been considered a threat to human health, tourism and fisheries. As a result of the dramatic increase in its abundance along the Mediterranean coast of Turkey in the summer of 2009, there were many cases of hospitalization recorded by Öztürk and Isinibilir (2010).

After a trawl catch, *R. nomadica* is on the deck

Blooms of stinging jellyfish of Indo-Pacific origin, like *R. nomadica,* cause damage to local economies when they become entangled in fishing nets or stranded on beaches where they can frighten tourists. Blooms of *R. nomadica* have been reported by Turan *et al*. (2011) and by Sakınan (2011) from the eastern Mediterranean Sea.

Phyllorhiza punctata Lendenfeld, 1884

Classification
  Animalia (Kingdom)
    Cnidaria (Phylum)
      Scyphozoa (Class)
        Rhizostomeae (Order)
          Mastigiidae (Family)
            Phyllorhiza (Genus)
              P. punctata (Species)

Phyllorhiza punctata is a Lessepsian jellyfish species reported from the eastern Mediterranean Sea. Juveniles of the alien shrimp scad fish *Alepes djedaba* have been observed nestling among its tentacles (Çevik *et al.* 2011). The impact of *P. punctata* on the biota and human activities in the eastern Mediterranean Sea is not yet known. This species is venomous with a very mild stinger.

Discomedusa lobata Claus, 1877

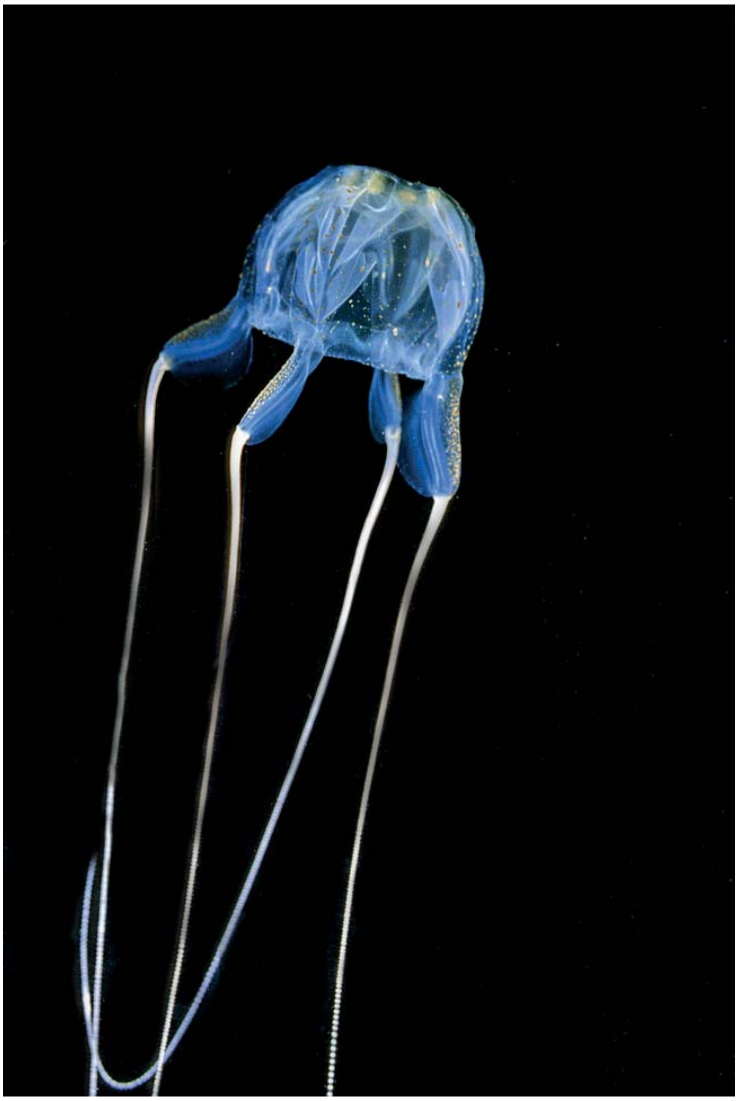
Classification
  Animalia (Kingdom)
    Cnidaria (Phylum)
      Scyphozoa (Class)
        Semaeostomeae (Order)
          Ulmaridae (Family)
            Discomedusa (Genus)
              D. lobata (Species)

Discomedusa lobata has been recorded in the Mediterranean Sea and in the northeast Atlantic Ocean. It was sampled for the first time from Izmit Bay in March 2011. Two years later, an increase in the abundance of this species was observed in the upper waters of the Marmara Sea near the Princes' Islands (Isinibilir *et al.* 2015). *D. lobata* is a mild-stinging species with little or no effect on humans (Montgomery *et al.* 2016).

CUBOZOA

Carybdea marsupialis (Linnaeus, 1758)

Classification
Animalia (Kingdom)
Cnidaria (Phylum)
Cubozoa (Class)
Carybdeida (Order)
Carybdeidae (Family)
Carybdea (Genus)
C. marsupialis (Species)

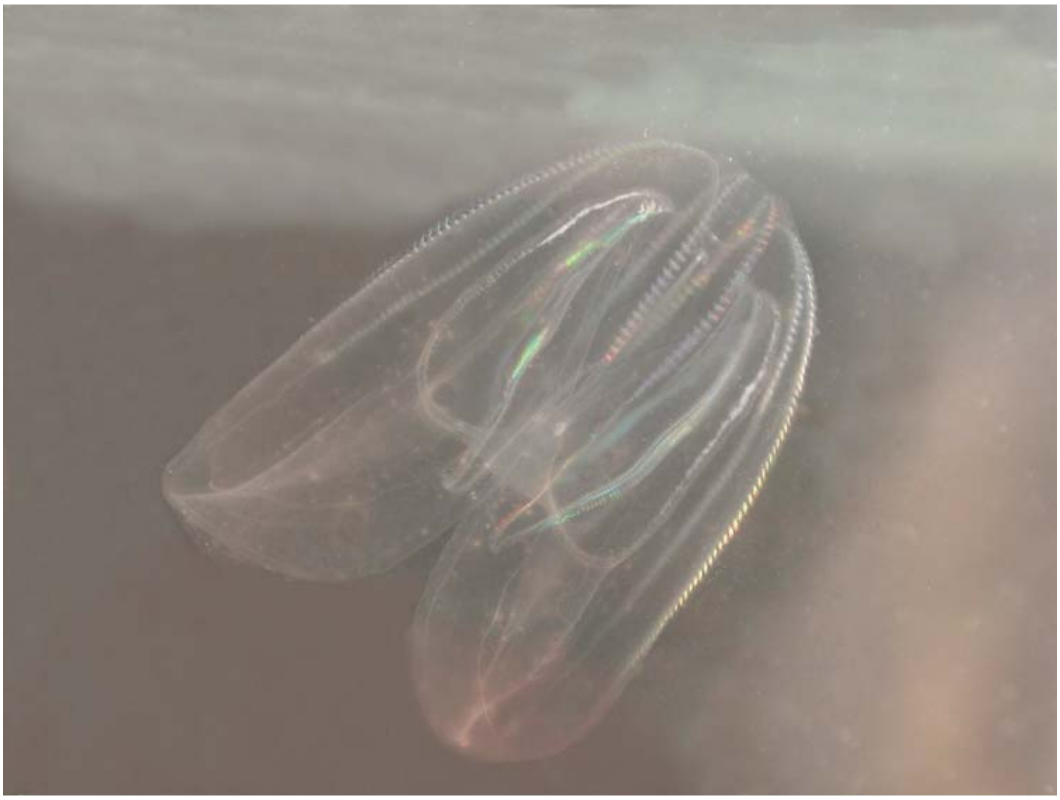


Carybdea marsupialis is the only cubozoan found in the Mediterranean Sea and was first recorded from the Turkish part of the Aegean Sea by Geldiay and Balık (1977). This species is translucent with bluish-white coloration. It does not present oral arms, only four thin whitish tentacles that extend from each side of the umbrella. *C. marsupialis* is a strong stinging species with severe effects on humans (Isinibilir and Yılmaz 2017). It is recommended to avoid all contact with this jellyfish. The sting produced by *C. marsupialis* is usually very painful. Bright red papules may appear on the skin, and in some exceptional cases muscle cramps, vomiting, tiredness and anxiety may occur.

TENTACULATA

Mnemiopsis leidyi A. Agassiz, 1865

Classification
- Animalia (Kingdom)
  - Ctenophora (Phylum)
    - Tentaculata (Class)
      - Lobata (Order)
        - Bolinopsidae (Family)
          - *Mnemiopsis* (Genus)
            - *M. leidyi* (Species)

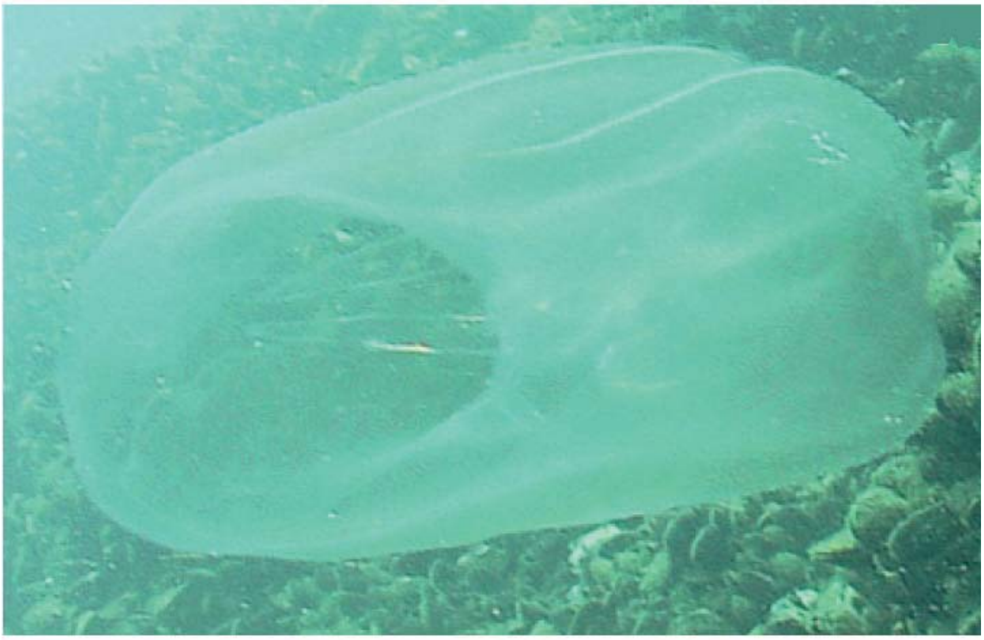


Mnemiopsis leidyi is a carnivorous ctenophore introduced into the Black Sea in the beginning of the 1980s in the ballast water of ships from the western North Atlantic (Shiganova 1998; Zaitsev and Öztürk 2001). Three major impacts of *M. leidyi* blooms on fisheries have been identified. (1) Excessive predation on fish eggs and larvae; for example, in shelf waters, *M. leidyi* has been estimated to graze up to 70 % of total ichthyoplankton stock (Tsikhon-Lukanina *et al*. 1993). (2) Feeding on larvae and adult fish food, such as zooplankton, thus causing starvation. (3) Further accelerating ongoing ecological change, presently being experienced due to eutrophication; for example, direct impacts of anoxia on the pelagic and benthic systems due to a massive precipitation of mucus and dead ctenophores.

The combined effects related to this introduced predator have resulted in a drastic decrease of fish production; 4–5 times for Black Sea shad and over 10 times for anchovy. The 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. There has been a decline in the biomass of both populations and catch in about the same proportions, which has caused large scale damage to the fisheries (Zaitsev and Öztürk 2001). Indeed, the annual loss in fish catches attributed to the *M. leidyi* plague has been calculated at approximately USD 200 million in the Black Sea and USD 30–40 million in the Sea of Azov, according to the GESAMP reports.

Bolinopsis vitrea (L. Agassiz, 1860)

Classification
Animalia (Kingdom)
Ctenophora (Phylum)
Tentaculata (Class)
Lobata (Order)
Bolinopsidae (Family)
Bolinopsis (Genus)
B. vitrea (Species)



Bolinopsis vitrea is widely distributed in subtropcial waters and also occurs in the eastern and western Mediterranean, including the Aegean and Adriatic Seas.

Öztürk *et al*. (2011) reported the ctenophore *B. vitrea* from the Turkish and Bulgarian regions of the Black Sea. In Turkish waters, a considerable aggregation of *B. vitrea* was found in Şile on the Asian side and at Kilyos on the European side in 2007. In 2010, individuals of this species were recorded at two locations in Bulgarian waters where it may have entered with currents or was released with ballast waters.

NUDA

Beroe ovata Bruguière, 1789

Classification
 Animalia (Kingdom)
  Ctenophora (Phylum)
   Nuda (Class)
    Beroida (Order)
     Beroidae (Family)
      Beroe (Genus)
       B. ovata (Species)

Beroe ovata is an alien ctenophore species in the Black Sea, although it is native to the Mediterranean and Marmara Seas. The likely mechanism of penetration of this comb jellyfish into the Black Sea is transfer in ballast water of ships from the estuaries along the North Atlantic Ocean where this species is tolerant to lower salinity. This is probably the same mode of invasion as for *Mnemiopsis leidyi*, which is a natural prey of *B. ovata* in the North Atlantic Ocean. An alternate hypothesis is that *B. ovata,* which lives natively in the Mediterranean and Marmara Sea, entered the Black Sea and acclimatized during the abnormally warm winters of 1997–1998 and 1998–1999 and summer of 1999. Since showing up in the Black Sea in 1998, *B. ovata*, a predator of the ctenophore *M. leidyi*, has helped to control *M. leidyi* populations. As a result, the planktonic food web structure has partially recovered by reducing the negative impacts of *M. leidyi*. *B. ovata* predominantly inhabits a 30 mile-width of the coastal zone of the Black Sea. Most probably the reproduction of this species takes place in open waters (Zaitsev and Öztürk 2001).

PART 3. JELLYFISH ENVENOMATION: EPIDEMIOLOGY, CLINICAL MANIFESTATIONS, MANAGEMENT AND PREVENTION

Introduction

Extreme climatic events driving immigration of invasive species and increases in jellyfish populations have resulted in an increase of jellyfish-related envenomation injuries across the globe (Kaffenberger *et al.* 2017; Oiso *et al*. 2005). There is a great diversity of cnidarian venoms and about 100 cnidarian species are considered harmful to humans (Tezcan 2016). Jellyfish envenomation generally occurs as itchy skin eruptions that appear on the skin after dermal contact with a jellyfish (Yoffe and Baruchin 2004). Additional systemic symptoms, such as malaise, fever, vomiting, and other digestive system or cardiovascular complaints, can occur in a minority of patients. While swimming or walking on the shore, we never know when and how we may be stung, and most stings occur by accident. In the event that we or our companions are stung by jellyfish, it is important to know how to diagnose and treat the envenomation. This chapter is meant to serve two purposes: 1) to show and describe the etiological factors and clinical appearance of jellyfish envenomation, 2) to provide the reader with updated information enabling the reader to initiate the most current means of treatment.

Epidemiology

Jellyfish stings are a common occurrence in the coastal waters of the Mediterranean Sea, and they are the main cause of marine envenomation, with an estimated 150 million envenomations annually (Cańas *et al.* 2018). It is also estimated that 60,000 to 200,000 annual stings occur along the Florida coast of United States (Burnett 1992). Although the symptoms of jellyfish envenomation are generally mild, the stings of some dangerous jellyfish species can be deadly. As a result there are a lot of human fatalities due to jellyfish stings, mostly occurring in tropical and subtropical waters in the World.

Jellyfish stings can affect swimmers, bathers, divers, fishermen, sailors, holiday makers walking on the beach, and even consumers of commercially available jellyfish products. Jellyfish are more common at the beginning and end of summer; however, they may appear at any time of the year. Envenomation cases tend to increase in warm and hot seasons of the year. Incidental netting of a jellyfish with long tentacles during fishing may increase the risk of envenomation (Bury *et al.* 2012). Deaths may occur both in the sea and on fishing boats (Byard 2013). Children, elders and immunocompromised victims may be severely affected (Fenner1998). Envenomation can happen as a result of being careless and making contact with the animal either accidentally or intentionally. Jellyfish envenomation may result in three outcomes related to the symptoms they cause: nuisance stings, severe envenomation with systemic effects, and human fatality. It is important to remember that a sting may start as a mild form of envenomation but progress into a life threatening situation (Fenner1998).

Pathophysiology

The jellyfish has a central bell and a mouth surrounded by several elongated tentacles (Figure 1) that range in lengths from 1 cm to 300 cm. These tentacles contain stinging venomous capsules called nematocysts (Berling and Isbister 2015). Jellyfish use the tentacles to catch small animals or even much larger prey using the venomous sting that can paralyze and kill its victim. If a person comes into contact with these tentacles accidently, either in the sea or on shore, the symptoms of jellyfish envenomation can develop (Currie and Jacups 2005). Touch or vibration in the water can trigger the nematocyst to shoot out the barb, which penetrates the skin. Then the jellyfish releases a mixture of proteinaceous toxin into the damaged skin. The venom is usually absorbed from the soft tissue of the underlying skin into the vascular circulation (Burnett and Calton 1987). Subsequently, the envenomation results in local, mostly skin related, symptoms, but may also involve systemic symptoms.

Clinical Manifestations

The severity of stings varies widely. A number of factors can affect the envenomation response. These are grouped in to four categories including 1) animal related (size, age, species, and health of animal); 2) human related (size, age, and overall health of the patient); 3) the duration of physical contact; 4) body surface and skin area that has been affected. For instance, due to the smaller body size of children compared with adult, effects of envenomation may involve more severe symptoms for children, particularly for stings involving larger specimens of jellyfish (Pereira *et al.* 2018).

Symptoms produced by a jellyfish sting vary in degree rather than quality. Pain is a common symptom and is usually described as immediate, intense, and burning in nature. The area of skin in contact with the jellyfish becomes a zone of redness surrounded by edema (Figure 2, 3). The pain, which can continue for hours or even prolong to a couple of days, may be extremely severe (Berling and Isbister 2015). Vesiculopapular lesions and bulla formation of the skin may develop. Subsequent sloughing of the tissues around the injured site may occur (Table 1). The lesions occur on different areas of the body including the lower limbs, upper limbs, trunk, head and neck, depending on where contact was made with the jellyfish (Haddad *et al.* 2018). Other symptoms which may present are: nausea, vomiting, pallor, fever, joint aches, shortness of breath, convulsions, delirium, low or high blood pressure, heart failure, respiratory distress and death (Table 2, 3, 4). Death may occur through three mechanisms: hypersensitivity, the effect of several toxins on the cardiovascular and the respiratory system or the effect of toxins on the liver. Most envenomation by jellyfish cause local reactions (Yoshimoto and Yanagihara 2002). However, in the case of an allergic reaction to the venom, patients may suffer anaphylactic-like reactions. It is stated that a single nematocyst is sufficient to induce anaphylaxis (Klotz *et al.* 2009). Fatalities due to anaphylactic-like or toxic reactions have also been reported (Stein 1989).

Diagnosis

In case of envenomation by jellyfish, it is essential to evaluate the victim with information about the details of accident. This information includes a description of the animal, location, time, onset, progression and quality of symptoms and signs, and any treatments that have been attempted. Two key factors are the main predictor of the outcome: estimating the extent of the envenomation, and assessing the possible progression. The sting may or may not have been witnessed, a clear history may or may not be available.

Diagnostic clues are gathered by a careful assessment of the clinical manifestations, experience and knowledge of the onset and progression of the symptoms, and a detailed history about the injury on site. However, the diagnosis of envenomation is sometimes overlooked by inexperienced physicians. So, health care providers should keep in mind that both misidentification and disregard of the possibility of jellyfish envenomation are possible, particularly in cases involving small sized jellyfish species.

First aid and Treatment

Please be prepared to manage an allergic reaction following a jellyfish sting.

The treatment of jellyfish envenomation is determined by the severity of the injury. Treatments vary widely, depending upon the type of jellyfish, the geographic location, the part of the jellyfish (body or tentacle), the size of the sting, and the individual patient (Haddad *et al*. 2009). It is strongly recommended to provide early consultation with a physician or toxicologist experienced in treating marine envenomation.

Here, we aim to give you some guidance to manage the sting. Prompt diagnosis and proper health care may dramatically help to reduce the detrimental effect of envenomation. One can start treatment at the site and continue until the admission to the hospital is completed.

List of recommendations for treatment of a jellyfish sting.

- Stay calm and leave the water or remove the victim from the water immediately because of the risk of anaphylactic shock and drowning.
- Informed somebody that you were stung by jellyfish and need medical help.
- Monitor the victim for severe allergic reaction.
- Rinse the wound with sea water. Do not place the wound under running fresh or tap water.
- Do not scrub the injured site, as the nematocysts may explode and intensify the local symptoms.
- Do not touch to the wound with bare hands. Remove any tentacles or foreign bodies by means of tweezers.

- Rinse the wound with vinegar to stabilize the nematocysts and reduce pain.
- Shave the affected area with shaving cream and a safety razor to help remove nematocysts (Figure 4).
- In case of persistent pain, soak the wound in heated, non-scalding water. In some cases, the hot water may be effective only for controlling the pain.
- Call 112 (in Turkey) or the local emergency hot line in the country as soon as possible.
- Initiate a preliminary assessment regarding vital signs, and plan first aid treatment.
- Check vital signs; such as circulation, airway and breathing.
- Carry out first aid treatment after a life-threatening injury before the arrival of emergency service.
- If there is no medical facility near to the accident location, one may take antihistaminic drugs and pain killer. Early medication will help to control clinical symptoms such as edema and pain and reduce the damage to the injured site.
- Apply an antiseptic solution and topical antibiotic ointment to the wound.
- Marine envenomation should not be underestimated. Monitor for systemic allergic reactions and wound infection.
- Once the victim has received the first aid and emergency treatment please contact Turkish Marine Research Foundation (TUDAV) (E-mail: tudav@tudav.org, Phone: +90 216 424 07 72) for the record.

The management for most jellyfish stings is the same, namely, topical acetic acid 5%, hot water immersion (42-45^{0}C, immerse for 30-90 min or until pain relief), and topical corticosteroid or antihistaminic cream (Rosetto *et al*. 2015). Using vinegar (acetic acid) helps to inactivate the tentacles which contain thousands of nematocysts (Seymour 2017). In severe cases a systemic corticosteroid treatment is needed (Seymour 2017; Hornbeak and Auerbach 2017).

To minimize the sea bather's interaction with the stinging nematocysts, swimwear should be changed upon leaving the water. It is recommended to wash the swimwear using hot water with detergent and fully dry it in the machine or sun before reuse (Hornbeak and Auerbach 2017).

The treatment may vary for stings caused by different species of jellyfish. Some injuries should be treated with the application of vinegar, while others should be cooled with ice pack or immersed in hot water. If cutaneous findings are predominant, the treatment includes supportive care, warm water rinses, vinegar soaks, topical corticosteroids, and topical antihistamines (Kaffenberger *et al.* 2017; Haddad *et al.* 2009). As the temperature of water will cool over time, hot-water baths need to be re-warmed every five minutes. Therefore, a thermal isolater can be used to keep the temperature at 42-45 $^{\circ}$C for a standard duration of 30 minutes (Lau *et al.* 2011). Due to the infection risk to the wound by numerous microorganisms found in freshwater or saltwater, specific wound care should be applied. In the case of infected wounds, tissue cultures should be taken for the identification of the microbe. Antibiotics should not be given prophylactically until the findings of infection are confirmed. Itchy skin lesions usually respond to systemic and topical antihistamines. Pain can be relieved by using corticosteroids and topical anesthetics (De Donno *et al.* 2014).

Pain management is essential in the treatment of envenomation. Ice packs or hot water application are widely used treatment approaches. Some medical scientists advise to use hot water immersion in order to relieve pain for first aid and treatment of jellyfish stings. Burnett reviewed 113 cases of jellyfish sting finding that the most common clinical feature was acute local pain of anaphylaxis or anaphylactic reaction; persistent or delayed local cutaneous syndrome were other documented features. Six cases resembled the Irukandji syndrome described from northern Australia, characterized by severe pain and signs of catecholamine release, including muscle cramping, elevated blood pressure, diaphoresis, and tremor. The author concluded that treatment with heat application, usually by means of a whole-body hot shower, appeared to provide better clinical improvement than parenteral analgesics or tranquillizers, particularly in patients with the Irukandji-like syndrome (Burnett and Calton 1987). Wilcox and colleagues report that evidence to support the benefit of ice packs is inadequate, and hot-water immersion is more effective in relieving the pain of stings (Wilcox and Yanagihara 2016). Isbister and colleagues insist on protocols recommending icepacks for reducing the pain of major box jellyfish (*Chironex fleckeri*) stings (Isbister *et al.* 2017).

Although there is a difference of opinion regarding the application of certain treatments such as vinegar soaking, hot water immersion, and ice pack application, researchers mostly prefer vinegar application to inactivate nematocysts and prevent their discharge. In 2013, it was reported in a Cochrane Review that no clear benefit was observed in treatment of jellyfish envenomation by means of different treatment managements (Li *et al.* 2013).

In severe envenomations, the sting begins with a mild to moderately painful burning sensation that progresses to the onset of severe systemic symptoms, such as chest pain, back pain, abdominal pain, gastrointestinal symptoms, agitation, hypertension and palpitation. Systemic symptoms or anaphylaxis may need respiratory and cardiovascular support, including airway support, supplemental oxygen, intravascular volume resuscitation, administration of epinephrine and corticosteroid. Rarely a delayed reaction may develop after 4-8 weeks at the wound site and may require topical or systemic steroid treatment (Hamann *et al.* 2014; Li *et al.* 2013, Cegolon *et al.* 2013).

Some victims who are susceptible to allergic reaction may experience a rapid appearance of respiratory and cardiac arrest within minutes of the sting. In case of an anaphylactic reaction occurring in the sea, an adrenaline treatment is advised to be administered subcutaneously (0.01 mg/kg) with intravenous hydrocortisone (10 mg/kg). Prompt treatment may help significantly with the recovery and improve the systemic condition (Pereira *et al.* 2018). The victim should be transported to the nearest Emergency department at the hospital in order to be observed and receive further treatment. In the case of severe injury, it may not be possible to save the victim's life. In a reported envenomation event, despite appropriate beachside first aid, the patient was conscious only several minutes before having primary respiratory arrest and, later, cardiovascular collapse that resulted in death (Stein 1989).

In the literature, ocular jellyfish stings have also been reported. The sting can cause burning pain, blurred vision, eyelid swelling, photophobia, epithelial keratitis, conjunctival edema, corneal stromal edema, endothelial cell swelling, corneal epithelial defects, anterior chamber inflammation, severe iritis, as well as increased intraocular pressure and chronic unilateral glaucoma. Though, there is no current definite treatment for ocular jellyfish stings, several practical choices are recommended. The eye should be initially irrigated with seawater at the scene, then followed with saline application. After washing the eye, it is essential to remove the foreign materials, patch it with topical antibiotic preparations and administer steroid and antihistaminic eye drops. A proper analgesic can be applied for an appropriate follow up time. Most injuries are self-limited and resolve spontaneously in two days; however, severe envenomation may require 1-2 months of healing (Mao *et al.* 2016; Glasser *et al.* 1992).

Prognosis

A wide range of injuries appear to be mild and result in complete recovery without sequelae (Kaufman 1992). However, complete recovery from a severe jellyfish envenomation may require many days and may have an adverse effects on the general health status of the victim. The injuries related to jellyfish stings can be serious, the pain can be significant, and secondary complications may be so special that medical attention may be required (Currie and Jacups 2005).

Prevention

To minimize the risk of jellyfish envenomation, the biological cycle and reproductive seasonal changes of jellyfish should be tracked. It is appropriate to alter activities during times when high jellyfish abundance may increase the risk of mass envenomation during aquatic activities, contests and entertainment (Haddad *et al.* 2018). To provide data relevant to the community, locals should continuously monitor and provide data about the risk of jellyfish stings. By tracking the populations of species over time, warnings can be issued regarding jellyfish blooms by means of media tools (news, internet, signpost etc.). Travelers also should get information about prominent factors affecting jellyfish abundance in the area they will visit, such as time of the year (summer, spring etc.), geographical site (temperate or tropical waters), weather (hot, winds), sea conditions (temperature, currents etc.), and accident reports (when, how and result of sting). In the presence of these conditions, holiday makers or fishermen should obtain all relevant information from available resources.

It is essential to follow the warning posters regarding dangerous jellyfish populations (Figure 5). In some countries, swimming zones are surrounded with stinger-resistant nets.

Swimmers should stick to the rules and not pass beyond these bordered swimming areas.

In areas where jellyfish are common, signposts should be used at beach lifeguard stations to provide jellyfish warnings when needed. Lifeguards on duty should patrol the beach every day, record species abundances and prepare a formal report for the local authorities. To be effective monitors, lifeguards need to be trained about the different jellyfish species and how to handle the envenomation cases on-shore.

Wearing special protective clothing provides a physical barrier and decreases the risk of serious stings. Health teams working on shores or in the sea should carry basic equipment for treating allergic reactions, as well as iced sea water, a vinegar soaked compress or vinegar bottle, hot water, and analgesics for fast applications (Haddad *et al.* 2018). Fishermen should be aware of potential injuries and should be trained on how to carry out first aid when away from a medical facility (Mode *et al.* 2005).

In Conclusion, jellyfish stings will be an increasingly important topic as a global threat to the health care, economy and tourism of many countries. There is a strong need to develop a simple and consistent first aid approach to treat jellyfish stings. In addition, well designed research studies are needed to understand the mechanism of envenomation. To this end, scientists should conduct a wide range of experiments regarding jellyfish venoms. Envenomation by jellyfish sting needs to be thoroughly studied, and workshops should be organized to disseminate information and teach precautionary measures to prevent further injuries.

Please for your own safety

do not touch jellyfish

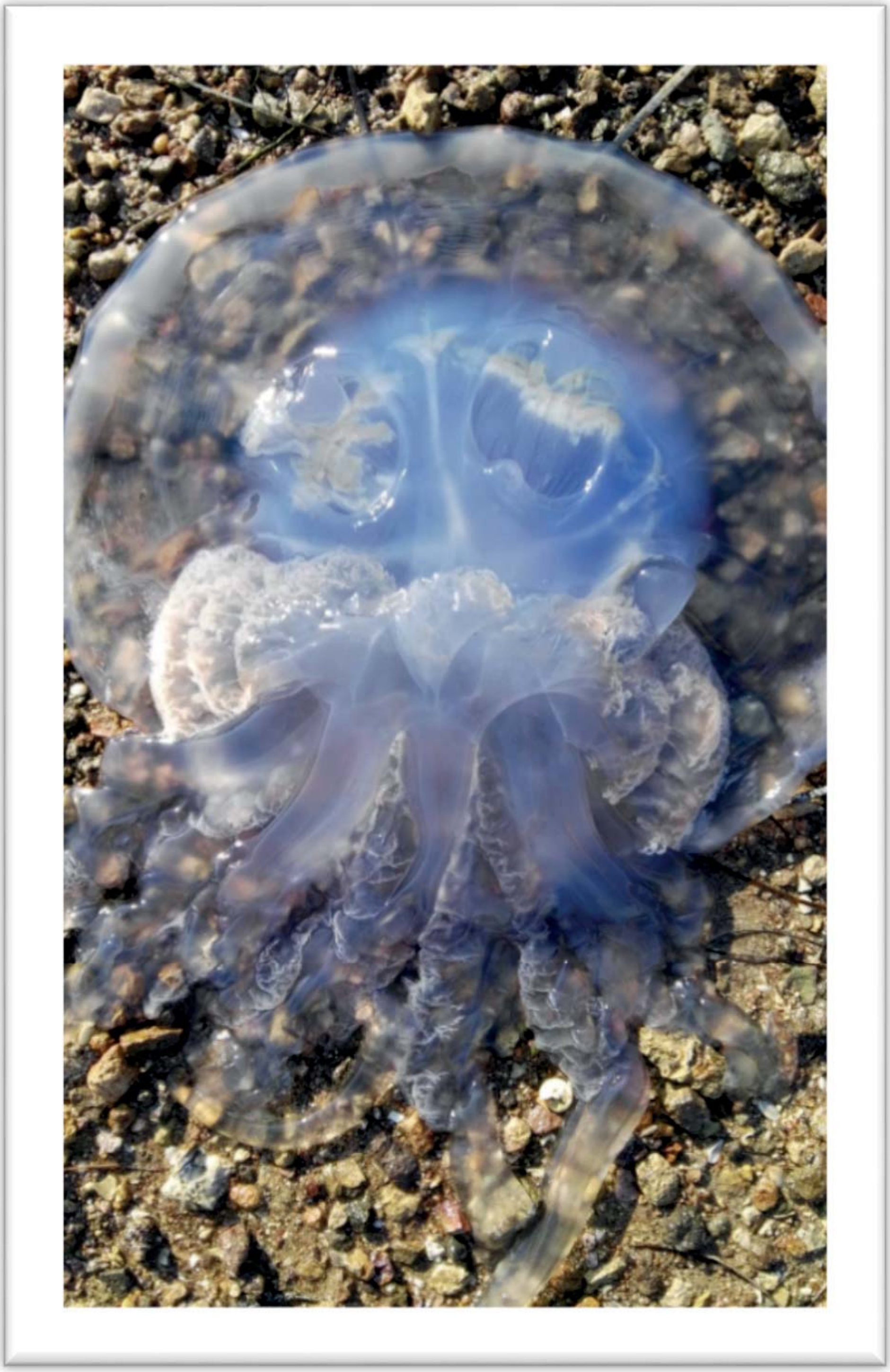


Figure 1. Jellyfish can be found on the shore and on beaches. Please be aware of their potential to sting, even if they appear to be dead.

Figure 2. The erythema (redness) and edema (swelling) with vesiculation on the lower waist of a patient.

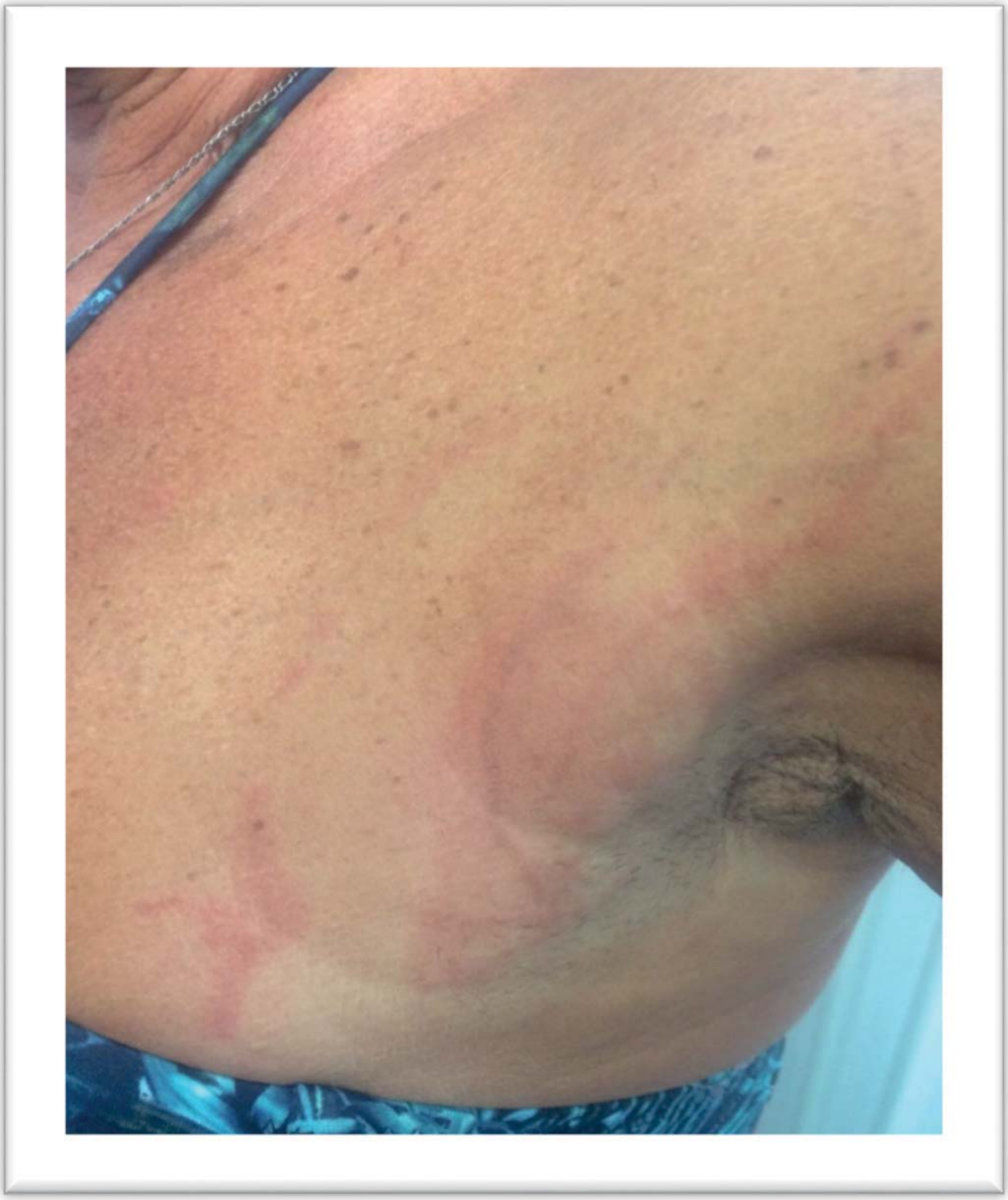


Figure 3. Symptoms of a jellyfish sting: burning pain associated with linear erythema, edema on the upper part of the trunk.

Figure 4. You may be able to remove nematocysts by shaving the affected area with shaving cream and safely razor.

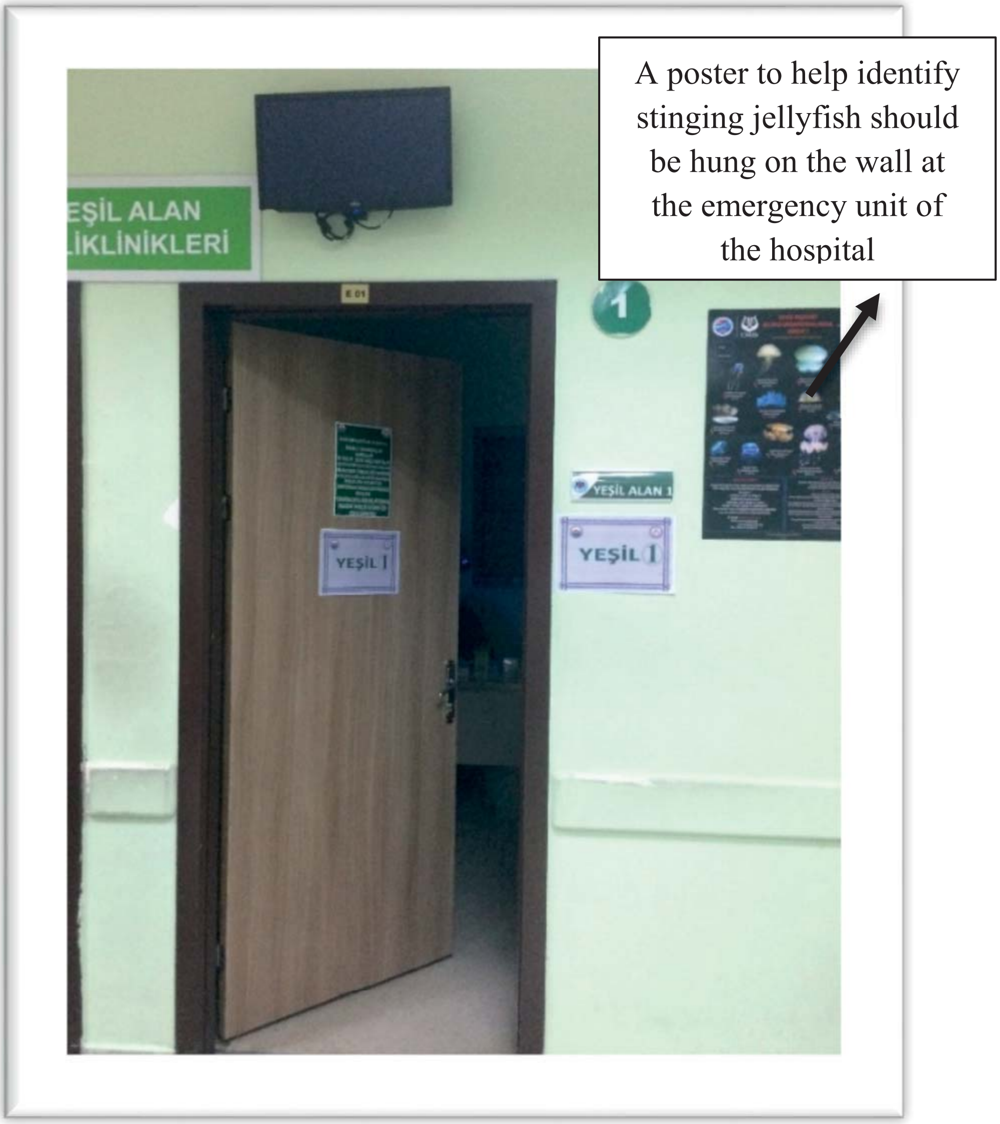


Figure 5. Medical Physicians at the Emergency department should be informed with warning posters.

Table 1. Local Symptoms and Signs

<table>
<tr><td rowspan="6">Local findings of the contact area</td><td>Intense pain</td></tr>
<tr><td>Burning sensation</td></tr>
<tr><td>Itching</td></tr>
<tr><td>Localized swelling</td></tr>
<tr><td>Erythema</td></tr>
<tr><td>Linear streak discoloration</td></tr>
</table>

Table 2. Systemic Symptoms and Signs

Several body systems may be affected (Skin, gastrointestinal, cardiovascular, respiratory, central nerve system etc.)	Nausea
	Vomiting
	Weakness
	Pallor
	Shortness of breath
	Syncope

Table 3. Warning signs of severe allergic reaction after jellyfish sting (Pereira *et al.* 2018)

Signs and Findings	Weakness
	Flushed, itching or burning sensation
	Respiratory failure
	Vomiting with blood
	Discolored secretion in the airway
	Swelling around the face, eyes, neck and tongue
	Facial flushing
	Agitation
	Drowsiness
	Skin lesions (erythematous plaque)

Table 4. Outcome of untreated patients

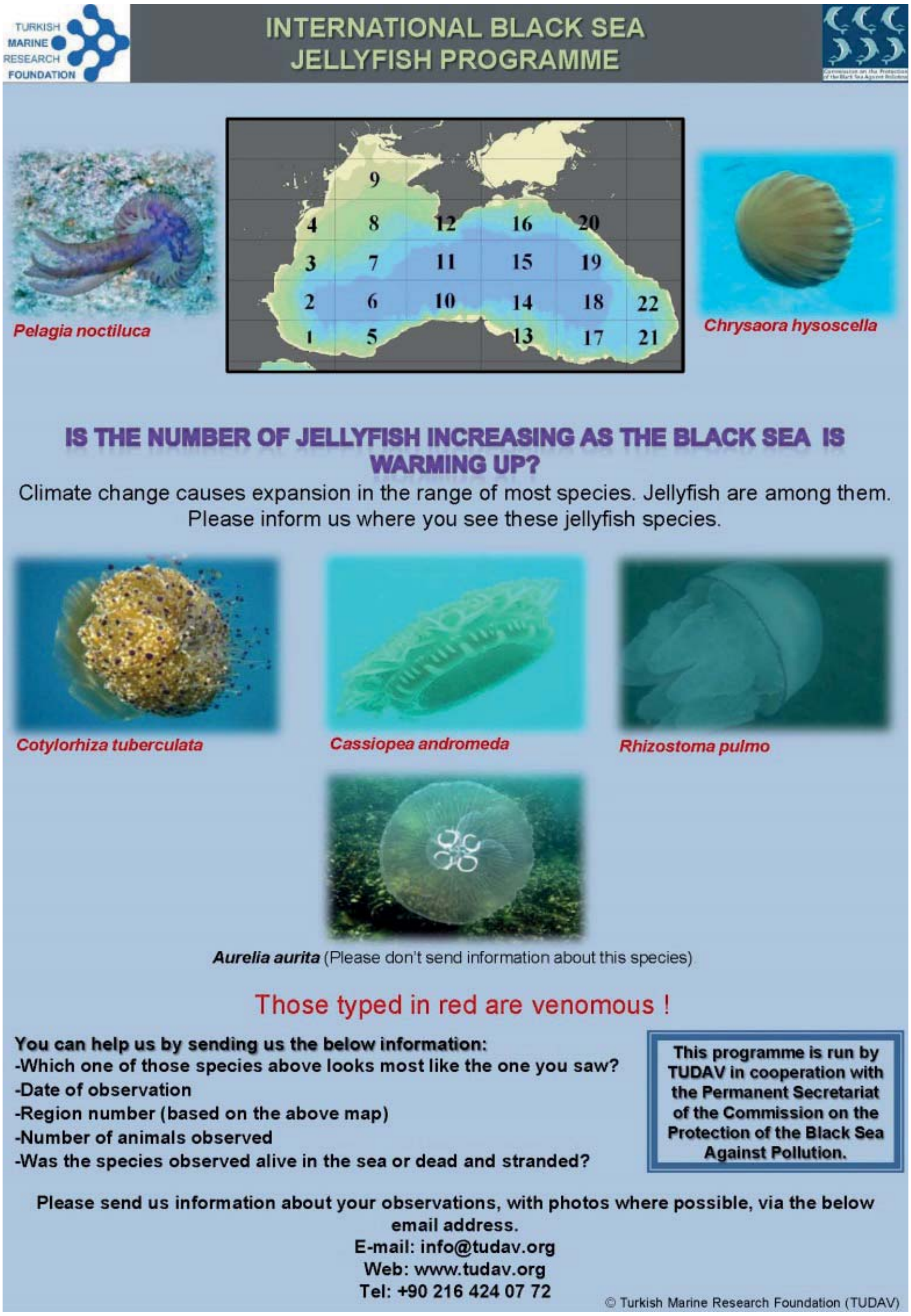
Untreated patients suffer	Defective scar tissue of wound
	Wound healing problems
	Respiratory distress
	Shock
	Death
	Coma

PART 4. JELLYFISH AND CITIZEN SCIENCE ACTIVITIES IN THE MEDITERRANEAN AND BLACK SEAS

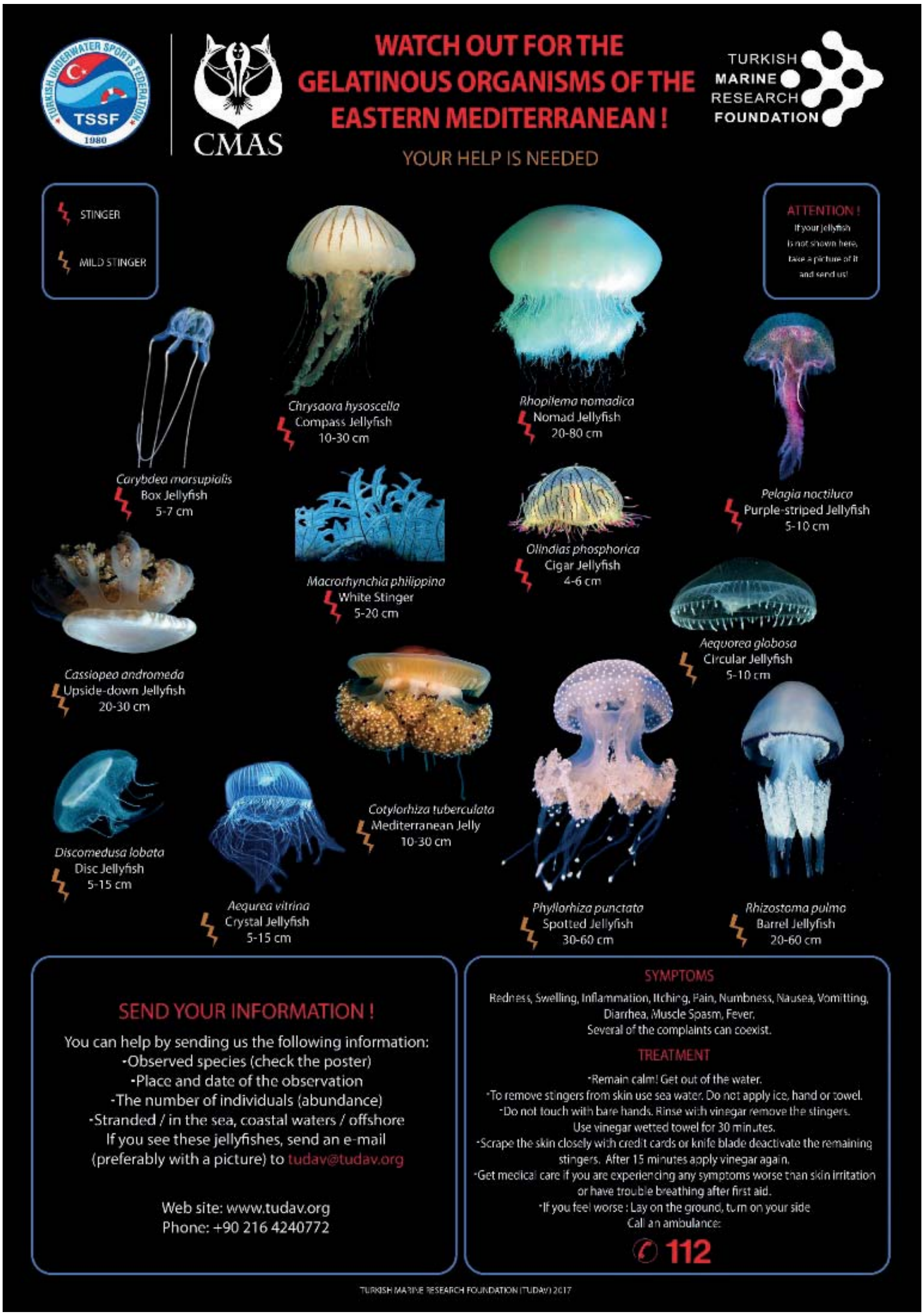
In recent years, some citizen science programs have been established in both the Mediterranean and Black Sea basins, and jellyfish species are now known better than before. However, jellyfish distribution and abundance in the Black Sea is much less known compared to the Mediterranean Sea.

Some citizen science programs established in the Mediterranean and Black Sea basins are listed below;

- http://www.icm.csic.es/bio/medusa/Castellano/CastProyecto.html
- http://www.ciesm.org/marine/programs/jellywatch.htm
- net.eu/en/jellyfish_map/index.html
- http://meduse.acri.fr/carte/carte.php
- http://www.ioikids.net/jellyfish
- http://www.meduzot.co.il/
- http://www.copernicus.eu/sites/default/files/documents/Copernicus_Briefs/Copernicus_Brief_Issue53_Jellyfish_July2015.pdf
- http://archipelago.gr/en/help-jellywatch-program/
- https://isea.com.gr/activities/programs/alien-species/is-it-alien-to-you-share-it/?lang=enhttp://www.cubomed.eu/en/
- http://www.yayakarsa.org/index.php/en/
- http://blackseawatch.org/
- jellyfish monitoring program (www.denizanasi.org)



Poster of the International Black Sea Jellyfish Programme prepared by TÜDAV



Poster of Gelatinous Organisms of the Eastern Mediterranean prepared by TÜDAV

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