CHAPTER 11

Dangerous aquatic organisms

Dangerous aquatic organisms may be encountered during recreational use of freshwater and coastal environments (Halstead, 1988; Williamson et al., 1996). Such organisms vary widely and are generally of local or regional importance. The likelihood and nature of human exposure often depend significantly on the type of recreational activity concerned.

Because of the wide variety of organisms that may be encountered, this chapter summarizes only those known to have caused significant ill-health, injury or death to recreational water users. These include both non-venomous organisms (disease vectors, "in-water" hazardous organisms and "water's-edge" hazardous organisms) and venomous vertebrates and invertebrates (see Table 11.1). Space prohibits full coverage of their geographic distribution, identification, management or first aid treatment. Readers are advised to turn to specialized texts for such information, such as the WHO publication *International Travel and Health*, which is updated annually and is available on the internet (http://www.who.int/ith). Rats, which may spread illnesses such as leptospirosis, are not included but are covered in chapter 5.

Two types of risks can be distinguished in relation to dangerous aquatic species. The first type of risk is infectious disease transmitted by species with life cycles that are linked to the aquatic environment. The second type is injury or intoxication (e.g., ciguatera, histamine poisoning, shellfish and so on) resulting from direct encounters with large animals or venomous species. Injuries from encounters with dangerous aquatic organisms are generally sustained in one of the following ways:

- accidentally brushing past a venomous sessile or floating organism when swimming;
- entering waters frequented by dangerous jellyfish (e.g., box jellyfish);
- inadvertently treading on a stingray, weeverfish or sea urchin;
- unnecessary handling of venomous organisms during seashore exploration;
- invading the territory of large animals when swimming or at the waterside;
- swimming in waters used as hunting grounds by large predators; or
- intentionally interfering with, or provoking, dangerous aquatic organisms.

Perceived risks involving dangerous aquatic organisms may have important economic repercussions in areas that depend to a large extent on recreational tourism as a source of income. An example is the decline in South African tourists visiting Lake Malawi because of news reports about schistosomiasis (bilharzia) cases. Similarly, news about malaria outbreaks in East Africa and dengue outbreaks in the Caribbean

TABLE 11.1. RELATIVE RISK TO HUMANS POSED BY SEVERAL GROUPS OF AQUATIC ORGANISMS

Organism	Discomfort	Requires further medical attention	May require emergency medical attention
Non-venomous organisms			
Sharks		✓	✓✓
Barracudas		✓	
Needlefish		✓	✓✓
Groupers		✓	
Piranhas		✓	
Conger eels		✓	
Moray eels		✓	
Electric fish		✓	✓✓
Seals and sea lions		✓	
Hippopotami		✓	✓✓
Crocodiles and alligators		✓	✓✓
Venomous invertebrates			
Sponges	✓	✓	
Hydroids	✓	✓	
Portuguese man-of-war	✓	✓	✓✓
Jellyfish	✓	✓	
Box jellyfish		✓	✓✓
Hard corals	✓	✓	
Sea anemones	✓	✓	
Blue-ringed octopus		✓	✓✓
Cone shells		✓	✓✓
Bristleworms	✓	✓	
Crown of thorns starfish	✓	✓	
Sea urchins (most)	✓		
Flower sea urchin		✓	✓(✓)
Venomous vertebrates			
Stingrays		✓	✓✓
Stonefish		✓	✓(✓)
Other spiny fish (e.g., catfish, weeverfish, etc.)	✓	✓	
Surgeonfish	✓	✓	
Sea snakes		✓	✓✓
Water moccasin		✓	✓

✓ ✓—associated with fatalities ✓(✓)—probably associated with fatalities.

have had a serious impact on local economies. Incidents that have less effect on general public health, such as repeated shark attacks, usually have a less intense, and shorter-lived, impact in this sense.

Many serious incidents can be avoided through an increase in public education and awareness. It is therefore important to identify and assess the hazards posed by various aquatic organisms in a given region and bring the results to public attention. Awareness raising should be targeted at groups at particular risk (such as those known to have suffered adverse health effects), which may include local and/or visiting populations. In addition, at locations where hazards involving dangerous aquatic organisms have been identified, procedures should be developed for treating any injuries sustained.

11.1 Disease vectors

Animals that carry diseases are typically small and in themselves relatively harmless, with only a few individuals of a population carrying the disease. If present in large numbers, however, they may represent a major nuisance and also be an aesthetic issue (see chapter 9).

11.1.1 Mosquitoes

Tropical freshwater or brackish water environments are havens for mosquitoes. Female mosquitoes require a blood meal (from humans or other animals) to develop their eggs. In the process of taking a blood meal, mosquitoes may ingest pathogens (e.g., the parasite causing malaria) from an infected person or animal. At the next blood meal (mosquitoes go through various cycles of egg production), they then inject the pathogen into the next person, and this will spread the disease. All mosquitoes go through an aquatic larval stage, but the exact ecological requirements vary for the different species in different regions.

Two groups of mosquito-borne diseases are of particular public health importance for those who visit areas where transmission takes place (so-called endemic areas): malaria and arboviral diseases. (The HIV virus, which causes AIDS, is not transmitted by mosquitoes.)

Malaria is caused by one of four species of parasite belonging to the genus *Plasmodium*. Malaria parasites are transmitted by *Anopheles* mosquitoes. These mosquitoes bite between dusk and dawn. Their breeding places are generally in clean fresh water, standing or slowly running, with some species breeding in brackish water coastal lagoons. They never breed in polluted water. Unlike *Culex* mosquitoes (see below), *Anopheles* mosquitoes do not produce the typical high-pitched buzz that is part of the nuisance experienced in mosquito-infested areas. The position of the mosquito body with respect to the wall (at a 45-degree angle) when the insect is resting is probably the easiest way to distinguish anopheline mosquitoes from culicine ones.

Arboviral diseases (arbo = arthropod-borne) are caused by infections that are exclusively transmitted by mosquitoes. They include yellow fever, dengue and various types of encephalitis, such as Japanese encephalitis, when it is associated with flooded rice fields in south, south-east and east Asia. Many of these infections, notably yellow fever and Japanese encephalitis, are preventable by vaccination. For dengue fever (also known as break-bone fever in some parts of the world) and its more severe variant, dengue haemorrhagic fever, there is, however, no vaccine available.

The *Aedes* mosquitoes, which transmit the dengue virus, breed in small water collections in a human-made environment—hence the urban/human settlement-associated distribution of the disease. While dengue haemorrhagic fever is an important cause of death among children during outbreaks of the disease, classic dengue is a much less severe but very debilitating disease lasting for 4–6 weeks. *Aedes* mosquito species have black and white banded legs, and they (sometimes ferociously) bite during daytime.

Culex mosquitoes, which breed in organically polluted water, are mainly known for the transmission of filariasis (which can eventually develop into elephantiasis). This disease is likely to develop only in people who have been exposed to infectious bites for many years.

11.1.2 Freshwater snails and Schistosoma

Certain species of small freshwater snails (*Bulinus* sp., *Biomphalaria* sp. and *Oncomelania* sp., the last one being amphibic) are the essential intermediate hosts for the larval development of trematode parasites of the genus *Schistosoma*. These snails live in tropical lakes (either natural or man-made), in slow-flowing rivers and in the irrigation and drainage channels of agricultural production systems. Contamination of these waters with human excreta from parasite carriers releases first stage larvae (miracidia) that invade the snails. Once the larvae have developed into their infectious stage inside the snail (cercariae), they are released into the water. They adhere to and penetrate the human skin. Following a complex trajectory through the human body (and an associated metamorphosis), they grow into adult trematode worms living in the veins of the liver or the bladder.

Humans infected by *Schistosoma* suffer from a slowly developing chronic, debilitating and potentially lethal tropical disease known as bilharzia or schistosomiasis. Typical symptoms include fever, anaemia and tissue damage. Upon diagnosis, complete cure is possible using the drug praziquantel.

Trichobilharzia ocellata is a schistosome parasite of ducks, which occurs in temperate areas and leads to a far less serious form of infection than outlined above. Cercarial dermatitis or "swimmers' itch" results when the infectious stage of the parasite, known in some cultures as "duck fleas" invade humans. Symptoms may include a prickling sensation shortly after leaving the water, which is followed by an itchy papular dermatitis. The rash is confined to immersed areas of the body. In severe cases the rash can be accompanied by fever, nausea and vomiting (Fewtrell et al., 1994).

11.1.3 Preventive measures

Preventive measures can be taken by the individual:

- Always try to obtain information from appropriate international agencies (e.g., WHO, 1997, 2002) or local health authorities about the local vector-borne disease situation and follow their guidance in risk prevention.
- In malaria endemic areas, take the recommended prophylactic medicine.
- Wear protective clothing (long-sleeved shirts, long trousers) at the indicated biting times.
- Protect exposed parts of your body with repellents (e.g., N,N-diethyl-meta-toluamide—DEET).
- Screened windows and air-conditioning help keep mosquitoes out of houses.
- On return from a malarial area, consult your physician about the possible risk of having contracted the disease, should you have symptoms such as fever, headaches, chills or nausea.

- Avoid swimming or wading in fresh water in countries in which schistosomiasis occurs. Wearing full–length boots, which prevent water contact if wading in the water, will decrease the chances of infection. Although vigorous towel drying after an accidental, very brief, water exposure may help to prevent the *Schistosoma* parasite from penetrating the skin, do not rely on vigorous towel drying to prevent schistosomiasis.

11.2 "In-water" hazardous organisms

Although attacks by "in-water" hazardous organisms, such as sharks, usually attract a lot of public and media attention, the organisms are endemic to certain regions only, and their real public health significance is variable.

11.2.1 Piranhas (freshwater)

Piranhas are restricted to the fresh waters of northern South America, in the Amazon Basin. The largest species is *Pygocentrus piraya*, which reaches a size of 60 cm. Piranhas have powerful jaws with very sharp teeth, which they use to communally attack and kill large prey animals. They can be dangerous to humans. Splashing of the surface water is sufficient to attract a school of piranhas.

11.2.2 Snakes (freshwater)

Some non-venomous but large freshwater snakes such as the semi-aquatic anaconda (*Eunectes murinus*) can present a danger. The anaconda, which reaches lengths of up to 7.6 m, lives in tropical South America. Anacondas generally constrict and suffocate large prey, often viciously (non-venomous) biting the victim before coiling. Attacks on humans have occurred, but the snake is not generally aggressive towards people and will usually endeavour to escape if approached (see section 11.5.6 for venomous snakes).

11.2.3 Electric fishes (freshwater and marine)

Approximately 250 species of fish have specialized organs for producing and discharging electricity and are capable of delivering powerful electric shocks. These specialized organs are used by the fish to locate and stun prey, as a means of defence and for navigation. The electric shock is delivered to a person when contact is made with the animal's skin surface. The majority of electric fishes continuously emit a low-voltage electric charge in a series of pulses, with only two groups of electric fishes posing a serious threat to humans. The most dangerous of these is the freshwater electric eel (*Electrophorus electricus*), capable of producing an electric field of more than 600 volts. It can grow up to 3.4 m and lives in shallow rivers in tropical and subtropical South America. The fish is probably the only electric fish capable of killing a full-grown human.

The most powerful marine electric fishes are the torpedo rays (*Narcine* sp. and *Torpedo* sp.), which are bottom dwellers in all shallow temperate and warm seas. Electric rays vary greatly in their electric potential, some generating an electric field of up to 220 volts. Although the shocks are strong enough to be dangerous, no

fatalities are known. Fishermen in European waters have been known to receive a shock from their line before seeing what was caught (Dipper, 1987).

11.2.4 Sharks (mainly marine)

Sharks live in all the oceans (excluding the Southern Ocean around the Antarctic continent) but are most abundant in tropical and subtropical waters. The majority of shark species are marine, and representatives are found at all depths. Some shark species migrate regularly from salt to fresh water, and a few inhabit freshwater lakes and rivers. Not all shark species are dangerous to humans.

Sharks are attracted by brightly coloured and shiny metallic objects, by the scent of blood, e.g., radiating from speared fish, and also by low-frequency vibrations and explosions. Sharks are furthermore attracted to nearshore garbage dumping grounds. In tropical waters, most shark attacks on humans occur during their habitual feeding times during late afternoons and at night. Sharks rarely "attack" humans, and such incidents are usually cases of mistaken identity, with the shark confusing the swimmer for its prey. Many attacks are a "bite," simply as a taste of the possible prey (Last & Stevens, 1994).

Shark species include the following:

- The great white shark (*Carcharodon carcharias*) lives mainly in the open ocean, although some swim into shallow water. Most of the attacks on people have happened in estuaries. The great white shark is responsible for the largest number of reported attacks on humans. It is thought that humans might be mistaken for its normal seal prey.
- The tiger shark (*Galeocerdo cuvier*) is extremely widespread in the tropics and subtropics. Following the great white shark, the second most reported attacks on humans are attributed to tiger sharks.
- The mako shark (*Isurus oxyrinchus*) is mainly an open ocean shark and occurs in all temperate and tropical oceans. It is often aggressive and dangerous when close to shore.
- The smooth hammerhead shark (*Sphyrna zygaena*), with its very distinctive head shape, lives in all warm water oceans.
- The silvertip shark (*Carcharhinus albimarginatus*) is very abundant around reefs and islands in the Pacific and Indian oceans.
- The bull shark (*Carcharhinus leucas*) is mainly located in the warm oceans of the world, although it can at times be found up the Amazon and rivers in Australia, Central America and south-eastern Africa (Halstead et al., 1990).

11.2.5 Barracudas and needlefish (marine)

The great barracuda (*Sphyraena barracuda*) is widely distributed throughout the subtropical and tropical regions of the open oceans. It is 1.8–2.4 m long and very rarely attacks humans. Barracudas, however, may intimidate divers and snorkellers by closely shadowing them. Like sharks, barracudas are attracted to shiny metallic objects and dead fish.

The various species of needlefish pose a more significant threat to humans. Needlefish are slender, possess very long, strong and pointed jaws and reach an average length of 1.8 m. They are most often found swimming in surface waters. At night, they are strongly attracted by bright lights. Cases of fishermen or divers on night expeditions being severely wounded and even killed by jumping needlefish have been reported (Halstead et al., 1990). Needlefish occur in the Caribbean, around the equatorial western African coast and near Japan and are widespread throughout the western Indian Ocean.

11.2.6 Groupers (marine)

Groupers live in the shallow waters of the Indo-Pacific on coral reefs and in sandy areas. Their size (the giant grouper, *Promicrops lanceolatus*, can reach 3 m) means that these generally non-aggressive fish are potentially dangerous. They are territorial fishes, and divers should look out for groupers before entering underwater caves and ensure that an exit is always open should a grouper wish to escape.

11.2.7 Conger and moray eels (marine)

The majority of eels are harmless, although they may attack and inflict fairly deep puncture wounds when provoked. Moray eels (*Gymnothorax* spp.) live in tropical waters on coral reef platforms, where they hide in crevices and holes among the dead coral. Conger eels (*Conger conger*) live in temperate waters of the Atlantic in rocky areas that offer them hiding places inside caves, holes and cracks.

11.2.8 Preventive measures

Preventive measures can be taken by the individual:

- Treat all animals with respect, and keep at a distance whenever possible.
- Avoid swimming at night or in the late afternoon in areas where large sharks are endemic.
- Avoid swimming in shark waters where garbage is dumped.
- Avoid wearing shiny jewellery in the water where large sharks and barracudas are common.
- Avoid attaching speared fish to the body where sharks, barracudas or groupers live.
- Avoid wearing a headlight when fishing or diving at night in needlefish waters.
- Look out for groupers and moray or conger eels before swimming into caves or putting hands into holes and cracks between rocks.

11.3 "Water's-edge" hazardous organisms

As with "in-water" hazardous organisms, attacks by "water's-edge" hazardous organisms, such as alligators, attract a lot of attention; however, the organisms are endemic to certain regions only, and their real public health significance is variable.

11.3.1 Hippopotami (freshwater)

The hippopotamus (*Hippopotamus amphibius*) is an aquatic mammal chiefly inhabiting freshwater rivers and lakes from the Upper Nile down to South Africa. Despite being a herbivore, the hippopotamus is responsible for a significant number of human deaths in Africa. Due to their sudden and violent nature and ability to swim quickly, hippopotami pose a serious threat to humans in the water. They are generally peaceable creatures, and most often a herd will scatter, or at least submerge, at the approach of humans, but attacks are not uncommon. The majority of incidents are due to ignorance of their habits, in particular moving between a group of hippopotami on shore and water.

11.3.2 Crocodiles and alligators (freshwater and marine)

Crocodiles are found in tropical areas of Africa, Asia, the western Pacific islands and the Americas. The majority of species live in fresh water. The largest living crocodiles may exceed 7.5 m in length. Crocodiles normally hunt at night and bask during the day, but might also hunt during the day if food is in short supply.

All crocodiles are capable of inflicting severe harm or causing death to humans. The more dense their populations, the more dangerous are individual crocodiles. The saltwater crocodile (*Crocodylus porosus*) of south-eastern Asia is probably the most dangerous of all the marine animals. It lives mainly in mangrove swamps, river mouths and brackish water inlets, but has been seen swimming far offshore (Halstead et al., 1990). The Nile crocodile (*C. niloticus*) has been rated as second only to the saltwater crocodile in danger to humans (Caras, 1976).

There are only two species of alligator: the Chinese alligator (*Alligator sinensis*) and the American alligator (*A. mississipiensis*). The Chinese alligator, found in the Yangtze River basin of China, is quite small (<2.5 m) and timid and is not considered to be a significant threat to humans. The American alligator, which lives in freshwater swamps and lakes in the south-eastern USA, is larger (up to 6 m in length) and potentially dangerous to humans. Attacks occur infrequently.

11.3.3 Seals and sea lions (marine)

Seals and sea lions are not aggressive towards humans under normal circumstances. During the mating season, however, or when with pups, bulls might turn aggressive and attack intruders. Of particular concern are the Californian sea lion (*Zalophus californianus*), found along the west coast of North America and the Galapagos, and the bearded seal (*Erignathus barbatus*), found on the edge of the ice along the coasts and islands of North America and northern Eurasia (Halstead et al., 1990).

11.3.4 Preventive measures

Preventive measures can be taken by the individual:

- Treat all animals with respect, and keep at a distance whenever possible.
- Avoid swimming in murky brackish water inlets, river mouths and mangrove swamps inhabited by saltwater crocodiles.

- Always try to obtain information from local authorities about the risk from hazardous organisms and ask for their guidance in risk prevention. If so advised, use a knowledgeable guide who can assess risks properly.

11.4 Venomous invertebrates

The effects of invertebrate venoms on humans range from mild irritation to sudden death. The invertebrates that possess some kind of venomous apparatus belong to one of five large phyla: Porifera (sponges), Cnidarians (sea anemones, hydroids, corals and jellyfish), Mollusca (marine snails and octopi), Annelida (bristleworms) and Echinodermata (sea urchins and sea stars).

11.4.1 Porifera (freshwater and marine)

Sponges are simple multicellular animals, living mainly in shallow coastal and fresh waters around the world. They either attach to some form of substrate (be it rock, seaweed or a hard-shelled animal) or burrow into calcareous shells or rock. Although most sponges are harmless to humans, examples of toxic sponges are found worldwide. Painful skin irritations, sometimes persisting for many hours, are the most common syndrome. No fatalities are known.

11.4.2 Cnidarians (marine)

Cnidarians are relatively simple, with a radially symmetrical body structure. Their body cavity has a single opening surrounded commonly by tentacles equipped with special cells known as cnidocytes. These cnidocytes contain characteristic capsule-like structures called cnidae, which in turn contain a thread that is mechanically discharged upon touch.

Cnidarians are separated into four groups: the Hydrozoa (plume-like hydroids, "fire corals," medusae and Siphonophora), Scyphozoa (free-swimming jellyfish), Cubozoa (box-shaped medusae) and Anthozoa (hard corals, soft corals and anemones). Hydroids and jellyfish possess so-called nematocysts (stinging capsules), which, when the cnidae thread is discharged, penetrate the integument (tough outer protective layer) of their prey and inject a toxin. Sea anemones and true corals, on the other hand, have spirocysts or ptychocysts with adhesive cnidae threads.

1. Hydrozoa

Most of the 2700 species of hydrozoa are harmless, but some can inflict painful injuries on humans. Well known examples of these are the sea firs, fire corals and Portuguese man-of-war. Apart from severe stinging cases from the Portuguese man-of-war, hydrozoan stings are not generally life threatening, although the pain can last for several days.

Stinging or fire corals (e.g., *Millepora alcicornis*) have nematocysts that vary in stinging intensity according to species (Sagi et al., 1987). These hydroid corals can cause a painful skin rash. They are generally found together with true corals in warm waters of the Indo-Pacific, the Red Sea and the Caribbean.

The stinging hydroid or fire-weed (*Aglaophenia cupresina*) is a hydroid colony. It resembles seaweed and grows on rocks and seaweeds in the tropical Indo-Pacific. If touched, it causes a nettle-like rash lasting several days (Rifkin et al., 1993).

The Portuguese man-of-war (*Physalia* spp.) is a free-swimming colony of open-water hydrozoans that lives at the sea–air interface. *Physalia* is easily recognized by the prominent floating blue or purple gas-filled bubble that supports the stinging cells on the tentacles and zooids hanging below. The tentacles may reach a length of up to 10 m. Different species of *Physalia* are widespread throughout all oceanic regions, except the Arctic and Antarctic, and may be blown onto beaches in swarms after strong onshore winds. The nematocysts remain active even when beached. Stings by the various *Physalia* species are the most common marine stings known at present. The Atlantic species (*Physalia physalis*) is the most dangerous and has been responsible for some severe stings (Spelman et al., 1982; Burnett et al., 1994) and three deaths (Burnett & Gable, 1989; Stein et al., 1989).

2. Scyphozoa and Cubozoa

The number and variety of potentially harmful Scyphozoa and Cubozoa are too numerous to mention here, but the subject has been widely reviewed by Burnett (1991) and Williamson et al. (1996). Williamson et al. (1996) give detailed accounts of the dangerous jellyfish species and describe the harm they can inflict on humans and the recommended treatment for stings from each of the individual species. Although most stings result in only a short-lived burning sensation, some can be dangerous, especially if the swimmer has a severe allergic reaction (Togias et al., 1985) or if the jellyfish is one of those rare species where the stings can be fatal.

The Scyphozoa, or true jellyfish, are typically pelagic and exist for the greater part of their life as medusae. They move by gentle pulsations of the bell, but are frequently driven ashore and stranded by wind and currents. All jellyfish are capable of stinging, but only a few species, particularly *Stomolophus nomurai* and *Sanderia malayensis*, are considered a significant hazard to human health (Mingliang, 1988; Williamson et al., 1996). Species of some genera, such as *Cyanea*, *Catostylus* and *Pelagia*, may occur in large groups or swarms.

The Cubozoa are the most dangerous cnidarians (Fenner & Williamson, 1996; Williamson et al., 1996). They are characterized by a roughly cube-shaped body or bell, with tentacles arising from fleshy extensions in each lower corner of the bell. Several species of box jellyfish have been implicated in human deaths, with *Chiropsalmus quadrigatus*, which causes some 20–50 deaths each year in the Philippines (Fenner & Williamson, 1996), and the Chironex box jellyfish *Chironex fleckeri*, found in summer months in the northern tropical waters of Australia (Baxter & Marr, 1969), being among the most venomous of all marine creatures. A death has also occurred in the south-eastern USA from the box jellyfish *Chiropsalmus quadrumanus* (Bengston et al., 1991). Respiratory failure may occur within a few minutes of being stung by *Chironex fleckeri* (Lumley et al., 1988).

3. *Anthozoa*

Hard corals can cause abrasion injuries if a swimmer simply brushes against their hard branches. Certain coral colonies also possess stinging nematocysts (*Goniopora*, *Plerogyra*, *Physogyra*), which can leave a rash if touched.

The majority of sea anemones are harmless, except when their tentacles come into contact with delicate parts of the body, such as the face, lips and underarms, resulting in a painful sting. One example is the common intertidal beadlet anemone (*Actinia equina*), found in the eastern Atlantic. More hazardous sea anemones include the hell's fire sea anemone (*Actinodendron plumosum*), found on the shady side of rocks and under coral ledges in the tropical Pacific. A sting from this anemone can cause skin ulcerations lasting for several months. *Triactis producta*, found in the Red Sea, gives painful stings that may later ulcerate (Halstead et al., 1990). A death has occurred after complications following a sting by *Condylactis* species (Garcia et al., 1994).

11.4.3 Mollusca (marine)

Molluscs are found in marine, freshwater and terrestrial environments. They all possess a distinct and well developed head, a muscular foot and a soft, variable-shaped body. Of the aquatic representatives of this large group, only some cephalopods and the cone shells (*Conus*) produce venoms harmful to humans.

All octopi possess two powerful horny jaws, which they can use to bite humans. The bites from the non-venomous (the majority) octopi result in small puncture wounds causing moderate pain. Certain species of octopus, such as the blue-ringed octopus (*Hapalochlaena* (= *Octopus*) *maculosa*) or the spotted octopus (*Octopus lunulatis*), are equipped with venom that aids in the capture of prey. Bites from these species can be deadly (the poisons are neuromuscular, producing muscular weakness and eventually respiratory paralysis) and should be treated with urgency (Williamson, 1987). Both species inhabit shallow coastal waters of the tropical Indo-Pacific and normally show no aggression towards humans. The majority of reported bites have resulted from handling or interfering with the octopi (Flecker & Cotton, 1955; Sutherland & Lane, 1969; Sutherland, 1983).

There are between 400 and 500 species of cone shells, all of them possessing a highly developed venom apparatus. The tropical and subtropical cone shells, *Conus* sp., are usually found in shallow waters along reefs and on or in sandy bottoms. They use their harpoon-like darts carrying the venom supply to catch prey and to discourage predators (Hinegardner, 1958). They often cause intense, localized pain at the site of the injury, accompanied by nausea, vomiting, dizziness and weakness. In more severe cases, victims experience respiratory distress with chest pain, difficulties in swallowing, marked dizziness, blurring of vision and an inability to focus. Fatalities are caused by respiratory paralysis (Flecker, 1936; Kohn, 1958; Endean & Rudkin, 1963; Russell, 1965). Most reported cases are from those organisms being handled.

11.4.4 Annelids (marine)

Of the annelids (segmented worms), only some bristleworms, named after two bristle-like setae attached to all their segments, are venomous. Bristleworms live under rocks and boulders. In venomous species, the setae sting; in the Caribbean fire worm (*Hermodice carunculata*), the sting leads to intense pain and a burning sensation.

11.4.5 Echinoderms (marine)

Very few of the radially symmetrical adult echinoderms are hazardous to humans. Most common minor injuries are abrasions or punctures acquired from contact with the spines or skin of echinoderms. Examples of venomous species are found only within the starfish and sea urchins.

The crown of thorns starfish (*Acanthaster planci*) is the only venomous starfish and lives on coral reefs in the Indo-Pacific. Its upper surface is covered with many long, sharp and venomous spines, which can inflict painful wounds if handled (Heiskanen et al., 1973). No serious injuries from *Acanthaster* have been recorded.

Sea urchins are found in all oceans, normally located on rocky foreshores and reefs. Most sea urchins can be handled safely, but a few species possess venomous spines or jaw-like pedicellariae capable of delivering very painful injuries (Halstead, 1971). These venomous species tend to be confined to the tropical and subtropical marine regions. Fatal incidents are said to have occurred from handling the flower sea urchin (*Toxopneustes pileolus*) from the Indo-Pacific, the most venomous sea urchin known, but these are difficult to confirm (Hashimito, 1979; Smith, 1977).

11.4.6 Preventive measures

Preventive measures can be taken by the individual:

- Always wear suitable footwear when exploring the intertidal area or wading in shallow water.
- Avoid handling sponges, cnidarians, cone shells, blue-ringed octopus, bristleworms or the flower sea urchin.
- Avoid brushing against hydroids, true corals and anemones.
- Avoid swimming in waters where Portuguese man-of-war are concentrated (often indicated by beached specimens).
- If swimming where jellyfish are prevalent, wear a wet suit or other form of protective clothing, such as the full-length stretch-fitting suits used by divers in tropical waters.

11.5 Venomous vertebrates

Venomous vertebrates deliver their venom either via spines, as with many fish species, or through fangs, as in sea snakes. Injuries caused by venomous marine vertebrates are common, especially among people who frequently come into contact with these marine animals. Potent vertebrate toxins generally cause great pain in the victims, who may also experience extensive tissue damage.

11.5.1 Catfish (freshwater and marine)

Catfish are bottom dwellers living in marine, freshwater or estuarine environments. They possess venomous dorsal spines, which can inflict painful wounds even when the fish is dead (Halstead, 1988). The majority of catfish stings result from handling catfish while sorting fish catches. Some species, such as *Heteropneustes fossilis* from India, have been known to actively attack humans, leaving a painful sting (Williamson et al., 1996).

11.5.2 Stingray (freshwater and marine)

Stingrays are found in the Atlantic, Indian and Pacific oceans. They are predominantly marine, but the South American river ray (Pontamotrygonidae) lives in fresh water. Stingrays tend to be partially buried on sandy or silty bottoms in shallow inshore waters. Up to six venomous spines in their tails can stab unwary swimmers who happen to tread on or unduly disturb them. All stingray wounds, no matter how minor, should receive medical attention to avoid the risk of secondary infection. Some injuries caused by venomous stingrays can be fatal for humans if the spine pierces the victim's trunk; deaths have been reported for both marine (Rathjen & Halstead, 1969; Fenner et al., 1989) and freshwater (Marinkelle, 1966) species.

11.5.3 Scorpionfish (estuarine and marine)

All species of scorpionfish possess a highly developed venom apparatus and should therefore be treated with respect. The estuarine stonefish (*Synanceia horrida*, syn. *S. trachynis*) is the most venomous scorpionfish known and occurs throughout the Indo-Pacific. The reef stonefish (*Synanceia verrucosa*) resembles coral rubble and lies motionless in coral crevices, under rocks, in holes or buried in sand or mud, where divers often mistake it for a rock. The pain associated with stings by a stonefish is immediate and excruciating and can last for days (Williamson et al., 1996). The lionfish and true scorpionfish are also venomous. Deaths have been attributed to stonefish but are very difficult to confirm (Smith, 1957; Cooper, 1991).

11.5.4 Weeverfish (marine)

Weeverfish are confined to the north-eastern Atlantic and Mediterranean coasts. All four species (*Trachinus* spp. and *Echiichthys* sp.) contain venomous dorsal and gill cover spines. They are small (less than 4.5 cm) and lie partly buried in sandy bays at extreme low water where swimmers and beach walkers frequently step on them. Weeverfish are regarded by some as the most venomous fish found in temperate European waters (Halstead & Modglin, 1958; Russell & Emery, 1960).

11.5.5 Surgeonfish (marine)

Surgeonfish are herbivorous reef dwellers equipped with a sharp, moveable spine on the side and base of the tail. When excited, the fish can direct the spine forward, making a right angle with the body, ready to attack. Large surgeonfish, such as the Achilles surgeonfish (*Acanthurus achilles*) and the blue tang (*Acanthurus coeruleus*) of

the warm seas of the western Atlantic, use their spines in defence and cause deep and painful wounds with a quick lashing movement of the tail (Halstead et al., 1990).

11.5.6 Snakes (freshwater and marine)

Poisonous snakes are air-breathing, front-fanged venomous reptiles, and many are associated with both the marine and freshwater environments. Of the 50 species of sea snake, the majority live close inshore or around coral reefs. They appear similar to land snakes, but have a flattened tail to aid in swimming. They are curious, generally non-aggressive creatures, but can be easily provoked to attack. All sea snakes are venomous and can inflict considerable harm if disturbed. White (1995) estimated a worldwide sea snake fatality rate of at least 150 per year.

Of the freshwater aquatic snakes, possibly the water moccasin or cottonmouth (*Agkistrodon piscivorus*) is the most dangerous to humans, the venom attacking the nervous and blood circulatory systems of the victim. The water moccasin is a pit-viper found throughout the south-eastern part of the USA. The species is never far from water and swims with its head well above the surface. When threatened, the snake opens its mouth wide to reveal the almost white lining, which gives it its common name. The species can be aggressive and is densely populated in some areas. Its bite can result in gross tissue damage, with amputations of the affected limb not uncommon (Caras, 1976). Other species of the genus *Agkistrodon* are found throughout North America and south-eastern Europe and Asia.

11.5.7 Preventive measures

Preventive measures can be taken by the individual:

- Always "shuffle" feet when walking along sandy lagoons or shallower waters where stingrays frequent.
- In catfish waters, fishermen should be extremely careful when handling and sorting their catch.
- Suitable footwear should be worn to avoid accidentally treading on weeverfish or stonefish.
- Wear boots in snake-infested areas.
- If possible, carry anti-venom in snake-infested areas.

11.6 References

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