

Marine creatures dangerous for divers in tropical waters

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ABSTRACT

Diving has been gaining in popularity in recent years with spectacular dive sites in tropical waters. Before anyone goes diving, they should learn about the risk factors associated with the exposure to hyperbaric conditions and also the risks from exposure to marine life. Apart from amazing views of the coral reefs, divers may be astonished by the magnitude of marine species diversity in local waters, ranging from predators (sharks, barracuda, moray eels) to venomous or stinging fish (jellyfish, anemones) and sea snakes. If travelers are unprepared and know little about the existing risk factors, a diving trip that was much looked forward to may turn out to have some very unpleasant consequences. The article describes the most common marine species which divers can come across in tropical waters. It also discusses the management of injuries caused by dangerous marine creatures.

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Key words: marine fauna, divers, danger, injuries

INTRODUCTION


No matter how careful and vigilant a person is, the risk of being bitten, stung or poisoned by a dangerous marine creatures will always be there [1]. The risk is obviously higher if a diver is careless and less watchful, for example when a person continues diving despite being tired. Divers should also be aware of the fact that eating local specialties, including seafood, may cause gastrointestinal disorders or fish toxin poisoning [2, 3]. While staying underwater, divers must be particularly careful about contact with marine fauna. Most problems and incidents can be avoided if divers follow the basic safety principle: You can watch, but do not touch! (Table 1).

PREDATORS

SHARKS (*SELACHIMORPHA*)

Researchers have identified approximately 350 shark species, of which only about 20 are considered to be dangerous to humans. The smallest shark (*Squaliolus laticau-*

lus) is only 15 cm long, while the biggest one – the whale shark – can reach the length of up to 20 m and the weight of 12 tons. Sharks can be found in all seas and oceans around the world but are generally most prevalent in tropical waters. Many shark species are able to reach estuaries and are often spotted in shallow coastal waters. Sharks were found to have the largest brains of all fish. Apart from the senses of sight, smell, hearing, taste and touch they also have two other species-specific senses; these are the sense of electrical currents and the sense of pressure changes, the first one mediated by special electroreceptors and the other by the lateral line. In dark waters, sharks can see 10 times better than humans [1]. Sharks are widely believed to be one of the most dangerous animal species in the world, which is partly the effect of the film series “Jaws” by Stephen Spielberg. In fact, only 27 of all the living shark species have been known to attack people or boats, of which no more than 10 species are considered dangerous to humans. The risk of a shark attack is much higher in shallow waters – the

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Table 1. Marine creatures dangerous for divers in tropical waters [1]

Marine fauna	Species/Family
Predators	Sharks (<i>Selachimorpha</i>) Barracudas (<i>Sphyraenidae</i>) Moray eels (<i>Muraenidae</i>) Triggerfishes (<i>Balistidae</i>) The serranid fish (<i>Serranidae</i>) The surgeonfishes (<i>Acanthuridae</i>)
Venomous fish	Rays (<i>Batoidea</i>) The scorpionfishes (<i>Scorpaenidae</i>) The stonefishes (<i>Synanceiidae</i>) The weevers (<i>Trachinidae</i>) The stargazers (<i>Uranoscopidae</i>) The rabbitfishes (<i>Siganidae</i>) The electric rays (<i>Torpedinidae</i>)
Cnidarians	Jellyfishes (<i>Scyphozoa</i>) Sea anemones (<i>Actiniaria</i>) Corals (<i>Anthozoa</i>)
Molluscs and echinoderms	Gastropods (<i>Gastropoda</i>) Octopuses (<i>Octopoda</i>) Sea urchins (<i>Echinoidea</i>)
Sea snakes	The beaked sea snake (<i>Enhydrina schistosa</i>) The annulated sea snake (<i>Hydrophis cyanocinctus</i>) The blue-ringed sea krait (<i>Liticauda laticaudata</i>) The yellow-lipped sea krait (<i>Liticauda colubrina</i>) The yellow-bellied sea snake (<i>Pelamis platurus</i>) The olive-brown sea snake (<i>Aipysurus laevis</i>)

animals most often attack swimmers, surfers, snorkelers and spearfishers. At deep depths (> 20 m) the risk is much lower [4]. A total of 150–200 shark attacks on humans are recorded each year, but less than 6% of the attacks are fatal. An analysis of the shark attack rate from 1960–2015 for 14 countries demonstrated the rate of merely one shark attack per one million people, but found that around 10% of the attacks involved scuba divers. Sharks have a poor sense of sight and are more attracted to the smell of blood or vibrations rather than the mere presence of a human in the water. In fact, their excellent sense of smell compensates for their poor eyesight and enables them to sense their victims from long distances. Sharks are able to detect electrical signals produced by the living creatures. If they are injured or scared they tend to be aggressive [5]. Shark attacks can be either provoked by the behavior of a scuba diver, when a shark tries to defend itself, or unprovoked, when a shark attack is unexpected and occurs for no clear reason. In general, a shark attack is more likely to occur under the following conditions: when the water temperature is > 20°C, when there is blood in the water and in areas where the number of prey is limited [6].

In order to minimize the risk of getting attacked by a shark, swimmers and divers are recommended to follow

a few simple rules. You should avoid swimming or diving at night or dusk as it is the time when sharks are most active and usually go hunting. You must not get into the water if you have an open bleeding wound (this also applies to menstruating women). Avoid waters which are fished and where fishing nets are emptied. If you see a shark approaching you, remain calm and be careful. Try not to make quick movements or escape as it might provoke an attack. You should rather try to withdraw calmly without losing the sight of the shark. Never try to feed sharks as it may also provoke an attack. Be careful not to come into contact with the rough skin of a shark, it may cause an injury, and the bleeding may in turn provoke an attack. In order to minimize the risk of a potential attack stay calm and try not to move, perhaps the shark will swim away. However, if you are attacked, you should hit the shark hard in the nose, eyes or the gills – this may scare it away. Another effective method of scaring the shark off is to direct a stream of air bubbles from the regulator towards the shark or to swim directly towards the approaching animal – this usually makes the shark turn away making it possible to avoid a direct contact with the shark [1, 4]. Shark bite injuries are usually quite severe and result in massive tissue loss – a shark tears off pieces of flesh from the victim with its sharp teeth. Massive bleeding that follows a shark attack can attract other predators. In case of a shark attack, the victim should be removed from the water as quickly as possible; the bleeding must be controlled, the wound dressed, and the victim should be taken to hospital immediately. A vast majority of shark attacks casualties die of a hemorrhagic shock [7].

BARRACUDAS (*SPHYRAENIDAE*)

There are about 20 known species of the barracuda. All of the barracuda species are predators but some are so small that they are not dangerous to humans. Interestingly, people living in the West Indies fear barracudas even more than they fear sharks and in some parts of the world it is the barracuda, and not the shark, which is called the ‘the king of the coral reef’. The fish is considered to be one of the most dangerous marine predators. Barracuda resemble a large eel. Their average length is 1–1.5 m, but some species can grow up to 2.5 m. Barracudas have long sharp teeth with which they can inflict major injuries and in some cases even bite off a person’s fingers or the hand. Barracuda normally reside near the coral reefs and in rock crevices. They usually attack to defend their territory rather than satisfy their hunger. They are known to form schools, which are dangerous to other marine animals. They show no fear of humans and are often seen to stay close to scuba divers. Unprovoked barracuda attacks are rare. An interesting fact is that the fish is attracted by bright colors and glittering objects such as scuba gear. For this reason, a barracuda may, for exam-

ple, mistake a glittering watch for prey and attack a diver causing severe injuries. Barracuda bites take a long time to heal and they usually require in-patient treatment [8, 9].

MORAY EELS (*MURAENIDAE*)

There are approximately 20 genera of the moray eel. Some may reach the length of up to 3 m, the width of over 30 cm, and the weight of up to 30 kg. They have a long, eel-shaped, slightly flattened body and very wide and strong jaws. They can be found in the coral reefs where they normally reside under the rocks or in crevices.

Moray eels rarely attack humans. The attacks are usually provoked by people, e.g., if a diver comes too close and puts their hand inside a crevice where a moray eel is hiding, the fish is very likely to attack in order to defend its territory. You should not feed, touch or approach moray eels as this can scare the fish and provoke an attack. Moray eels often look out for their prey in shallow waters and therefore it is possible to come across the fish while wading in the sea close to the rocks or the reefs [10, 11].

TRIGGERFISH (*BALISTIDAE*)

Scientists have identified more than 25 different species of the triggerfish. The fish can be found in all tropical waters. It is considered to be the most aggressive fish inhabiting the coral reef. Triggerfish is a solitary species. It has large and sharp teeth adapted for crushing corals and therefore its bite can cause a severe injury. The green giant triggerfish is the largest species of the triggerfish genus, and can reach the length of up to 90 cm. The animals show no fear of scuba divers and can attack them if they approach their nest. The triggerfish is found at the depth of up to 50 m [1, 12].

THE SERRANID FISH (*SERRANIDAE*)

This extremely large fish can be found in the tropical waters of the Indo-Pacific Ocean and the Caribbean Sea. There are approximately 400 different species of the serranid fish belonging to 67 genera. Some species are small, while others can be very large, e.g., the giant grouper. *Epinephelinae* are the largest of the *Serranidae* family, their average length is 1.5–2.5 m, but some can grow up to 3.5 m and weigh as much as 300 kg. The serranid fish should be treated as potentially dangerous to humans because of its large size, wide jaws and sharp teeth. They show no fear of scuba divers. They must not be fed as they can bite a diver on the hand [13].

THE SURGEONFISHES (*ACANTHURIDAE*)

These brightly colored fishes are commonly found in tropical waters of the coral reefs. The size of the different species of the surgeonfish ranges from 15 cm to more than 1 m, but their average length is around 50 cm. There are

around 80 species belonging to the surgeonfish family. They form schools and can be found at the depth of up to 100 m. The surgeonfish is a territorial species which tends to be aggressive towards other fish of their own species. Although they are not predatory, they may potentially be dangerous to scuba divers because of their extremely sharp spines on each side of their tail that can cause a severe injury to anyone who tries to touch or hold the fish in a careless manner. If it is scared and cannot retreat, the fish can attack a human using its scalpel-like spines. The fish can inflict deep lacerated wounds by moving its tail [1, 14].

FIRST AID AFTER AN ATTACK BY A MARINE PREDATOR

If you are attacked and injured by a marine predator or a dangerous fish, the wound must be cleaned, washed with water and disinfected (e.g., using iodine solution) as quickly as possible. The wound should be then covered with a sterile dressing. The treatment normally involves the administration of painkillers, anti-tetanus and anti-shock medications and antibiotic therapy. In case of deep or extensive wounds, surgical treatment will usually be necessary [15].

VENOMOUS FISH

A vast majority of venomous fish produce and use their toxins for self-defense. The venomous spines or barbs, at the base of which venom glands are located, can reach the length of up to 30 cm in some species. The greater weever, for example, which can be found along the coastline of the Mediterranean Sea and east coasts of the Atlantic Ocean have their venomous spines located on each of their gill covers and their dorsal fin. The fish can inflict extremely painful puncture wounds. Most species of the venomous fish are known to lead a sedentary lifestyle and are usually found in shallow coastline waters. When a person is wading in the shallow waters, they may accidentally step on a venomous marine creature and sustain a puncture wound on the sole of their foot. For this reason, it is not safe to walk barefoot on the beach or in the waters rich in marine life. Instead, swimmers are recommended to wear specially designed water shoes to prevent possible injuries [16–18].

RAYS (*BATOIDEA*)

Rays belong to one of the largest groups of marine animals. There are seven recognized families of *Batoidea*, of which two possess venomous spines – these are *Dasyatidae*, commonly known as stingrays, and *Myliobatidae* including eagle and manta rays. Rays inhabit calm and shallow waters such as lagoons and can be found on the sandy seabed of the coral reefs. The most common rays include: the common stingray (*Dasyatis pastinaca*), which lives in the Mediterranean Sea and the Black Sea, the south-

ern stingray (*Hypanus americanus*) inhabiting the Gulf of Mexico and the Caribbean Sea, and the spotted eagle ray (*Aetobatus narinari*) which can be found across all tropical seas and oceans. Stingrays spend most of their time partly buried in the sand on the ocean floor, with only their eyes and a part of their tail sticking out. Stingrays will usually only attack to defend themselves when they are disturbed or accidentally stepped on. They attack by whipping their tail which is equipped with a venom spine at its end. The stingrays usually sting people in their feet and the lower extremities less commonly on other parts of the body. The pain starts immediately or within 10 min of the sting. It is sharp, excruciating or throbbing. The wound itself is either a laceration or a puncture wound. The removal of the stingray spine causes further tissue damage. The sting site becomes swollen and the surrounding skin turns white, then blue and eventually red. A person stung by a stingray may experience signs and symptoms which are indicative of poisoning, such as blood-tinged sputum, vomiting, diarrhea, sweating, tachycardia, muscle paralysis. A sting by a stingray may be fatal [1, 19].

THE SCORPIONFISHES (*SCORPAENIDAE*)

The family of the *Scorpaenidae* is large and includes around 100 species which inhabit both tropical and temperate seas and oceans. The *Scorpaenidae* includes one of the world's most venomous fishes, which can normally be found close to coral reefs. The largest of the species grow up to 1 m long. Most of the fish have camouflage coloration. Because of the differences in the structure of their venom glands they are divided into the lionfish (*Pterois*) and the scorpionfish (*Scorpaena*). They can be found in shallow waters, close to the coral reefs, the ocean bed and sandy beaches. They show no fear of people. Their venomous spines are hidden beneath their elongated fins. Because of their camouflage coloration the scorpionfish are difficult to spot, especially in shallow waters, where they normally reside. When disturbed they take a defensive position and prepare for an attack by erecting their dorsal spines and spreading their other fins. Both the lionfish and the scorpionfish have up to 20 sharp spines with venom glands located at their bases. The lionfish spines are long and straight while the scorpionfish have shorter and thicker spines. When a person gets stung by either of the two species, they will immediately feel acute throbbing pain which radiates from the sting site all through the affected limb and lasts for up to several hours. The injured site turns white and then blue and an inflammatory response occurs. The symptoms which are associated with a sting by a scorpionfish or a lionfish include vomiting, diarrhea, arthralgia, delirium, convulsions, shortness of breath, arrhythmia, hypotonia and in extreme cases cardiac arrest [20].

THE STONEFISHES (*SYNANCEIIDAE*)

The fish belonging to the *Synanceiidae* family, commonly known as the stonefish, lives in shallow waters of the coral reefs; they can be found inside cracks, caves and crevices or buried in the sand on the ocean floor. They are considered to be one of the most venomous and therefore dangerous marine animals. They grow up to 40 cm long, on average. They are found in the Red Sea, the Indian Ocean and the Pacific as well as in the coastal regions of Australia. They have 13 short but thick dorsal fin spines at the base of which their multiple venom glands are located. People usually get stung as they accidentally step on the fish which is lying motionless on the ocean floor often partially buried in the sand. The injuries caused by the stonefish are much more serious than those inflicted by the scorpionfish. The pain can last for many days and it can be so excruciating that it may result in a loss of consciousness. A swelling and an inflammatory response usually occurs at the sting site; in some cases muscular paralysis may ensue. Other signs and symptoms of a sting by a stonefish include: lymphadenopathy, arthralgia, vomiting, delirium, convulsions, shortness of breath, arrhythmia and eventually death in some cases. A victim must immediately leave the water and seek medical attention as quickly as possible. The treatment is long and can take several months, but even if it is successful, the poisoning can cause permanent health damage [21].

THE WEEVERS (*TRACHINIDAE*)

The fish belonging to the *Trachinidae* family are one of the most venomous marine creatures inhabiting the temperate seas and oceans. The species is distributed in warm waters along the east coast of the Atlantic Ocean, i.e., along the coasts of Norway, the British Isles as well as along the coasts of the Mediterranean Sea and the Black Sea. The fish inhabits the muddy ocean floor where it often buries itself in the sand. It can be found both in deep and shallow waters (at the depth of only 1 m) and therefore it might be dangerous for swimmers or those wading in the water along the coast as well as for scuba divers. Its venom apparatus consists of a venomous spine above the eye, long spines on each of their gill covers, 5–7 dorsal fin spines and 2 anal fin spines all connected with venom glands located at their bases. Its venom shows both neurotoxic and chemotoxic properties. The sting causes excruciating pain which radiates all through the affected limb; the pain is most intense after 30 min of the sting. Sometimes the pain is so severe that a victim of a sting can lose consciousness. Redness and swelling occur around the sting site, which persist for around 10 days. An infection of the affected site may lead to tissue necrosis. The common signs and symptoms of a weever sting include: excitement, tremors, sweating,

vomiting, arthralgia and in more severe cases: shortness of breath and cyanosis, arrhythmia, delirium, disturbance of consciousness and convulsions. A sting by the weever fish can cause death in extreme cases. The treatment and the convalescence are long and can take up to several months [1, 22].

THE STARGAZERS (*URANOSCOPIDAE*)

The stargazer is a relatively small fish, reaching the length of 40 cm. The species inhabit the east coastline of the Atlantic Ocean (from Portugal to the Republic of South Africa), the Mediterranean Sea and the Black Sea; it resides on the ocean floor and spends its time buried in the sand. The stargazers are active during daytime. Some species have a worm-shaped lure, which they use to attract the prey's attention. The venomous apparatus of a stargazer consists of two large venom spines located on their gill covers above their pectoral fins. A sting by the stargazer causes a painful injury and swelling of the affected site. In some cases the pain is so intense that it may lead to a loss of consciousness. The common signs and symptoms associated with the stargazer sting include: shivers, sweating, dizziness, arthralgia, shortness of breath, arrhythmia, convulsions and a loss of consciousness. A sting inflicted by the Atlantic stargazer (*Uranoscopus scaber*) can cause death [1, 23].

THE RABBITFISHES (*SIGANIDAE*)

The rabbitfish, also known as the spinefoot, are a small species (their average length is 35 cm long) commonly found in the Red Sea, the Indo-Pacific and Polynesia. They resemble the surgeonfish. The venomous apparatus of the rabbitfish consists of 24 spines connected with venom glands located at their bases. The signs and symptoms which occur after getting stung by the rabbitfish are similar to those associated with a sting by the scorpionfish and usually include: acute excruciating pain, cyanosis, arthralgia, shortness of breath, arrhythmia and convulsions. Although quite serious, the signs and symptoms are not life-threatening [24]. Other species of venomous fish which are distributed in warm waters include: catfish, gafftopsail catfish, chimarea, toadfish, dragonets (e.g., spotted dragonet), snake eels (e.g., *Ophichthys semicinctus*). The wounds inflicted by these species are usually quite painful and cause local signs and symptoms including redness, swelling, infection at the sting site, occasionally tissue necrosis and hard-to-heal wounds.

THE ELECTRIC RAYS (*TORPEDINIDAE*)

Torpedinidae is a family of electric rays. They are not particularly dangerous to scuba divers; however, a close encounter with the fish can be very unpleasant. The fish is equipped with electric organs and is capable of generating

electricity which they either use for self-defense or to capture their prey. They are primarily found along the coastline of the Mediterranean Sea, the Indian Ocean, the Pacific and the Atlantic Ocean as well. The best known species of the electric rays include: the leopard torpedo (*Torpedo panther*), the common torpedo (*Torpedo maculata*), the Atlantic torpedo (*Torpedo nobiliana*) and the Brazilian electric ray (*Narcine brasiliensis*). Electric rays have flat, disc-shaped body. They are usually brightly colored with darker spots on the top of their body; they have small retracted eyes, two dorsal fins and a well-developed caudal fin. They have two electric organs which are placed on both sides of their head; the largest species are capable of generating an electric shock of up to 300 volt. The electric rays differ in size; the smallest species are no more than 20 cm long, while the largest ones can grow up to the length of 180 cm and can weigh a few dozen kilograms. They are solitary bottom dwellers which spend most of their time buried in the sand or mud. Approaching or touching the animal may provoke an electric discharge, which can be very unpleasant and may even immobilize a diver for a short period. The recovery is swift and the electric shock from the ray causes no long-term complications [1].

FIRST AID AFTER BEING STUNG BY A VENOMOUS FISH

If you get stung by a venomous fish, the first aid will normally aim at relieving the pain, minimizing the toxic effects of the venom and preventing infection. Rays and catfish inflict lacerated wounds, which must be disinfected as quickly as possible. A sting by a venomous fish is often quite small and therefore difficult to clean of the venom. In some cases it might be necessary to make an incision at the sting site in order to bleed the wound or clean it. After it has been cleaned, the wound should be left to heal naturally through the growth of the granulation tissue. If you get stung by a venomous fish, it is recommended to immerse the affected limb in hot water (45°C or more) for 30–90 min or for as long as you can stand without getting burnt. If you get stung on the torso, you can use hot compresses to neutralize the effects of the neurotoxin. Doctors are divided on whether or not a tourniquet should be used. If you do apply a tourniquet, you will need to loosen it periodically, at least every 20 min in order to restore the normal blood flow. Larger wounds should be cleaned with warm water and disinfected using povidone iodine solution, the necrotic tissue and any foreign bodies should be removed and then the edges of the wound should be brought close together, a surgical drain should be inserted and left for 1–2 days, finally an antiseptic and a sterile dressing should be applied on the wound. The wound must not be stitched or stapled. A broad-spectrum antibiotic and post-exposure tetanus prophylaxis (if a patient has not been

vaccinated in the last 10 years) are recommended. Severe pain can be treated with non-steroidal anti-inflammatory drugs, and if they do not help, narcotic analgesics can be used. If a person manifests any generalized respiratory or circulatory signs and symptoms, the standard treatment should be applied to maintain their functions. If possible, antivenom should be administered (it is only available for stings by the stonefish) [16, 18].

CNIDARIANS

Cnidarians encompass a broad category of marine species which belong to the group of *Coelenterata* and include jellyfishes (*Scyphozoa*), sea anemones (*Actiniaria*) and corals (*Anthozoa*).

JELLYFISHES (SCYPHOZOA)

They are potentially dangerous to swimmers and scuba divers because of their venomous properties. Their venom apparatus consists of numerous nematocysts which are small elongated venom-filled capsules. When attacking their prey or trying to defend themselves they discharge thread-like spines from the nematocysts and inject the venom into the body of their prey or an attacker. Some jellyfish have tentacles of more than 15 m long. For this reason, if a diver sees anything which might potentially be a jellyfish, they should stay away. Even beached and dead jellyfish can inflict severe stings. In most cases, a sting by a jellyfish, corals or sea anemones causes an inflammatory response – with redness or a burn occurring locally. Some jellyfish (e.g., *Dactylometra*, *Chyropsalmus* or *Carybdea*) are particularly venomous; their sting can cause generalized signs and symptoms as well as severe skin lesions including tissue necrosis. Such stings are hard to heal [25, 26].

The Portuguese man-of-war (*Physalia physalis*) can be potentially dangerous to scuba divers who go diving in the Indian Ocean or the Atlantic Ocean. Although it is often mistaken for jellyfish, it is in fact a colonial hydrozoan which lives on the surface of the ocean. The Portuguese man-of-war has purple-blue pneumatophore and extremely venomous tentacles which are up to several meters long. The stings inflicted by the tentacles are painful and extremely dangerous as they can cause a severe poisoning, and in extreme cases even lead to death of an affected person [27].

The sea wasps (*Chironex fleckeri*) are known to have caused around 60 deaths in the Great Barrier Reef off the coast of Australia. The sea wasp is considered to be one of the most venomous jellyfish in the world. Its bell is relatively small, around 20 cm in diameter, but has several dozen long transparent tentacles. Its venom is so potent that it can kill a person within minutes [28]. Another dangerous jellyfish that can be found in tropical waters along the coasts of Australia is the Irukandji

jellyfish (*Carukia barnesi*), a small species of the jellyfish which is the size of a human finger. Its sting can result in the Irukandji syndrome associated with catecholamine release [29, 30]. A sting from cnidarian species can cause a variety of signs and symptoms, including the anaphylactic shock [31].

When swimming or diving in waters where cnidarians are distributed, you should always be wearing a diving suit that protects your skin from jellyfish stings. The recommended first aid for a jellyfish sting (urticaria or contact dermatitis) is to rinse the affected area with vinegar. On some tropical beaches, you will even find bottles of vinegar to be used as first aid to treat stings. Obviously, not all jellyfish stings can be treated with vinegar only. If you are stung by the Portuguese man-of-war, vinegar should not be used as it can cause nematocysts to activate and trigger a stronger inflammatory response. In severe cases, when the sting is life-threatening, the only treatment option will be to give the victim cardiopulmonary resuscitation; cardiopulmonary resuscitation should be performed by qualified medics. Administration of antivenom is an effective treatment option; however, it is only available for stings by a limited number of sea stingers, e.g., the sea wasp [32, 33].

SEA ANEMONES (ACTINIARIA)

Sea anemones are either sedentary or semi-sedentary species in the class of Hexacorallia. The latter species are capable of moving slowly on their pedal disc with which they attach to hard surfaces. They live singly and are known for their vivid colors which they owe to carotenoid pigments. Some species live in symbiosis with other animals, e.g., small fish. Sea anemones are well adapted to a wide range of habitats and can be found throughout the world across all seas and oceans and at various depths. Yet, a vast majority of the species inhabit tropical waters. Sea anemones have cylindrical body which varies in size from a few millimeters to as much as 1.5 m in diameter. Anemones have a ring of tentacles growing around its central mouth and multiple stinging cells which they use in self-defense and to hunt prey. Sea anemones are predators, they use venom to paralyze their prey and next their tentacles to move the prey into the mouth. The tentacles are also used for catching the passing plankton [34].

CORALS (ANTHOZOA)

Corals are marine invertebrates which belong to the class of *Cnidaria*. The species have a structure of a polyp. Polyps form colonies which usually grow in shallow waters along the coast but some species can be found as deep as 6000 m. Attached to the ocean floor, they inhabit tropical or sub-tropical waters that are well-oxygenated and rich in sunlight. There are more than seven thousand different species of corals that can be classified into two broad subclasses:

Hexacorallia and *Octocorallia*. Singly living species vary in size from several millimeters to more than 10 cm, but the largest ones can grow up to 1.5 m in diameter. Coral polyps produce limestone which forms the structure of the ecosystem commonly known as the coral reef. Most species are sessile creatures (they lack the ability of self-locomotion) but some may be surprisingly mobile. Most corals feed on zooplankton, but bigger species are capable of catching bigger prey, such as crustaceans, mollusks and small fish. They paralyze and catch the prey using stinging cells which are located on their tentacles. Many species of crustaceans, starfish and fish feed on corals [34].

MOLLUSCS AND ECHINODERMS

Both swimmers and divers are at risk of exposure to venomous mollusks, snails and cephalopods (which are equipped with a venom-producing apparatus) and sea urchins.

GASTROPODS (GASTROPODA)

Marine species of gastropods have colorful and beautifully sculptured spiral shells which are desired by shell collectors. Many tropical snails, however, produce toxic venom, which can cause a severe poisoning or in extreme cases even death. Cone snails and terebra snails have a harpoon-like tooth loaded with venom which they fire into the prey. Once the prey has been stung, the venom is injected into its body under high pressure. Although murex snails and *Aplysia* species are not equipped with a venom apparatus, they are capable of producing toxic secretions in their salivary glands to overpower their prey [1]. Both cone and terebra snails inflict puncture wounds. If you are stung, the sting site turns white at first and then cyanosis, itching, numbness, intense pain and a burning sensation follow. The localized symptoms may soon progress into generalized ones including muscle paralysis, difficulty breathing and arrhythmia, and in extreme cases death. Gastropod stings should be managed in the same way as stings by venomous fish [35]. The most venomous species of marine gastropods include the textile cone (*Conus textile*), the geography cone (*Conus geographus*) and terebra (*Terebra maculata*). The species are widely distributed in the Red Sea, the Indian Ocean and the Pacific Ocean [36]. *Murex haustellum*, the species classified in the family of murex snails, which is capable of producing toxic salivary secretions is primarily found in the Mediterranean Sea and the Black Sea [1].

OCTOPUSES (OCTOPODA)

All octopuses are equipped with venom apparatus that is capable of producing highly toxic secretions that enter the victim's body through a puncture wound inflicted by the

animal's horn beak. The wound is usually quite small, but it may bleed heavily and be associated with a burning or itching sensation spreading all through the affected limb. The octopus bite causes redness, swelling and a rise in body temperature. In severe cases signs and symptoms of a poisoning may ensue, including a headache, vomiting, difficulty breathing and arrhythmia, the last two symptoms can be potentially life-threatening. Injuries inflicted by octopuses as well as a poisoning by an octopus should be managed in the same way as stings by venomous fish. The blue-ringed octopus, a small species with an arm span of only up to 20 cm, is considered one of the most dangerous marine animals; its toxin can be deadly to humans. When disturbed, it can become aggressive and attack an intruder. It is known to attack and kill animals which are much bigger and stronger. The blue-ringed octopus is found in the Pacific Ocean, especially along the northern coasts of Australia. Each year, several people are reported to die from a sting by this marine creature [37]. *Octopus vulgaris*, the giant Pacific octopus with an arm span of more than 6 m, is venomous both to marine animals as well as to humans. It mainly inhabits tropical waters but some species can be found in the Black Sea, the Mediterranean Sea or the Caribbean Sea [38].

SEA URCHINS (ECHINOIDEA)

Sea urchins are one of the most common species of echinoderms. Sea urchins are found in both tropical and temperate climates. The long-spined urchins are considered the most dangerous because their sharp venomous spines can easily puncture the human skin and break off inside the body. Sea urchins are venomous and their sting can cause both localized and systemic poisoning. A sting by a sea urchin is painful and the pain can radiate all through the affected limb. In extreme cases a person who has been stung by a sea urchin may experience difficulty breathing, fits or seizures, face muscles paralysis, partial paralysis of other body parts or a loss of consciousness. The severity of signs and symptoms will depend on the species of the sea urchin and the number of stings. Deaths from sea urchin stings are extremely rare. The stings are managed in the same way as stings by other venomous fish. The removal of broken spines may be difficult and may require a surgical procedure. The black long spine urchin (*Diadema setosum*) is a typical long-spined sea urchin with the body of 10 cm in diameter and extremely long and sharp spines that can reach the length of more than 30 cm. The species can be found throughout the Indo-Pacific and in the Red Sea [39].

SEA SNAKES

Marine snakes belong to the *Elapidae* family and include approximately 50 different species. Although they are marine animals, some can be found near estuaries. Sea snakes are

primarily found in tropical waters of the Indo-Pacific Ocean. They are adapted to a variety of habitats, the yellow-bellied sea snake, for example, is known to be drifting deep sea, moving extremely long distances with the ocean currents but some species are found in shallow coastline waters. The beaked sea snake, the yellow-lipped sea krait and the annulated sea snake also known as the blue-banded sea snake (*Hydrophis cyanocinctus*) are typical representatives of marine snakes [40].

THE BEAKED SEA SNAKE (*ENHYDRINA SCHISTOSA*)

This highly venomous sea snake is considered to be the most dangerous of all marine snake species. The species is known to be aggressive and is responsible for the majority of deaths from sea snakes bites in humans. It grows up to the length of around 2 m and is found all throughout the Indian Ocean including in the Persian Gulf, the warm waters of the Malay Archipelago, the northern coasts of Australia and the coasts of New Guinea [41].

THE ANNULATED SEA SNAKE (*HYDROPHIS CYANOCINCTUS*)

Although it is generally less dangerous than the beaked sea snake, its bite may also be potentially life-threatening to scuba divers. Its maximum length is approximately 130 cm; the largest animals can grow up to 150 cm. It is often found in shallow coastline waters overgrown with mangroves. During the wet season the species travel inland – sometimes they can be spotted a few kilometers away from the shore. It is commonly distributed in the Indian Ocean, from the Persian Gulf to Japan and Australia [42].

THE BLUE-RINGED SEA KRAIT (*LITICAUDA LITICAUDATA*)

The colorful blue-ringed sea krait is one of the most common sea snakes. It has a black head with characteristic yellowish patches. Its average length is around 1 m. Although the species is not aggressive towards humans and its bites are rarely reported, the snakes can be dangerous as they have very potent toxic venom. The species can be found in the waters of the Indian Ocean – along the coasts of India, the Malay Archipelago, northern coasts of Australia and New Guinea, the Philippines and the Solomon Islands [43].

THE YELLOW-LIPPED SEA KRAIT (*LITICAUDA COLUBRINA*)

The yellow-lipped sea krait, also known as the banded sea krait or the colubrine sea krait, is one of the most common species of the sea snakes inhabiting the coral reefs of the Indo-Pacific. It has characteristic black rings all throughout the length of its body and vertically flattened paddle-like tail which is adapted for swimming. The upper

surface of the snake's body has a grayish color, while the belly is *yellowish*. The black rings narrow or are interrupted at the bottom part of the snake's body. The yellow-lipped sea krait is one the few sea snakes which regularly comes ashore, especially at dusk and during the night. On average, it grows up to 140 cm long. The yellow-lipped sea krait has extremely potent toxic venom, which they use to paralyze their prey. Fortunately, the snake is not aggressive towards humans. Nevertheless, you must remain extremely cautious whenever getting close to the species [44].

THE YELLOW-BELLIED SEA SNAKE (*PELAMIS PLATURUS*)

The yellow-bellied sea snake is yet another marine snake which can potentially be dangerous to humans. It is the only pelagic sea snake and as such it spends its entire life away from the shallow waters of the coastline. It can be found in tropical waters across the Indian Ocean and the Pacific. The snake is bicolored – black on the upper surface of its body and yellow at the belly with the two colors sharply demarcating from each other. Its length rarely exceeds 1 m. Bites in humans are extremely rare, but the snake's venom is particularly potent and highly toxic [45].

THE OLIVE-BROWN SEA SNAKE (*AIPYSURUS LAEVIS*)

The olive-brown sea snake is commonly found along the coasts of New Guinea, Indonesia, New Caledonia and the northern coasts of Australia. Their body is thick and massive, the largest adults can exceed 1.8 m long. It has a flattened, paddle-like tail with slightly frayed edges. The snake is not aggressive and will not attack until provoked, but its bite can be dangerous to humans as its venom is highly toxic [46]. Marine snakes are one of the most venomous animals in the world. Some sea snakes have venom which is several times more potent than that of the Indian Cobra. The mortality from a sea snake bite has been estimated at 15–30%. Fortunately, a majority of marine snakes have an underdeveloped venom apparatus and are generally not aggressive towards people, and tend to stay away from swimmers and scuba divers. Still, a direct contact with the animals should be avoided as their bite may be life-threatening. Most species are colorful and do not exceed the length of 1 m, but the largest sea snakes can grow up to around 2 m. Marine snakes are most dangerous to fishermen; a bite can occur when fishers are emptying the fishing nets or while they are wading in shallow waters. The signs and symptoms of sea snake envenomation develop quite slowly. In some cases, no signs or symptoms will occur, and a person may not even know that they had been bitten. However, after a bite by a more venomous snake, signs and symptoms usually begin within 30 to 90 min. Sea

snake venom contains a neurotoxin affecting the nervous system. The initial symptoms of envenomation might include excitement and agitation in some cases or anxiety and restlessness in other cases; the victim can feel mild pain at the bite site. Hemolysis, rhabdomyolysis and a respiratory failure will often ensue. Tongue stiffness, muscle numbness weakness and pain can also occur. Muscle paresis and paralysis gradually spreads upwards from the lower extremities towards the torso and then the head. This results in trismus, facial and eye muscles paralysis. Eventually complete muscle paralysis and kidney damage occur followed by bradycardia, difficulty breathing, cyanosis, convulsions, vomiting, loss of consciousness and eventually death which is due to the paralysis of the respiratory muscles. In most cases, a bite by a sea snake will leave no visible marks on the skin of the victim but it will cause certain systemic signs and symptoms resulting from the neurotoxic effects of venom. A bite by a sea snake is a medical emergency, the victims will need to get prompt medical assistance and will generally require in-hospital treatment (dialysis, mechanical ventilation, maintaining fluid and electrolyte balance) [47, 48].

FIRST AID AFTER BEING BITTEN BY A VENOMOUS SEA SNAKE

A bite by a marine snake should always be considered an emergency. The victim should lie still and try to avoid any effort or movement as it may facilitate the spread of the neurotoxin. A tourniquet should be applied above the bite site and antivenom should be administered, if available. Whenever possible, the snake that had bitten the victim should be caught and brought to the nearest medical facility for identification [46–48].

CONCLUSIONS

The diversity of marine animal species is enormous. The underwater world attracts many people with its beauty, but at the same time, it may pose a serious threat to human health or life. Admiring marine creatures is usually perfectly safe for divers' health. However, in some situations direct contact with aquatic animal species may result in the occurrence of pathological lesions of varying severity such as superficial injuries of the epidermis, dermatitis, major injuries inflicted by marine predators that can lead to disability or death of a person, or life-threatening envenomation or intoxication caused by contact with venomous creatures. Every year, tens of thousands of diving enthusiasts go on a holiday to tropical destinations. If they are planning to go diving during their holiday, they should not only learn how to deal with hyperbaric conditions, but also how to give first aid and effectively manage injuries, intoxication or envenomation caused by marine creatures.

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