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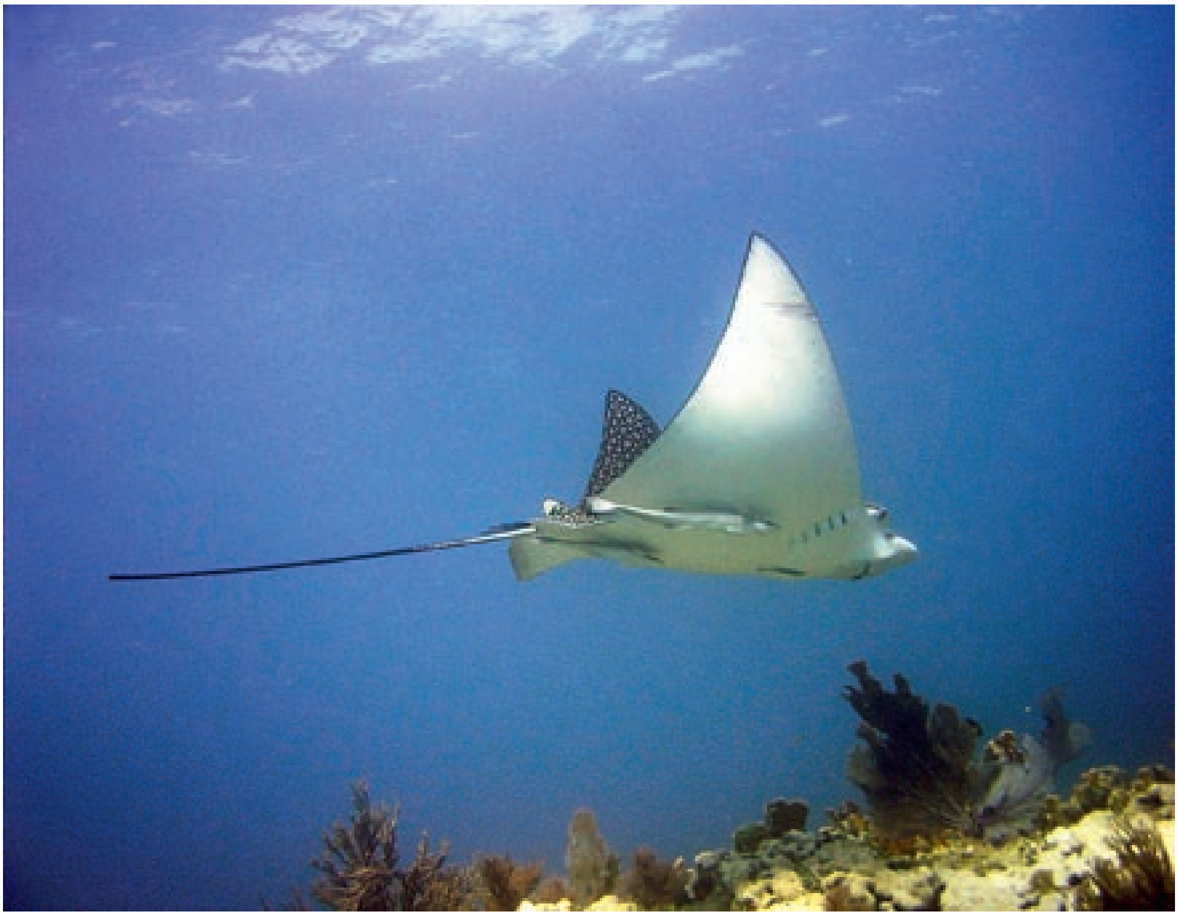
the Beauty of the Beast

The Present and Future of Elasmobranches in Europe


the Beauty
of the Beast

Contents



Spotted eagle ray (*Aetobatus narinari*) photographed in the Florida Keys, U.S.A. © OCEANA/ Houssine Kaddachi.

Executive Summary

- Sharks represent one of nature's most successful creations. They have roamed our oceans for over 400 million years and survived various extinction events to evolve into predators that are perfectly adapted to the marine environment. Early sharks looked very different from today's modern sharks, but these animals have always had a strategic advantage over their rivals with a hydrodynamic body shape and a flexible skeleton made of cartilage.

- The over 1,000 extant species of sharks and related rays, skates, guitarfishes and sawfishes (the group of cartilaginous fish collectively known as elasmobranches) present an incredible range in body shape and size, living in every marine environment from warm coastal coral reefs to the cold dark depths of the oceans. European waters are home to nearly 140 elasmobranch species.

- Sharks have unique and complex biological characteristics and an extremely sophisticated sensory system. Generally, they grow slowly, produce few young, and are long-lived. The prominent images of a shark's attack and capture of its prey is only the last step in a longer process of detection and pursuit, in which the animal takes full advantage of each highly developed sense.

- Sharks are important in maintaining the health and balance of marine communities. As apex predators, they directly and indirectly shape the flora and fauna components of the ecosystem. Removing sharks can destabilize the food web and have widespread negative ecological impacts on community structure and function. Indeed, declining shark populations are already resulting in disrupted marine ecosystems around the globe.

- According to the IUCN Red List of Threatened Species, over 20% of elasmobranch populations around the world, and over 30% in Europe, are threatened with extinction. The extensive declines in shark populations are primarily due to fisheries overexploitation, as sharks are caught as targeted and accidental catches in many different fishing gears, including gillnets, purse seines, longlines and trawls, and from small artisanal boats to giant industrial vessels.

- Sharks' particular biological characteristics make them extremely vulnerable to fisheries exploitation and many populations cannot recuperate at the same rate at which they are exploited. There is evidence that sharks are disappearing at unprecedented rates around the globe and indeed some species have already become locally extinct.

- In 2006, over 750,000 tons of elasmobranches were reported caught around the world, but estimates based on the shark fin market reveal that real catches can be up to four times higher than this amount. The European Union is the second shark catching state in the world, with Spain accounting for nearly half of the EU's catch. Spain is the European centre for shark fisheries and trade.

- Sharks are primarily targeted for their valuable fins, which can reach up to €500/kg on some markets, and the high demand for shark fins can lead to the cruel and wasteful practice of shark finning. Sharks are also caught for their meat, livers and cartilage. Unlimited shark fisheries, nonexistent or lax fisheries management regimes, uncontrolled trade in shark products, habitat degradation and contamination are all threatening sharks on a global scale.

- Shark conservation is hampered by a general lack of political will, gaps in scientific knowledge and negative public images. Legislative reform in fisheries management and threatened species protection are straightforward ways to protect elasmobranches. Increased public awareness and changes in public opinion are also integral to safeguarding sharks.

Terminology note: The term "shark" is sometimes used in this report to refer not only to true shark species, but also to the closely related rays, skates, and chimaeras. Together, these species make up the group known as chondrichthyan fishes due to their common cartilaginous skeleton. This definition of "shark" is also often used in international fisheries policy and management documents, as well as some of the documents referenced in this report. The author has attempted to distinguish between sharks or other chondrichthyans in the discussions in this report whenever possible.

1/ Introduction

They say that even bad publicity is good publicity. This is not the case, however, for the misunderstood shark. This incredibly complex and captivating ocean predator has been plagued by bad publicity for years, contributing to an unfortunate situation that has hampered conservation efforts and put its very survival in danger.

Sharks have been represented by media outlets as oceanic villains- the bad guys to be defeated or the monsters to be eliminated. However this is exactly the opposite of what we should be doing, as we need these top predators present in the oceans to maintain healthy and stabile marine ecosystems. A general fear and low public awareness, coupled with an overall lack of scientific data and political will, has led us down a dangerous path for the future of sharks and our oceans.

Sharks have historically had low economic value in most countries. And as research priorities are often linked to the economic value that fisheries yield, relatively little research has been carried out on sharks and today there remains large knowledge gaps on their life history, geographical distribution, migration paths, sustainable exploitation levels, and commercial trade patterns. Nevertheless, we do know that the over 500 shark and over 600 related ray species are found in all waters of the globe, from cold arctic waters to warm tropical seas. In general, they grow slowly, are long lived, and produce few young- a dangerous combination in these days of insatiable industrial fishing, as many populations are unable to recover from high levels of exploitation. Today, sharks are primarily caught without limit in targeted fisheries, but they are also incidentally taken in fisheries targeting other species. Approximately 200 million sharks and related rays are killed each year due to fishing practices.

Figure 1. Number of European elasmobranch species per IUCN Global Red List Category[1]

Critically Endangered	7
Endangered	6
Vulnerable	17
Near Threatened	21
Least Concern	18
Data Deficient	13
Not evaluated	54
TOTAL SPECIES	136

Filets of bluefin tuna, swordfish and blue shark (12€/k) in a fish stand at the quay of the port of Marseille, France. © OCEANA/ María José Cornax.

1 The IUCN (International Union for the Conservation of Nature) Red List of Threatened Species is the world's most comprehensive and authoritative inventory of the global conservation status of plant and animal species. Species are assessed on a formal set of criteria and placed in one of the following categories: Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, Data Deficient and Not Evaluated. Species qualifying as Vulnerable, Endangered or Critically Endangered are considered *Threatened* with extinction. Individual geographic populations of certain species may be listed in distinct categories. This table shows global status.

1/ Introduction

As markets for shark products are continually being developed, sharks are now predominantly caught for human consumption, in particular that of their fins, which have rocketed in value. This can lead to the cruel and wasteful practice of shark finning, which only utilizes up to 5% of the entire animal. Shark parts can also be used to produce cosmetic ingredients, medicinal supplements, and jewellery. Increasingly, they are exhibited in public aquaria and marketed in adventure tourism for divers wanting to swim alongside these wonders of the sea.

In addition to fishing and trade, other threats such as habitat degradation and water contamination are decimating shark populations around the globe. The loss of these animals will set off a chain reaction throughout the oceanic food web, contributing to negative outcomes such as the disappearance of other species and the disruption of entire marine ecosystems. These super-predators have survived hundreds of millions of years to become perfectly adapted to their marine surroundings. However, today's ultimate predator, *man*, is causing potentially irreversible effects on something that has gone unchanged over millennia. Legally binding shark fisheries management and protection through environmental conventions are two ways of safeguarding sharks, but increased public awareness and understanding is equally important.

This report provides an overview of shark characteristics while highlighting their uniqueness and importance in the marine world. The many threats faced by these animals today are also detailed, and methods to ensure their future survival are presented.

Sharks today have more to fear from us than we do from them. © Rob Stewart/ Sharkwater.

2/ A natural history of sharks

Sharks have been described as everything from fierce blood-thirsty monsters to majestic creatures from long-ago. They are portrayed in popular western media as dangerous man-eaters, but revered as mystic and powerful beings by some indigenous Pacific cultures. What is true is that these are ancient, complex and diverse creatures.

What is a shark?

In its most basic sense, a shark is a fish with a skeleton made of flexible cartilage instead of rigid bone. Sharks belong to the taxonomic class Chondrichthyes[II], the group of over 1,168[1] species of fish with cartilaginous skeletons, thus separating them from the nearly 30,000 species of teleost (bony) fishes (class Osteichthyes). Chondrichthyans are highly-adapted and diverse, ranging widely in size and living in every marine environment, from warm coastal coral reefs to the cold dark depths of the oceans[2]. There are two main groups of Chondrichthyes: the subclass the Elasmobranchii[III], which includes sharks and batoids (1,125 species), and the subclass Holocephali[IV], which includes chimaeras (43 species)[3].

This report focuses on elasmobranches, the group of 1,125 species of fish made up of sharks and batoids (skates, rays, guitarfishes and sawfishes).[V] Elasmobranches have five to seven paired gill openings on both sides of their heads, tiny tooth-like scales, and practice internal fertilisation (a form of animal reproduction in which eggs are fertilised inside the female's body). Sharks and some other elasmobranches have thousands of teeth that are continually produced and shed over a lifetime, and they typically present a cylindrical body shape. Sharks are also characterised by a large caudal fin and one or two dorsal fins, sometimes with spines. Batoid fishes are much like flattened sharks and are characterised by short bodies and two expanded pectoral fins that have an appearance similar to wings[7].

Despite this simple classification of sharks, there exists a wide diversity in body size and shape. Sharks can range from the tiny cookie-cutter shark (*Isistius brasiliensis*), with a small cigar-shaped body that measures approximately 45 centimeters (18 inches) and who takes round cookie cutter-shaped bites out of its prey, to the immense and gentle whale shark (*Rhincodon typus)*, the largest living fish in the sea. The uniquely patterned whale shark filters plankton (microscopic plants and animals) from the water and can reach up to 20 metres (66 feet) long. Another curious shark is the frilled shark (*Chlamydoselachus anguineus)*, a rare primitive species, dating back at least 95 million years[8], with an eel-like body and a flattened snake-like head. Its name comes from its gill tissue which slightly extends from the body, giving the shark a frilly look.

II From the Greek *chondros* (cartilage) and *ichthos* (fish).
III From the Greek *elasmos* (plate) and *branchia* (gill).
IV From the Greek *holo* (whole) and *cephali* (head).
V This report does not discuss chimaeras in detail; they are briefly treated in a separate text box. See Annex I for a taxonomic cladogram of elasmobranches.

Of rats, rabbits, elephants and ghosts: the chimaeras

In addition to the elasmobranches, the subclass Holocephali makes up the other half of the class Chondrichthyes, the cartilaginous fish. The holocephalans are the chimaeras, also known as ratfish, rabbitfish, elephant fish, and ghost sharks because of their peculiar appearance. Chimaeras comprise just over 40 species in three families, but additional species are likely to be found[5]. Seven species are found in European waters. Much data is lacking on these species and their conservation status is largely unknown.

Like the elasmobranches, chimaeras have a skeleton made of cartilage, employ claspers for internal fertilisation and lay eggs. They also have a venomous spine on their back for defence, present in some elasmobranches such as bullhead sharks (Heterodontidae family), dogfish sharks (Squalidae family) and stingrays (Myliobatoidei suborder).

However, chimaeras are unlike elasmobranches in that they lack dermal denticles and only have four gill slits. Their upper jaw is fused to the skull and their teeth are few and plate-like for grinding. Chimaeras are also characterised by their big heads, large eyes, wing-like pectoral fins and streamer-like tail; some can have long snouts. Chimaeras commonly live on the ocean floor and can be found all around the world except in the far polar regions[6].

This male elephant fish (*Callorhinchus milii*) uses its plough-shaped sensory snout to scan the seafloor for the electrical pulses given off by buried prey. © marinethemes.com/ Kelvin Aitken.

Another unique shark, the tasselled wobbegong (*Eucrossorhinus dasypogon*), photographed in the Raja Ampat archipelago of Indonesia. Coral reef destruction and fisheries are threatening the habitat of this elasmobranch found only in the Southwest Pacific Ocean[4]. © Carlos Suárez.

The story of the shark

The story of the shark is a very long one, beginning over hundreds of millions of years ago. The exact geological origin of these fish is hard to know- since sharks are made of cartilage and not bone, their skeletons do not easily fossilise. The earliest and most abundant fossils of sharks are scales, but clearly the most important and revealing ones are teeth[9,10]. The shark fossil record has revealed up to 3,000 species of sharks[11]. Based on these fossils, it is known that early sharks looked very different from modern ones. However, even early on, these animals had a strategic advantage over their rivals: a hydrodynamic body plan and a flexible skeleton of cartilage, which gave them strength without weight. Sharks' faultless adaptations allowed them to survive numerous mass extinctions, watch the dinosaurs' arrival and departure from the planet, and witness the moment when land mammals, first took a dip in the sea, eventually evolving into today's dolphins and other cetaceans.

2/ A natural history of sharks

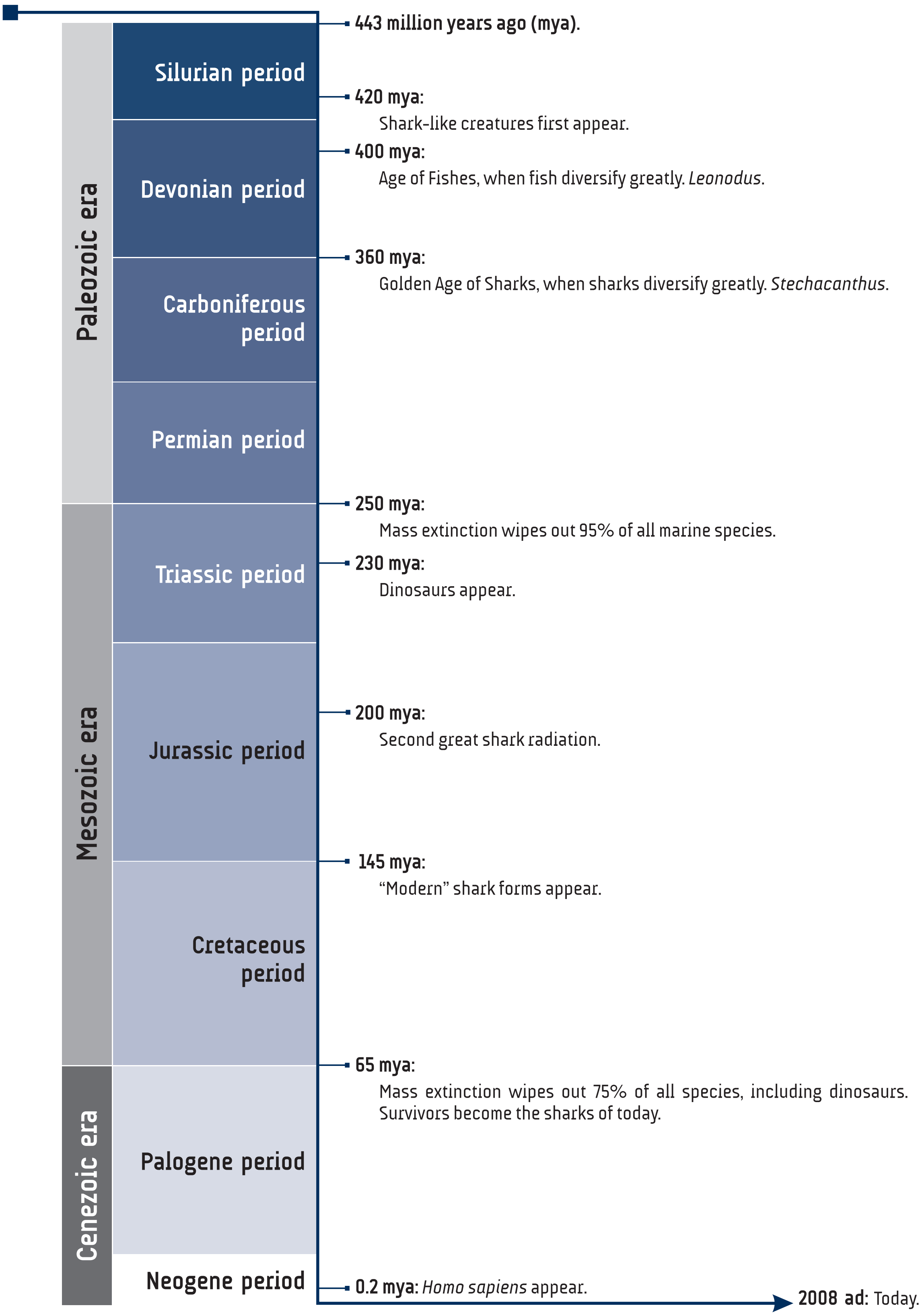
Fossil shark teeth for sale in Las Palmas, Spain. © OCEANA/ LX.

Shark-like creatures first appeared at the beginning of the Silurian period, about 420 million years ago, before vertebrates and many plants existed on land. They then flourished during the Devonian period, 400 million years ago[12], in a time known as the "age of fishes" when all fishes, including sharks, diversified greatly. The earliest known fossil teeth of true sharks come from this period- they were tiny teeth, 3-4 mm (0.14 inches) in size, belonging to a peculiar small shark known as *Leonodus*[13].

About 360 million years ago, at the beginning of the Carboniferous period, sharks diversified and proliferated even more in what is referred to as the "golden age of sharks". This period saw the evolution of sharks with the typical body plan we see today, but also those with some very odd ones. The one-metre (three feet) long *Stethacanthus* had a cap of teeth on its head and an enormous dorsal fin structure sticking out of its back lined with teeth-like scales and looking much like a shaving brush. While theories on the function of this structure are numerous, it most likely played a role in defence or courtship[14].

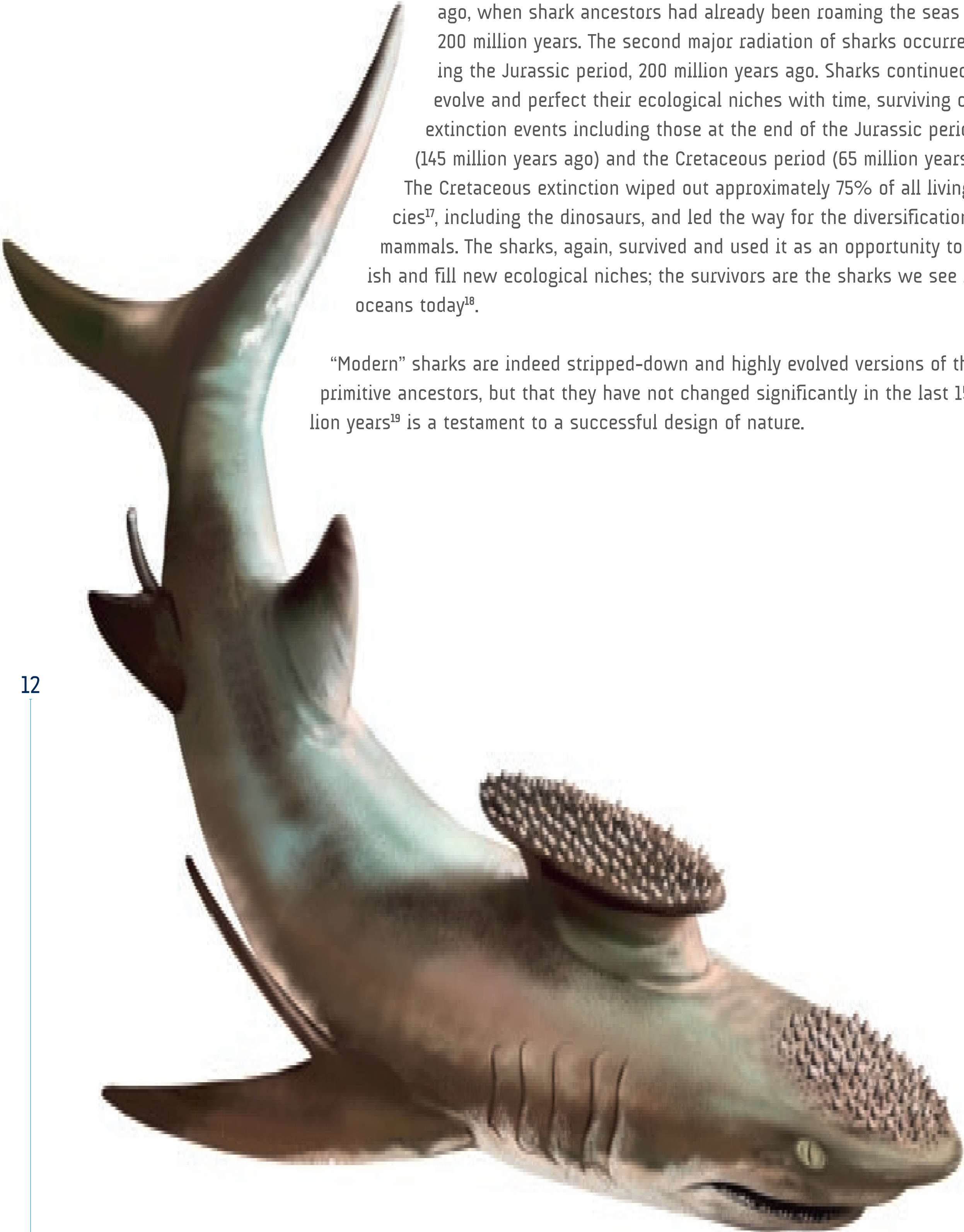
Then after many millions of years with little evolutionary change, sharks suddenly found themselves on the verge of extinction. This was due to the greatest mass extinction event of all time, which occurred in the Permian period at the end of the Pelaeozoic era, about 250 million years ago. This extinction wiped out approximately 95% of all marine species[15], including many sharks[16]. Those sharks that did survive took advantage of the niches opened up by the catastrophe and populations began recuperating at the beginning of the Mesozoic era, 245 million years ago.

Figure 2: Prehistoric Timeline



The dinosaurs then appeared, in the Triassic period 230 million years ago, when shark ancestors had already been roaming the seas for 200 million years. The second major radiation of sharks occurred during the Jurassic period, 200 million years ago. Sharks continued to evolve and perfect their ecological niches with time, surviving other extinction events including those at the end of the Jurassic period (145 million years ago) and the Cretaceous period (65 million years ago). The Cretaceous extinction wiped out approximately 75% of all living species[17], including the dinosaurs, and led the way for the diversification of mammals. The sharks, again, survived and used it as an opportunity to flourish and fill new ecological niches; the survivors are the sharks we see in the oceans today[18].

"Modern" sharks are indeed stripped-down and highly evolved versions of their primitive ancestors, but that they have not changed significantly in the last 150 million years[19] is a testament to a successful design of nature.



Stethacanthus lived around 360 million years ago. © 2007 The Field Museum/ GEO86500d_SiDePF02_i7, illustration by Karen Carr.

The biggest fish in the pond

One of the most celebrated sharks of all time is Megalodon, the largest predatory fish to have ever roamed the seas. First appearing approximately 16 million years ago toward the begining of the Neogene period, Megalodon[VI], which means "big tooth", was larger than *Tyrannosaurus rex*[20] and three times longer than the present day great white shark (*Carcharodon carcharias*), its likely closest relative. Today, little more than fossilised teeth are what remain of Megalodon; the thick, broad, triangular teeth measure up to 18 centimetres (7 inches), easily longer than a man's hand, and weigh up to 0.4 kilograms (0.75 pounds). Paleontologists can use these teeth to reconstruct what the animal really looked like and estimate that it measured nearly 18 metres (60 feet) and had a mass of over 70 tons[21]. Megalodon clearly dominated the ocean world.

Megalodon and the great white coexisted in the oceans for nearly 10 million years. These two predators coexisted by living in different areas and feeding on different prey. Megalodon likely inhabited warmer waters, and since the ocean was markedly warmer when it existed than today, it thrived all around the globe. Indeed, Megalodon teeth have been found in many parts of the world, including Europe, North America, South America, and Asia. Based on its size, scientists estimate that Megalodon consumed an average of 1,135 kg (2,500 pounds) of food per day, including whales, large fish, and other sharks. The great white inhabited cooler waters and primarily prayed on seals.

However, something caused the Megalodon to suddenly go extinct while the great white survived. The exact cause of Megalodon's extinction about 1.6 million years ago is not known, but it was likely due to a combination of different factors including lower water temperatures and sea level, shrinking habitat, and less available prey. The great white, on the other hand, thrived by exploiting rich feeding areas available in the cooler waters[22].

Megalodon remains the most studied and controversial extinct shark, and debate continues today about the exact relationship between it and the great white. Most paleontologists agree that while Megalodon is related to the great white, it is not its direct ancestor. The extinct shark known for its "big teeth" is probably more like a great uncle to the one known today for its "jaws"[23].

VI From the Greek *mega* (big) and the Latin *odon* (tooth).

2/ A natural history of sharks

Today there remains a great diversity of shark and related elasmobranch species all around the world: there are 494 true sharks and 631 species of related rays, skates, guitarfish, and sawfish[24]. Among these species are the diamond-shaped giant manta ray (*Manta birostris)*, which appears to "fly" gracefully through the oceans with its large fins, and the unpredictable bull shark (*Carcharhinus leucas)*, with its amazing ability to tolerate fresh water and its tendency to dwell in shallow waters along coasts and rivers. Indeed, new species are continually being discovered and named.

Approximately 136 species of elasmobranches can be found in European waters, including 80 species of sharks.[VII] The Mediterranean Sea is home to approximately 80 species of sharks and rays, although this sea has been named the most dangerous place in the world for elasmobranches as many species are now uncommon or threatened with extinction, mostly due to the development of fishing activities[25,26].

Where do sharks live?

Sharks and rays live everywhere, and each species has evolved to live in its specific habitat. These habitats span the entire globe; sharks can be found everywhere from warm tropical oceans, where we find the scalloped hammerhead (*Sphyrna lewini*), to frigid polar waters. The large Greenland shark (*Somniosus microcephalus*) can even live in Arctic waters down to 1 °C (34 °F)[27]!

Some sharks are coastal species and prefer to live close inshore on the continental shelf, like many sharpnose sharks (*Rhizoprionodon* spp.). Other sharks are pelagic, living far from shore in the open ocean, like the oceanic whitetip shark (*Carcharhinus longimanus*), which cruises the open ocean in search of prey.

Other sharks are benthic, or "bottom dwelling". The angelshark (*Squatina squatina*) lives on or in muddy and sandy bottoms of the continental shelf. And while those known as "deep-sea" sharks generally live about 300-1500 metres (985-4920 feet) deep, some can live down to incredible depths. The Portuguese dogfish (*Centroscymnus coelolepis),* sometimes caught for its valuable liver oil, can be found down to a depth of 3,675 m (12,057 ft)!

A bluntnose sixgill shark (*Hexanchus griseus*) seen 121 metres (397 feet) deep on the Seco de Palos seamount near Murcia, Spain during the 2007 Oceana Ranger Mediterranean Expedition. This deep-sea shark is particularly known for having six pairs of gill slits, instead of the more common five. © OCEANA.

VII See Appendix II for a list of European elasmobranch species.

Certain elasmobranches can even inhabit freshwater rivers and lakes. The bull shark (*C. leucas*) has an amazing ability to tolerate fresh water and is known to travel 100 km (62 miles) upstream in warm rivers like the Mississippi and the Amazon. Because this shark often dwells in shallow fresh waters commonly used for recreation and sport activities, it is considered one of the most dangerous to human beings. Other elasmobranches are exclusive to fresh water, such as the "river sharks" (*Glyphis* spp.) found in the Indo-Pacific, although they are now extremely rare due to habitat degradation[28].

The home ranges of sharks also vary widely, depending on the species. Some sharks are migratory and roam the seas, sometimes crossing entire oceans to travel from feeding and hunting grounds to breeding or pupping areas. Species such as the great white shark (*C. carcharias*), whale shark (*R. typus*), and basking shark (*Cetorhinus maximus*) are all migratory for one reason or another. Data recovered from electronic tags placed on great white sharks have revealed that they range across vast stretches of the open ocean, suggesting that this represents an important period in the life history of these animals[29]. Researchers once discovered a female great white that travelled 20,000 km (12,427 miles) in less than nine months, crossing the entire Indian Ocean and back[30]!

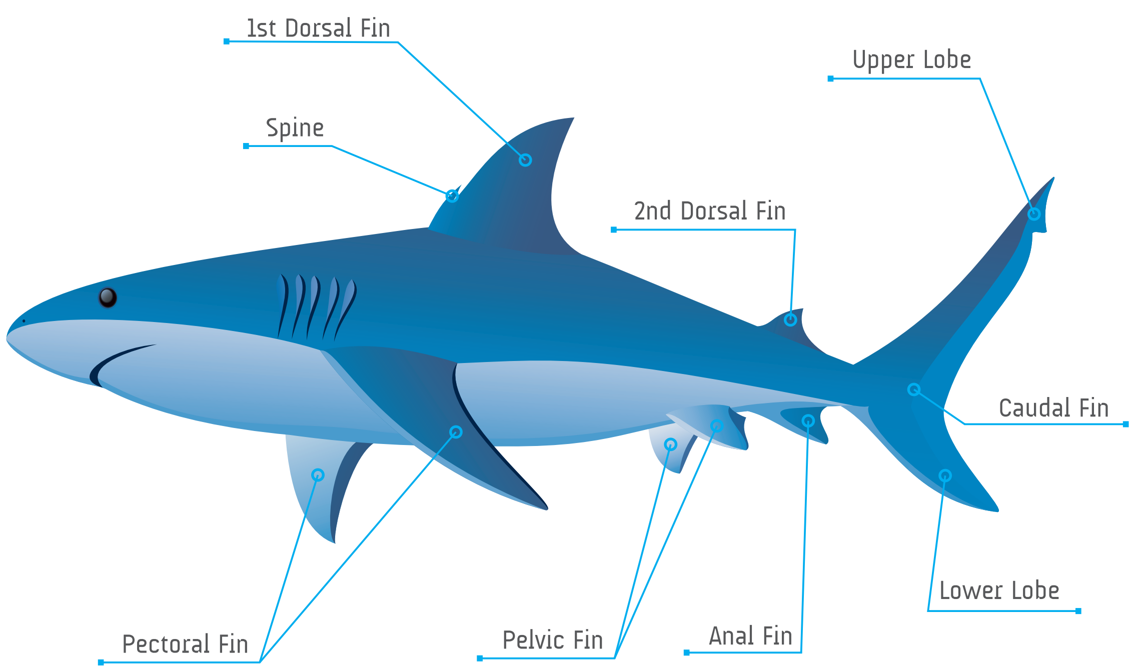
Many other elasmobranches like guitarfishes (Rhinobatidae) and skates (Rajidae, Anacanthobatidae, Arhynchobatidae) are benthic and live on the sea floor.

Sharks, from the outside in

A basic tour of the shark can reveal its very interesting and distinguishing characteristics. Starting on the outside, curious similarities can be seen between the structure of this highly evolved animal and that of an airplane. This is because shark morphology follows the principles of aerodynamics and physics. Like with planes flying through the air, its streamlined body cuts down on friction and drag in the water, allowing it to reach great speeds and high levels of manoeuvrability. The shortfin mako (*Isurus oxyrinchus*) is the fastest shark, easily reaching speeds of over 30 km/h (20 mph).

Most sharks have five types of fins: pectoral, pelvic, dorsal, anal and caudal, as seen in Figure 3. The pectoral fins provide lift as the shark swims forward, just like the wings of a plane. The caudal fin, or tail fin, sways back and forth and propels the shark forward through the water, providing thrust like a jet engine. Caudal fins vary in shape and size, depending on the lifestyle and habitat of the species. Dorsal fins, pelvic fins and anal fins (not present in all sharks) are used for stabilization. Sharks can either have one or two dorsal fins, and some even have spines attached to them, like the Port Jackson shark (*Heterodontus portusjacksoni*). The spine is a highly modified dermal denticle used in defence against predators. In sting rays, (Myliobatoidei suborder), one or more spines with poisonous tissue are present on the dorsal side of the tail.

Figure 3: The Fins of a Shark.



Two poisonous spines are visible on the long tail of this sting ray (Myliobatoidei), photographed in Lanzarote, Spain. © Carlos Suárez.

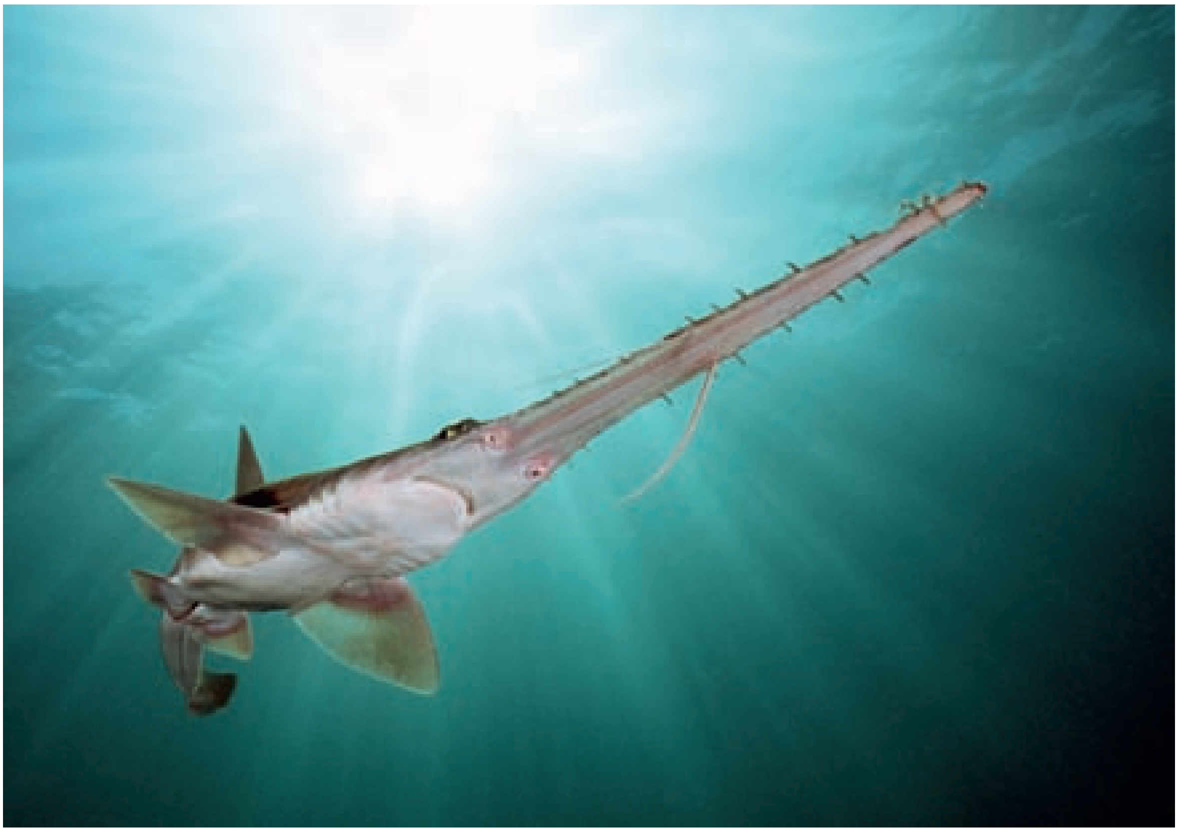
Hitching a ride

Many sharks and large rays can be seen with smaller fish attached to their undersides. These fish are remoras, or suckerfish, of the family Echeneidae. The dorsal fin of these fish has been modified into an oval-shaped sucking disk with flap-like structures on the top of the head. These flaps can open and close to create suction, which the fish uses to attach itself to larger marine animals such as sharks. These fish can use the disk to slide around on the surface of the shark without loosing its grip[31].

Remoras are primarily found in tropical waters and they do not harm the animals they are attached to. This type of relationship is known as commensalism, in which one animal benefits and the other is not affected. Remoras attach to sharks and rays for the benefit of transportation, and they feed on the food scraps left behind by their host.

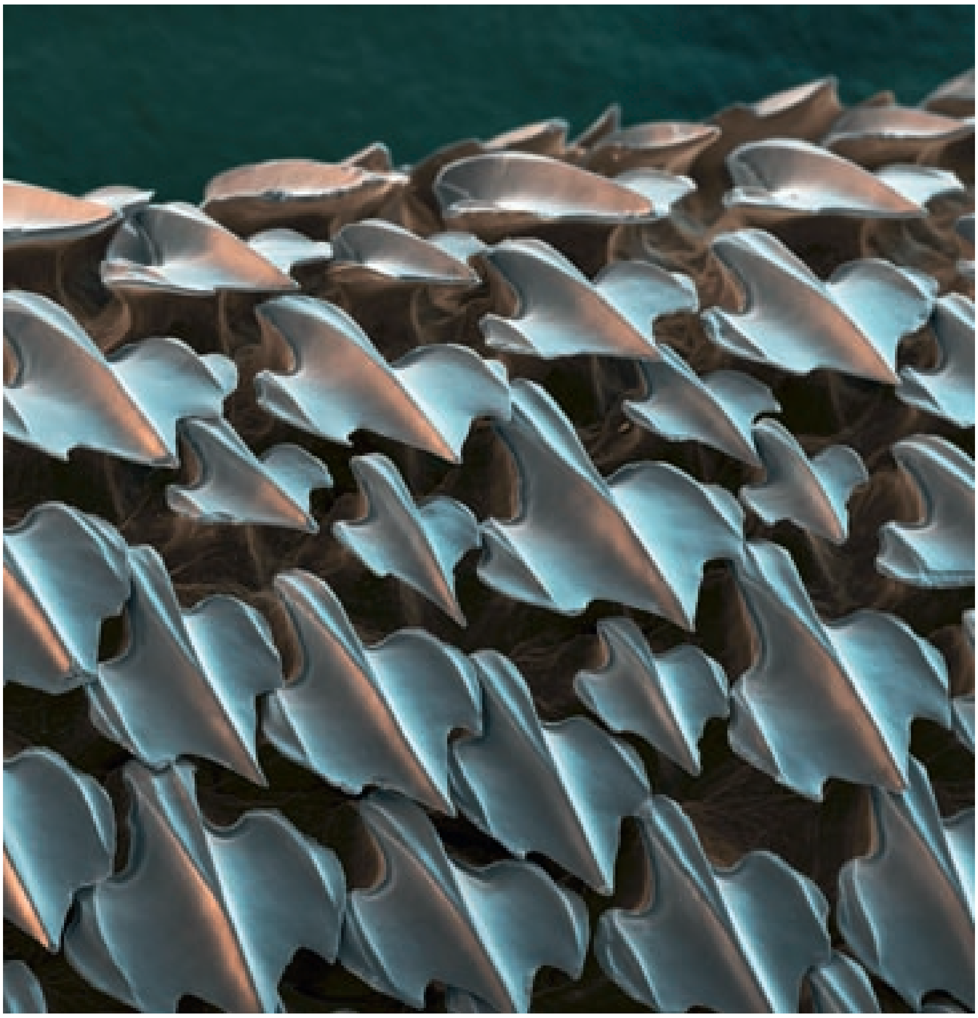
Remoras attached to the underside of a shark. © Rob Stewart/ Sharkwater.

Looking closer at the body of the shark, tiny scales with a tooth-like structure are seen covering its surface. Called dermal denticles (meaning "skin teeth"), or placoid scales, they overlap one another along the body, facing tailward. This is why a shark that is rubbed from head-to-tail feels smooth, but if rubbed from tail-to-head would feel rough like sandpaper. Sharks present a variety of dermal denticle shapes which are adapted to the lifestyle of each species. While the shark grows, the dermal denticles do not; instead, the shark grows additional scales through the skin to cover its increasing body area[32]. Sharks can loose up to 20,000[33] scales a year, which are replaced by new ones. The silky shark (*Carcharhinus falciformis*) has extremely small scales giving it a "silky" feel to the touch. And the teeth on the rostrum of sawsharks (Pristiophoridae) are actually just enlarged dermal denticles[34].



The Eastern sawshark (*Pristiophorus* sp. A) is a commercial species found over the continental shelf from 40 to 300 metres (130 to 985 feet) deep. © marinethemes.com/ Kelvin Aitken.

Dermal denticles provide physical protection from wounds and also help the shark swim by reducing friction from the water. The tiny ridges of the dermal denticles improve the shark's hydrodynamics by preventing the tiny eddies that normally form in the water along the shark's body from coming in contact with the body surface. This works in the same way that dimples on a golf ball improve its aerodynamic properties. In fact, engineers are investigating the design of shark dermal denticles for use on the surfaces of aircrafts and boats!. Large, cold-blooded sharks typically cruise at an unhurried 2.4 km/h (1.5 mph), but mackerel sharks (Lamnidae family) have a special circulatory system that allows them to reach increased swimming speeds.[VIII] Scientists believe the top swimming speed of the great white (*C. carcharias*) to be at least 40 km/h (25 mph). But it is the shortfin mako (*I. oxyrinchus*) that is typically regarded as the fastest-swimming shark. The shortfin mako is an open ocean sprinter with a highly streamlined body and lunate tail. One mako has been reliably clocked at 50 km/h (31 mph). They can even catch the fastest fishes, like swordfish (*Xiphias gladius*) which have leaping speeds of up to 97 km/h (60 mph)[35].



Coloured scanning electron micrograph (SEM) of a shark's scales. (magnification: x80). The tip of each sharply pointed scale is made of dentine overlayed with dental enamel. The lower part of each scale anchors it into the skin. © age fotostock.

VIII See *Warm-blooded sharks?* text box.

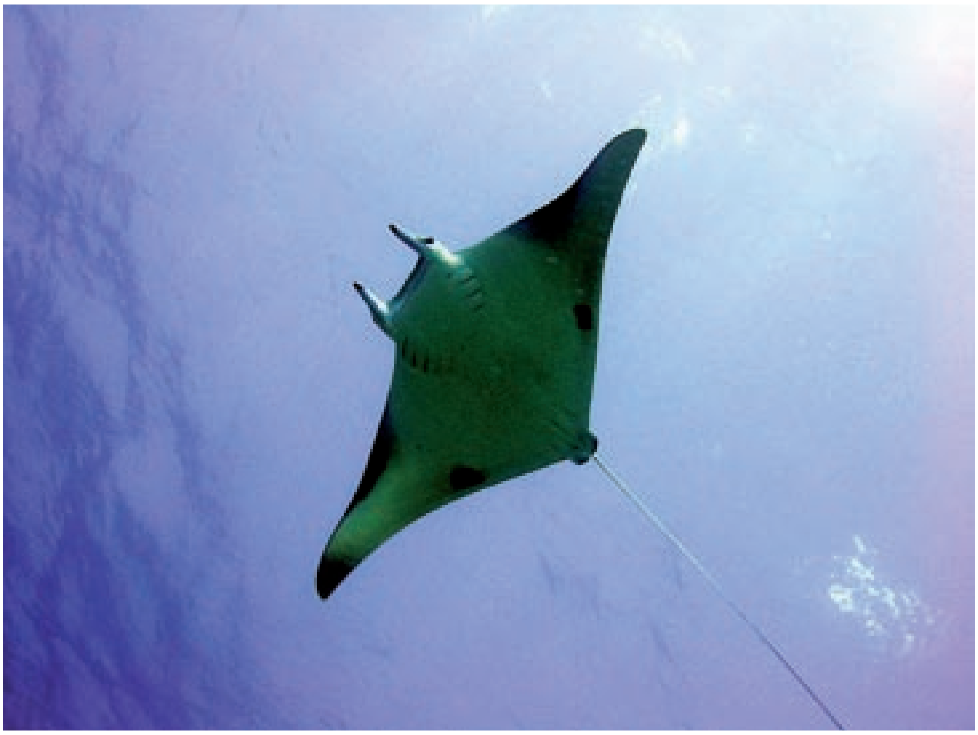
This Caribbean reef shark (*Carcharhinus falciformis*) in Los Jardines de la Reana, 77 km (48 miles) to the south of Cuba, displays countershading.
© Carlos Suárez.

The colouring of the shark's body is no coincidence either. Many sharks display a type of cryptic coloration to make them less visible to predators or prey. Pelagic sharks are often shades of grey or brown on the top half of their body, and white on the underside. When seen from above, the shark tends to blend into the dark blue sea or seabed below it, and when viewed from below, it blends into white sky above. This countershading helps the animal blend into its environment, giving it an advantage while pursuing prey or escaping from predators.

To examine the inside of the shark, the flow of water can be followed as it enters the body. Sharks do not have lungs but instead breathe with gills that take oxygen out of the water. Sharks have five to seven gills slits on each side of the head near the front of the body and they respire via ram-ventilation. In this process, oxygen-rich water enters the mouth due to the forward swimming motion of the shark and is pushed back to pass over the gills. Gas exchange occurs when tiny filaments in the gills comb oxygen out of the water and shuttle it to vital organs[36].

As batoids (Rajiformes order) are generally flattened vertically, their gill slits are located on the underside of their bodies. Elasmobranches that live partly buried in the seabed, like some rays, have spiracles on the top of their heads to aid in respiration. These small openings located behind the eyes function like a suction tube which takes in water and passes it over the gills on the underside of the body.

The inside of the shark has a characteristic that distinguishes it from all other fish- it lacks bones! Instead, the shark skeleton is composed of lightweight and flexible rubbery cartilage. This simple skeleton, shared by rays, has been advantageous to sharks, affording them great strength and high manoeuvrability without weight.



The five gill slits of this devil ray (*Manta* spp.) in Cabo Pulmo, Mexico, can be clearly seen on the underside of its body. © Houssine Kaddachi.

A spiracle behind the eye of a stingray (Myliobatoidae) buried in the seabed in Cabo Pulmo, Mexico. © Houssine Kaddachi.

Another unique characteristic inside the body of the shark is that it lacks a swim bladder. Swim bladders are gas-filled chambers present in most fish that serve to provide them with neutral buoyancy and allow them to float. The shark instead has a large liver filled with low-density oils that, among other functions, helps regulate buoyancy and ensures it does not sink. The liver also gives the shark vertical mobility so that it can move up and down in the water column with ease. One of the most important oils found in the shark's liver is "squalene", a compound much less dense than seawater. The squalene of deep-sea sharks such as the leafscale gulper shark (*Centrophorus squamosus*), whose liver can comprise up to one-third of the weight of the entire animal, has been harvested for pharmaceutical and commercial uses, putting some populations in danger.

Warm-blooded sharks?

Many marine creatures, including most sharks, are ectothermic (cold-blooded), meaning their body temperature fluctuates with that of the seawater around them. Because sharks cannot actively maintain a constant body temperature, many live in warmer waters that provide them an optimal living environment.

Enter the mackerel sharks. These sharks of the Lamnidae family, including the great white (*C. carcharias*) and porbeagle (*Lamna nasus*), have an exceptional adaptation that has allowed them to enter colder and deeper waters: these sharks can elevate and maintain body temperatures 5-10 °C (9-18 °F) warmer than the seawater in which they live[37]. Being nearly endothermic (warm-blooded) affords mackerel sharks a predatory advantage from increased swimming speeds and muscle strength.

The sharks in this family have a higher concentration of red muscle around their spinal column than most sharks. This muscle contains a dense network of small blood vessels, called the rete mirabile (or "wonderful net"), which provides a counter-current exchange system of arteries and veins that cycles warm blood to muscles and internal organs[38]. This special system retains much of the metabolic body heat generated by swimming and muscular activity, allowing parts of the body to reach elevated temperatures.

But being warm-blooded in cold water also means these sharks have high metabolic requirements and that they must continually fuel their bodies with food. A warm-blooded shark may need more than ten times as much food as a cold-blooded shark the same size. The distribution of mackerel sharks is thus largely dictated by the availability of prey. Mackerel sharks are most abundant inshore in cold, temperate waters as their preferred prey, large fishes and energy-rich marine mammals, are commonly found there as well[39].

The six senses

Despite the myth that sharks are machines with only one thing on their minds, recent studies are revealing complex behaviour in these animals that goes beyond the mere instinct to hunt. Sharks and rays have some of the largest brains among all fish. Hammerheads (*Sphyrna* spp.) and the giant manta ray (*M. birostris*) have the largest and most complex brains of all elasmobranches. It has also been found that more species are social, communicate with body language (by changing posture or swimming movements), live in groups and even hunt in packs.

A Galapagos shark (*Carcharhinus galapagensis*) displays threat behaviour by pointing its pectoral fins downward.
© Neil Hammerschlag/neil4sharks.org

For example, the blue shark (*Prionace glauca*) spends most of its life in a group of the same sex. Large schools of scalloped hammerheads (*S. lewini*) often congregate around seamounts and islands. Other sharks like the great white (*C. carcharias*) pair up or form small groups of roughly the same sex and age at certain times of the year[40]. Some sharks have even shown they are able to learn from experience and display problem-solving abilities and curiosity. Great whites have been known to lift their heads out of the water to look around and investigate their surroundings!

Schooling hammerheads (*Sphyrna* spp.).
© Rob Stewart/ Sharkwater.

2/ A natural history of sharks

Sharks have an extremely developed and sophisticated sensory system. The attack and capture of prey is only the last step in a longer process of detection in which the shark takes full advantage of all of its highly developed senses.

Smell is the most important sense for sharks—they can smell thousands of times better than humans, and can detect chemicals and substances dissolved in the water millions of times over. Sharks have paired nostrils located on the underside of the head that are used solely for the sense of smell (not dually with respiration as in other animals). This highly developed sense can detect prey and dissolved substances far away from its source. Sharks can actually distinguish if one nostril is receiving a stronger scent, and they swim towards their prey in a zigzag motion to ensure that both nostrils are receiving balanced scent signals, in this way perfectly honing in on their target. Sharks can also use their sense of smell to detect pheromones (sexual chemicals) in potential mates during reproduction periods[41].

A lemon shark (*N. brevirostris*) with its left nostril visible. © Willy Volk.

Contrary to popular belief, sharks also have extremely good vision and often depend on this highly developed sense. Vision in sharks is well adapted to the marine environment and long-distance sight, and their eyes are similar in form and structure to those of other vertebrates with a widening and contracting pupil that reacts to light conditions and a retina with “cone” and “rod” structures for colour and light sensitivity. Sharks cannot close their eyes, but some species have an additional inner lower eyelid called a nictitating membrane. This thin but tough membrane, known as a “third eyelid”, can close upwards to protect the eye, particularly during attacks on prey. The great white shark (*C. carcharias*) lacks this nictitating membrane, but instead rolls its entire eye backward for protection during the last seconds of a strike.

The great white shark appears to have a cold, blind look in the final moments of a strike, as its eyes roll backward for full protection. At this moment, the shark highly relies on its acute sense of electroreception to finalize the attack on its prey. © Ezequiel Andréu Cazalla/ Turmares.

Large round eye of the Caribbean Reef shark (*Carcharhinus perezi*), revealing a pupil surrounded by the iris. © Carlos Suárez.

Like in many other animals such as deer and cats, elasmobranch eyes also have an internal reflective "mirror" known as a "tapetum lucidum". This pigmented layer behind the retina reflects light inside the eye to improve vision in very low light levels. As such, sharks see better than many of their prey at low light levels like dawn or dusk, and thus this represents an optimal time for them to hunt. The tapetum lucidum of many deep-sea sharks, whose circular pupils are permanently dilated, gives them huge glowing green eyes which capture whatever tiny bits of light are available in the ocean depths[42].

Skates and rays also have good vision, and many species have crescent-shaped pupils as opposed to the circular pupils of mammals, affording them, among other benefits, decreased distortion, a larger field of vision and enhanced contrast[43]. Many batoids have an intricate flap of tissue hanging over the eye's iris. This flap, called the "pupillary operculum" is often fringed and has the effect of changing the behaviour of light passing through it and onto the animal's retina. This structure of the eye helps batoids to be more sensitive to movements within a large visual field[44].

The reflective tapetum lucidum and green eyes of a deep-sea shark. © OCEANA/ LX.

Eye of an undulate ray (*Raja undulata*) with pupillary operculum's finger-like extensions partially covering the iris. © OCEANA/ Carlos Suárez.

Other deep-sea sharks have severely limited vision. The eyes of at least two species of sleeper sharks, the Greenland shark (*S. microcephalus*)[45] and the Pacific sleeper shark (*Somniosus pacificus*)[46] are almost always infected with a parasitic copepod (small aquatic crustacean) called *Ommatokoita elongata*. An adult female of this copepod typically embeds itself into the cornea of each eye of the shark, ultimately causing enough damage to severely impair the shark's vision. Although these sharks go partially blind, it does not affect their ability to survive as they rely on other senses, such as smell, to remain efficient hunters in the dark oceans depths. Some even speculate that the copepod's relationship with the shark is actually mutualistic (beneficial to both species), as the colourful copepods might help lure prey species to the shark[47].

In addition to smelling and seeing, sharks also use their sense of hearing to detect prey up to hundreds of metres away. Sharks have no outer ears, but tiny openings on their heads lead to inner hearing organs with structures very similar to the inner ears of mammals. The shark sense of hearing is incredibly sensitive to sound, especially the low-frequency signals (25-100 Hz) characteristically emitted from wounded animals. The sensory cells in shark ears also govern orientation and control equilibrium as they swim through the water.

Sharks have a sense of touch, which as in all animals is simply a detection of changes in pressure applied to the body, but they can also detect changes in the pressure of the water surrounding them. Like in other fish, sharks and rays have a "lateral line" that runs along each side of the body. The lateral line is a hydrodynamic system that consists of a row of small fluid-filled pores leading to a canal inside the body with special sensory cells. These cells help the shark detect changes in water pressure and direction resulting from animal movements and vibrations. This system helps sharks detect the movements of potential prey at very close range, and even lets them find prey in total darkness. Skates and rays that feed on bivalves buried in the seabed can use their lateral line to detect the weak vertical jets of water their prey create while breathing[48].

Being the highly adapted and evolved animals they are, it may not come as a surprise that sharks and rays also have an additional sense shared by only a very few other species in nature. This extraordinary sixth sense called "electroreception" is used to detect the minute electric fields that all living creatures generate, for example from heartbeats and muscle movements. Sharks can detect these electric fields at very close range and even in the seabed, and use this sense when finalizing their attack on prey. This electrosensory system is based on jelly-filled receptors called ampullae of Lorenzini which are scattered around the head and snout of sharks and clearly visible as tiny black pits. Hammerheads (*Sphyrna* spp.) have more ampullae than any other group of sharks and are extremely adapted at scanning the seabed for prey, swinging their head back and forth as if it were a metal detector. This sense may also help orient sharks to the earth's magnetic field, something useful when migrating across oceans[49].

Scalloped hammerheads (*S. lewini*) belong to the group of sharks with the most electric receptors. © Rob Stewart/ Sharkwater.

Ampullae of Lorenzini visible on the snout of this mako shark (*I. oxyrinchus*). © OCEANA/ LX.

Electroreception has been advantageous to sharks throughout the millennia, but today's technological advances may actually be interfering with this highly evolved sense. Electrical and magnetic fields from anthropogenic sources in the water present possibilities of interfering with sharks' sense of electroreception. For example, off-shore windpower facilities that create electricity generate electromagnetic fields as the electricity is transferred from the turbines to shore[50]. These electric and magnetic fields may ultimately affect the orientation and behaviour of fish with high electrosensitivity[51].

Finally, sharks also have a sense of taste. These animals have taste buds in their mouths but they do not have actual tongues that move around like in other vertebrates. A shark's sense of taste is particularly sensitive to the presence of fat in the tissue of their prey. High-energy fat is a preferred ingredient for any shark meal, and sharks will often abandon a food source if an initial test bite reveals it is low in fat. Human surfers, for example, simply aren't fatty enough for sharks' taste, literally!

Shocking!

The electricity produced by the muscles of all living creatures is taken one step further in certain rays. The eleven species of electric rays (suborder Torpedinoidei) have two kidney-shaped organs, modified from gill musculature, which can be contracted to produce an external shock. The shock can be directed upward in certain species, possibly to deter potential predators, or downward to incapacitate prey. This tactic can help even the most sluggish rays capture fast-moving prey[52]!

The flat disk shape of electric rays gives them extra stability and helps them glide with ease through the water. Many electric rays partially bury themselves in the sand during the day and actively forage in the water column at night, using their ampullae of Lorenzini to detect the electric stimuli given off by prey[53] before actually stunning it with their own electric current.

Voltage has been recorded anywhere from eight volts up to 220 volts, as in the case of the Atlantic torpedo ray (*Torpedo nobiliana*). These animals were not unknown to the ancient Greeks and Romans, who used their electric charge to treat ailments such as headaches and gout[54] or pain from operations[55].

A spotted torpedo (*Torpedo marmorata*) in Tarifa, Spain. This electric ray jumps on fast moving prey, such as benthic fishes, paralysing it with electric discharges of up to 200 volts.
© OCEANA/ Juan Carlos Calvin.

Shark reproduction

Most elasmobranches exhibit a conservative "K-selected" life history strategy, meaning that they grow slowly, reach sexual maturity late in life, produce few but large young, and are long lived[IX]. For example, the giant devilray (*Mobula mobular*) has one huge pup at a time and some deep-sea sharks, such as the Portuguese dogfish (*Centroscymnus coelolepis*), live over 70 years. While this life history strategy has always been advantageous to sharks, it is exactly what makes them so vulnerable to fisheries exploitation today, as many populations cannot recuperate at the same rate at which they are exploited. Catching a pregnant female shark can have severe consequences, as two or even more generations are eliminated at once.

In general, very little is known about the life history and reproduction of most shark species, but reproduction methods are highly varied and advanced. Like humans, elephants and whales, sharks invest considerable amounts of energy and resources to produce few, but large and well developed young that have a good chance of survival to adulthood.

Elasmobranches require internal fertilisation, something unique among fish, and male sharks and rays have special extensions of their pelvic fins known as "claspers" to insert packets of sperm into the female. Courtship and mating can be a violent act which often involves the male biting and shoving the female, as especially exhibited between nurse

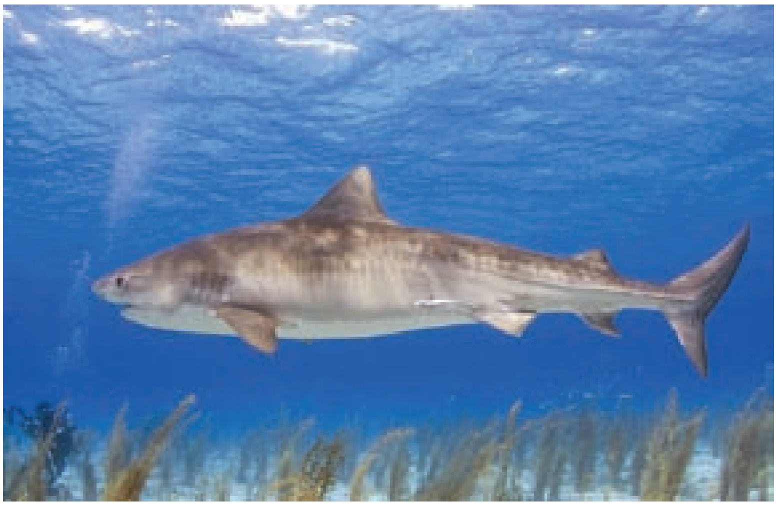
Pregnant white tip reef shark (*Triaenodon obesus*) in Cocos island, Costa Rica. © OCEANA/ Houssine Kaddachi.

IX Compare with the "r-selected" life history strategy of most other fish which grow rapidly, disseminate millions of tiny eggs and have short life spans.

sharks (*Ginglymostoma cirratum*). As a result, females of many shark species have developed thicker skin than their male counterparts to protect them from the sometimes deep wounds they receive[56].

Shark reproduction is either viviparous (live bearing) or oviparous (egg laying). The most common type of reproduction is viviparity, occurring in about 60%[57] of sharks, in which embryos develop inside the body of the mother as opposed to outside in an egg. Viviparity can assume a number of strategies, but the most complex and advanced is placental viviparity, occurring in about 10% of all sharks including hammerheads (*Sphyrna* spp.). In this strategy, a yolk sac develops into a placenta which is attached to the mother's uterine wall. A placental cord connects to the embryo and transfers nutrients from the mother to the pup[58], similar to that in mammals. This strategy allows for large litters to be nourished at one time and young are born fully functional but receive no parental care.

Another form of vivaprity common in sharks occurs without a placenta and is known as ovoviviparity. Here, the female retains fertilised eggs inside her body until development is complete. The eggs hatch inside the mother who then gives birth to fully-developed pups. Nutrition is achieved through absorption of the egg yolk. Ovoviviparous females can have long gestational periods (the time during which offspring develop in the uterus) - that of the spurdog (*Squalus acanthius*) can be up to two years, one of the longest gestational periods known for any vertebrate[59].



The tiger shark (*Galeocerdo cuvier)* is the only ovoviparous shark of the Carcharhinidae family. This species can produce litters of up to 70 relatively small pups[60]. © Willy Volk.

About 40% of sharks are oviparous[61], employing the other type of reproduction in which the mother lays eggs that hatch outside her body. These eggs are permeable to water and oxygen and embryos are nourished inside with a yolk sac. The eggs come in a variety of shapes and are often anchored to the seabed or seagrasses in nursery grounds so that once born, the sharks can develop safely and away from predators. The development period can take over a year, after which sharks emerge from the eggs as tiny replicas of adults, already able to hunt prey. Egg case are commonly referred to as "mermaid's purses" and can sometimes be found washed ashore on the beach.

Horn shark (*Heterodontus francisci*) egg case.
© ManYee Desandies.

Certain species exhibit additional ways of providing nourishment to developing embryos in addition to a yolk sac. Female bat rays (Rhinopteridae family) secrete a nutrient-rich liquid called histotroph, or uterine milk, that the developing embryo absorbs through its gills and spiracles[62]. Some other species, including the porbeagle (*L. nasus*), produce additional unfertilised eggs that the growing young eat in a process known as oophagy. And still another practice, called intrauterine cannibalism, occurs when the developing pups not only feed on these unfertilised eggs, but also on other developing embryos until only one surviving pup remains. The sand tiger shark (*Carcharias taurus)* displays this behaviour. While this activity may seem bizarre or cruel, the shark that is eventually born is much larger and stronger as a result, with increased chances of survival.

Sleepswimming

Sharks are often thought of as animals always on the move, swimming in an endless pursuit of prey. But sharks must also constantly move in order to breathe. So how, then, do sharks sleep? The answer is that a shark's continual forward movement, as necessary per its biological design, does not actually mean that it doesn't sleep, or at least rest.

The truth is that sharks don't sleep the same way humans do. Instead, sharks enter into a restful mode in which they shut down different parts of their brain at different times. This allows them to keep swimming in a stupor-like state, with decreased activity levels and brain functions. This is the shark equivalent of sleepwalking, and it can occur at any time of day.

Experiments carried out on the spurdog (*S. acanthias*) have shown that the instrument that coordinates swimming, the central pattern generator, is located in the spinal chord and not the brain. This shows that the spurdog can shut down part of its brain and mentally "go to sleep" while still receiving the order to swim[63].

Indeed some sharks do have the ability to rest motionless on the seabed and can save energy by doing so, such as the nurse shark (*G. cirratum*), often seen lying on the sandy sea floor or in caves. These sharks have a second respiratory system in which the spiracles, small modified gill slits located behind the eyes, actively pump water over the gills.

White tip reef sharks (*Triaenodon obesus*) rest on the ocean floor in Cocos island, Costa Rica. © OCEANA/ Houssine Kaddachi.

Fish food

All sharks are carnivores. This means they all eat other animals, although the sizes and types of their animal prey span the spectrum from miniscule zooplankton to large whale carcasses. Each species' diet is adapted to the ecosystem in which it lives and the type of prey commonly found there. However not all sharks hunt in a predatory way, and not all are exclusive carnivores. And *none* include humans on their list of preferred meals, as we are not nutritionally to their taste.

Ironically, the largest shark (and for that matter, the largest fish on the planet), the whale shark (*R. typus*), eats some of the smallest invertebrate and plant components of the sea-microscopic zooplankton and phytoplankton that drift in the water column. Tiny crustaceans and small fish also make up a component of its diet. The whale shark does not hunt its prey; it is a suction feeder that forcefully draws huge quantities of plankton-rich water into its huge mouth and expels it through the gills. The whale shark can process over 6,000 litres (1,500 gallons)[64] of water an hour! The basking shark (*C. maximus*), rather common in the Mediterranean Sea, is another shark that filter feeds on plankton. The basking shark is often seen swimming with its large mouth open so that water can passively flow over its gills, which function both for respiration and feeding.

The whale shark (*R. typus*) eats tiny plankton. © Carlos Suárez.

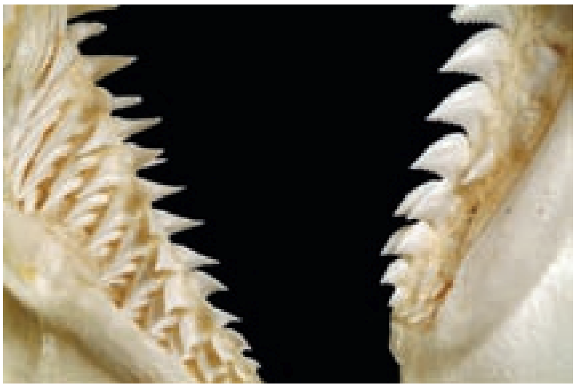
The world's largest *predatory* fish, the great white shark (*C. carcharias*) begins life preying on large crustaceans, fish, and other elasmobranches, but as it grows larger its diet switches to marine mammals such as cetaceans (including dolphins) and pinnipeds (including seals, elephant seals and sea lions). Whale carcasses and sea turtles sometimes also make meals for great whites. The great white's sometimes vicious hunting pattern has been the focus of many an ethological study and documentary film- the shark is known for its giant leaps out of the water while pursuing a blubbery seal. Studies have shown that about 50% of great white attacks on prey are successful, depending on environmental conditions[65].

In between these two extremes are the hundreds of other sharks that eat locally available crabs, squids, octopuses, lobsters, fish, molluscs, sea-birds, and sometimes dolphins, dead whale carcasses and even other sharks and rays. Many skates and rays feed on bottom-dwelling or buried prey, such as bivalves, worms and crustaceans. Some batoids blow jets of water from their mouth or create a plunger-like suction that uproots prey from the sea floor[66].

Blacktip shark (*Carcharhinus limbatus*) feeding on fish. © Rob Stewart/ Sharkwater.

Despite perceptions of sharks being insatiable predators, studies have shown that most only eat every four to seven days[67], consuming up to 10% of their body weight in a week[68]. That said, sharks can also go weeks at a time between meals if food availability or environmental conditions are not favourable. Unlike warm-blooded animals, cold-blooded sharks do not need to continually fuel their bodies with food to regulate their temperature[69].

Shark teeth, often traded or made into jewellery, come in a variety of shapes and sizes depending on the diet and targeted prey of each species. Whereas the great white (*C. carcharias*) has 5 cm (2 in) long triangular and serrated teeth useful for tearing chunks of meat, the nurse shark (*G. cirratum)* has flatter and thicker teeth useful for crushing mollusc shells. Sharks can produce up to 30,000 teeth in a lifetime, which are continually shed and replaced in a conveyor belt-like manner once broken or worn down. As older teeth in the front drop out, newer ones in the back move forward to replace them. Teeth can be replaced from every 10 days to every several months.



Shark jaws and teeth from two different species, revealing conveyor belt system. © Smithsonian Institution.

Sharks use their mouths as hands to examine and "feel out" unfamiliar objects and potential prey. Their teeth can be thought of as fingers, sensing if something is a potential food source. A shark's upper jaw can detach from its skull in an adaptation geared to perfecting the hunt- once a shark attacks, it protrudes the upper jaw out from the skull to better grab its prey.

Mako shark (*I. oxyrinchus*) teeth and detachable jaw, Ponta Delgada, Azores. © OCEANA/ LX

Shark attack!

Shark attacks on humans are sensational news items, but the truth is that sharks very rarely attack humans with the intention of eating them. We are simply not prey to them. Sharks can attack humans when directly agitated by them, but most interactions are the result of poor environmental conditions or a shark's own inquisitive manner. Encounters are thus classified as provoked or unprovoked[70].

Provoked attacks are usually defensive responses caused by human interactions with sharks. This can occur when a shark feels threatened by a swimmer, spear-fisher or diver and tries to defend its territory. These attacks can also occur after physical interactions, for example, when trying to remove a shark caught on a hook or in a net, from feeding, or from attempting to touch one.

Unprovoked attacks happen when the shark makes the first contact. "Hit and run" attacks are the most common type, in which a shark inflicts a single bite or wound to a human, leaves and does not return. These are often cases of mistaken identity in conditions of poor water visibility or harsh physical environments, such as in breaking surf or strong currents. In other cases, a hit and run attack may be the result of inquisitive behaviour. Many sharks exhibit curiosity and use their mouths and teeth to "feel out" unfamiliar objects. Contrary to popular perception, sharks have amazingly good eyesight and do not typically mistake surfers for fatty seals on surfboards! In this type of attack, sharks simply abandon the target when they realize it is not what they were hoping for; these interactions are rarely life-threatening.

The other types of unprovoked attacks are "bump and bite" and "sneak attacks". As their names imply, shark can circle its target and bump it prior to the actual strike, or approach it without warning and inflict multiple bites. While less common, these types of attacks are more dangerous to humans because they often result in numerous and more serious injuries.

Shark attack! (continuation)

There are three shark species commonly known as the most potentially dangerous to humans. Sometimes referred to as the "devil's triad", these are the great white (*C. carcharias*), the tiger shark (*G. cuvier*), and the bull shark (*C. leucas*). However, other sharks can attack as well, including the oceanic white tip (*C. longimanus*), and it is important to remember that these are wild animals and as such they must be treated with caution. Encountering a shark in the wild should be treated no differently from crossing a bear in the woods or a tiger in the jungle- one should never approach these animals or attempt to touch them. The following tips should be followed in the water to avoid any shark encounter[71]:

- Swim, dive and surf in a group.
- Avoid being in the water at dawn, dusk or night.
- Don't splash too much, and keep pets out of the water.
- Don't swim in areas with sewage or where people are fishing.
- Don't enter the water if bleeding from an open wound.
- Don't wear shiny and flashy jewellery in the water, or excessively bright colours.
- Don't stray too far from shore, and be careful around sandbars, drop-offs and river mouths.
- Don't swim in areas where sharks are known to be present!

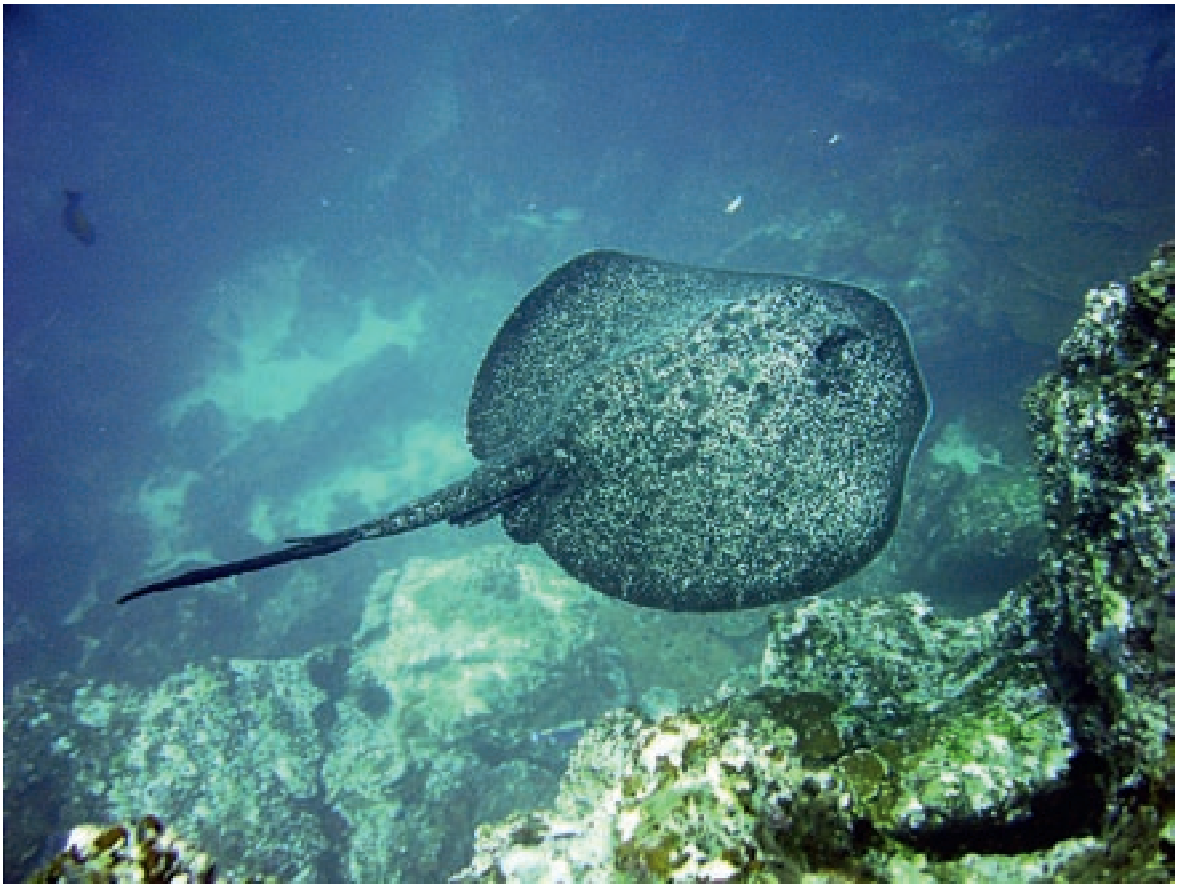
The odds of being attacked by a shark are one in 11.5 million[72]. From those attacks that do occur, only an average of 10 per year are fatal. In the end, humans have a much higher probability of being struck by lightening, attacked by an alligator or killed by a dog than by a shark. Today sharks have much more to fear from us than we do from them.

3/ The role of sharks in the marine environment

The shark's unique and complex biological characteristics have helped it become an animal that plays a vital role in the marine ecosystems in which it lives. Increasing evidence of the shark's important ecological role is being revealed as we see negative effects occurring in marine systems where it has been overfished.

Sharks are commonly referred to as apex predators, super predators, and top predators. Regardless of the term used, the certainty is that most shark species sit at the top of the marine food web and that they are animals not normally preyed upon by others. Like other top predators at or near the top of the food web, the numbers of sharks are relatively small compared to those of other fish[73]. However, being at the top of the food web puts them in a position to play a crucial ecological role in structuring the dynamics and maintaining the balance of marine ecosystems[74].

These top predators of the sea act similarly to lions on land, culling the sick or weak animals and ensuring that the stronger and healthier individuals survive. Their constant predation also keeps the sheer sizes of their prey populations in check. In a chain of events, this can then effect the structure and species composition of other trophic (food web) levels below them[75]. In the end, the state of shark populations has an indirect effect on the fauna and even flora components of the larger marine community.



Blotched fantail ray (*Taeniura meyeni*) in Cocos island, Costa Rica. © OCEANA/ Houssine Kaddachi.

3/ The role of sharks in the marine environment

A coral reef of Abaco Island, the Bahamas. © OCEANA/ Houssine Kaddachi.

As an example, we can examine an exceptionally simplified version of a stable coral reef ecosystem. In this situation, tiger sharks (*G. cuvier*) feed on carnivorous fish such as groupers (Serranidae). Grouper populations are thus kept in check, and do not overly deplete the populations of their preferred prey, herbivorous parrotfish (Scaridae). There remain enough parrotfish to eat the algae off the corals that would otherwise blanket and smother the reef. This balanced system displays species diversity and robust populations.

But what happens when we start taking sharks and rays out of the oceans? These elasmobranches are being snatched out of the seas through aggressive targeted fishing and uncontrolled accidental catches. This results not only in direct effects to the elasmobranch populations caught but also in indirect effects to the greater ecosystem in which they live. And these effects almost always mean bad news for our oceans.

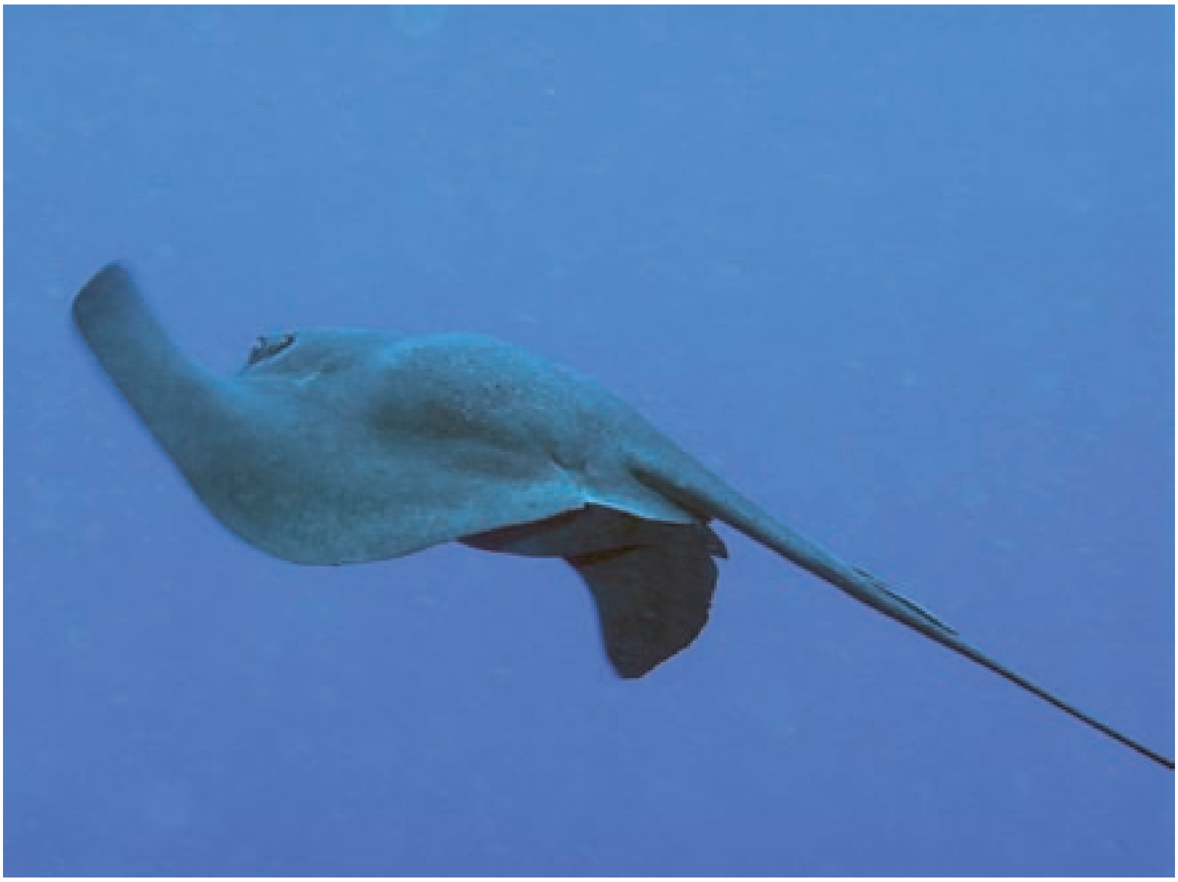
Direct effects

The direct effects on elasmobranches caught as targeted or accidental catch in fisheries operations include:

1.- Decreased abundance within the elasmobranch population: the clear result of overfishing is declines in elasmobranch populations. This has particularly been observed in recent years, and the large reported annual catch data is compounded by high amounts of unreported by-catch (the incidental capture of non-target species) in many fisheries.

2.- Shifts in size structure within the elasmobranch population: because of market preferences or the properties of certain fishing gear, the largest individuals are often targeted in fishery operations and in some populations, smaller individuals become prevalent and predominant[76]. As growth is a life-history trait that is partially inheritable, continued fisheries pressure can cause populations to evolve over time and shift to smaller length compositions. This may also affect the reproductive ability of populations, as fecundity (the ability to produce offspring) often increases proportionately with body size.

3.- Local or global extinction: there is a real possibility of extinction due to overfishing with endemic (locally restricted) species. For example, more than half of the skate species in the Indo-West Pacific region are endemic, but this is also where the highest elasmobranch catches occur and in many cases, with minimal fishing control[77]. These factors can contribute to an above average extinction rate. In addition, new studies have also shown that even some of the fastest, most wide-ranging pelagic shark species, such as the porbeagle (*L. nasus*), are also threatened with extinction on a global scale due to overfishing[78].



Pelagic stingray (*Pteroplatytrygon violacea*) in Palomas Island, Murcia, Spain. © OCEANA/ Juan Cuetos.

The overfishing of top predators also has an indirect effect on the larger structure and function of marine communities. Through processes of predation and competition, the presence or absence of sharks can affect other populations in the food web. Removing sharks from ocean ecosystems can destabilise this system and even lead to the eventual disappearance of other populations, including commercially-caught fish and shellfish species lower in the food web.

3/ The role of sharks in the marine environment

Giant electric ray (*Narcine entemedor*) in Cabo Pulmo, Mexico. © Houssine Kaddachi.

Indirect effects

The indirect effects from the disappearance of sharks on marine communities and other populations can include:

1.- Increased abundance of their prey populations: The removal of sharks can affect the abundance of their typical prey species. For example, many large sharks feed on smaller sharks and other elasmobranches; studies have linked increased abundances in small sharks with the overfishing of larger shark species. This can be known as "predatory release".

2.- Shifts in population size structure within communities: The same fishing gears that remove larger individuals from shark populations also encourage the removal of larger-sized fish species from communities in general. This affects the species composition and diversity within the community. As larger species are removed, a community may shift to being dominated by smaller, faster-growing fish species[79]. Generally, as populations of larger elasmobranches decline within a community, those of smaller species increase.

3.- Increased abundance of their competitor populations: removing elasmobranches from a community may cause a "competitive release" for the species they normally compete with. This means that some species will be left without competitors for resources; as they are left to thrive in a system without competition, their populations can increase.

All of these direct and indirect effects can destabilise oceanic food webs and create cascading trophic interactions. As sharks are a necessary link in the marine food web, removing them can set in motion a domino effect that cascades through the food web in complex and unforeseen ways, collapsing the stability they previously maintained and contributing to damaged ecosystem functions.

Real life examples

Below are eight real life examples of how the disappearance of sharks can cause cascading effects and contribute to disrupted marine ecosystem structure and function:

1.- Hawaiian coral reefs have been affected by the disappearance of sharks. Through trophic interactions, the removal of tiger sharks (*G. cuvier*) from a Hawaiian coral reef likely played a part in the decline of other important commercial fish species, including tuna (*Thunnus* spp.). As the shark populations declined, some of their prey species such as sea birds, increased. Sea birds are a major tuna predator, so the highly-valued tuna population dropped with increased sea bird predation. The chain of reactions continued, and the crash of the tuna population led to an increase in the populations of demersal fishes, now in a situation of predatory release[80].

2.- Another example of predatory release can be seen in the northern Gulf of Mexico, where the coastal elasmobranch community structure underwent significant change in the second half of the 20th century. In this area, longline fishing produced marked declines in large shark species, including dusky sharks (*Carcharhinus obscurus*), tiger sharks (*G. cuvier*), white sharks (*C. carcharias*), and hammerheads (*Sphyrna* spp.). Smaller sharks, skates and rays are a key component in the diet of these larger sharks, and the reduced predation led to changes in the larger community structure with increased populations of these smaller elasmobranches, including the smooth dogfish (*Mustelus canis*)[81].

A group of marbled rays (*Taeniura meyeni*) in the Maldive Islands. © Carlos Suárez.

3/ The role of sharks in the marine environment

3.- The cascading trophic effects from the overfishing of large predatory sharks along the Atlantic Coast of the United States can be traced down to changes in commercialised bivalve fisheries. Over the past 35 years, populations of large sharks such as the bull (*C. leucas*), sandbar (*Carcharhinus plumbeus)*, tiger (*G. cuvier*) and hammerhead (*Sphyrna* spp.) have dropped over 85%. The elasmobranch species that are typically prey of these large sharks consequently exploded; for example the cownose ray (*Rhinoptera bonasus*), in a situation of predatory release, increased an average of 8% per year. The prey of these elasmobranches, including many commercially important bivalve species such as the bay scallop (*Argopecten irradians*) and quahog clam (*Mercenaria mercenaria*), were severely depleted. Bivalve populations were so wiped out that the century-old North Carolina bay scallop fishery was closed[82] and in many restaurants along the east coast of the United States the famed clam chowder is no longer served[83]. The overfishing of these large sharks in recent decades contributed to an ecological, and culinary, bankruptcy.

4.- Tiger sharks (*G. cuvier*) were also seen to be a factor in microhabitat changes of vital seagrass communities in Australia[84]. In western Australia's Shark Bay, tiger sharks prey on dugongs (*Dugong dugon*) and the grazing patterns of these large herbivorous marine mammals reflect their attempts to escape shark predation. When tiger sharks are abundant, dugongs graze on the low-quality seagrasses located on the edge of the meadow, as it provides escape opportunities in case a tiger shark attacks. When tiger sharks are scarcer, dugongs venture into the centre of the meadow to graze on the high-quality nutrient rich leaves that grow there. In this way, the regular comings and goings of tiger sharks means that dugongs keep seagrass growth in the entire meadow in check. However, when tiger sharks are removed from the ecosystem through overfishing, dugongs overgraze on the centre patches of the seagrass meadow and disrupt the benthic communities that live there. This shows that the mere presence (or absence) of tiger sharks indirectly affects the structure of microhabitats in this seagrass community.

5.- Tiger sharks (*G. cuvier*) have also been shown to indirectly influence ecosystem dynamics through the grazing patterns of green sea turtles (*Chelonia mydas*). In another study in Shark Bay, Australia, the presence of tiger sharks altered the grazing patterns of the turtles[85]. Like the dugongs, green sea turtles preferred to graze on the higher quality seagrass microhabitat in the centre of the bank (higher in organic carbon and nitrogen), although grazing there is more dangerous due to lack of escape routes and longer distances to deeper water. However, when the risk of predation by tiger sharks was higher, healthy turtles foraged along the safer bank edges where lower quality grass was found. Thus, the effects of the presence of sharks were transmitted through the ecosystem, as turtle grazing alters the seagrass's nutrient composition and the community's detrital cycle, which may in turn affect the smaller residents of the ecosystem. The loss of turtle predators like sharks could result in negative community level impacts on these seagress beds.

3/ The role of sharks in the marine environment

6.- Using a model of a Caribbean marine ecosystem, the overfishing of sharks was shown to carry down cascading effects to lower trophic-level fish species, and to contribute to the decline of coral reefs in general[86]. In the study, the depletion of sharks meant that their prey species, carnivorous fish such as grouper (Serranidae), were able to increase in numbers. The increased predation by these fishes decreased the numbers of herbivorous fishes such as parrotfishes (Scaridae). Parrotfishes are important grazers of macroalgae that grow on coral heads, but in their absence the Caribbean reefs became dominated by algae growth, smothering the existing coral and preventing coral polyps from settling and building new reef. This led to a homogonous habitat with fewer available niches for fish and thus lower species diversity[87]. The impacts from the overfishing of sharks led to a deterioration of the Caribbean coral reef ecosystem.

7.- Another model has demonstrated how the presence of sharks and the risk of predation they represent can contribute to spatial ecological shifts as well. Harbour seals (*Phoca vitulina)* often base their foraging decisions on the presence of Pacific sleeper sharks (*S. pacificus*): when the sharks were present, the seals remained in the surface waters and foraged on Pacific herring (*Clupea pallasii*), a fatty but widely dispersed fish. However, when sharks were removed and no longer presented a predation risk, the seals shifted to deeper waters to forage on walleye pollock (*Theragra chalcogramma*), a larger and more reliably present source of food[88]. Thus, the sharks in this study where shown to affect community structure through the foraging responses by one of their prey species.

Caribbean reef sharks (*C. perezi*) in Jardines de la Reina, Cuba. © Carlos Suárez.

Caribbean reef shark (*C. perezi*) in Abaco Island, the Bahamas. © OCEANA/ Houssine Kaddachi.

8.- Finally, a new study of four Pacific Ocean atolls has shown the correlation between human activities, shark abundance and the structure and function of coral reef ecosystems. Two uninhabited atolls, Kingman and Palmyra, governed by the United States, were found to have a higher abundance of top predators like sharks than the populated atolls of Tabuaeran and Kiritimati, belonging to the republic of Kiribati and subjected to fishing and contamination. Approximately 60% of the biomass of the pristine atolls was comprised of sharks, the highest found on any coral reef. This creates an inverted biomass pyramid in which top predators dominate the ecosystem. Along with a higher abundance of sharks, the uninhabited reefs were also found to have a higher abundance of reef-building corals, ten times fewer microbes, less incidence of coral disease, and a higher capacity to recover from warm water episodes[89]. The pattern on the inhabited atolls was just the opposite and sharks were practically absent; instead, small planktivorous fish dominated the degraded reefs with a bottom-heavy biomass pyramid. This study sheds more light on the linkages between the depletion of top predators and the degradation of coral reefs.

In these examples from around the world we can see how removing sharks triggers cascading effects that results in complex and unexpected outcomes, sometimes both ecologically and economically significant. A common lesson is that maintaining the populations of marine top predators is critical for sustaining healthy ecosystems.

3/ The role of sharks in the marine environment

The loss of sharks can also be detrimental to the human populations who rely on them as a source of food, employment, and income. Fish, including sharks caught in artisanal fisheries, provide approximately 20% of the animal protein consumed in low-income food-deficit countries[90]. In fact, in coastal communities of developing countries such as Mexico, India and Sri Lanka, shark meat provides a substantial source of protein[91]. However, while artisanal shark fisheries have seemingly operated sustainably over the decades[92], shark catches are now declining as large industrial fleets are fishing in the waters of these developing countries, threatening the economic and food security the sharks traditionally provided coastal communities.

Artisanal fishermen with caught sharks in Mantanani Island, Sabah, Malaysia. © Rob Stewart/ Sharkwater.

4/ The threats faced by sharks

Nearly all of the ocean's megafauna are in a state of decline. Over 90% of the large predatory fishes, such as tuna, swordfish and sharks have already disappeared from the oceans[93]. According to the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species, 21% of elasmobranch species assessed (126 out of 591[94]) are categorised as *Globally Threatened*[X]. For the European populations assessed to date by the IUCN, the percentage of threatened species goes up to one-third, with another 20% at risk of becoming so. In the Mediterranean, a sea with a long history of fishing, the data is even more ominous- 42% of the elasmobranch species living there are considered threatened with extinction, making this sea the most dangerous place on Earth for sharks and rays[95]. In fact, several species of large predatory sharks in the Mediterranean Sea, including the porbeagle (*L. nasus*) and thresher shark (*Alopias vulpinus*), have decreased over 97% relative to their abundances up to 200 years ago.[96]

A shark with fishing hook, the Bahamas. © Rob Stewart/ Sharkwater.

There is clear evidence that these slow-growing and extremely vulnerable species are disappearing at an unprecedented rate across the globe[97]. Numerous studies have confirmed the devastating collapse of coastal and oceanic shark populations due to overfishing and by-catch. For example, scalloped hammerheads (*S. lewini*), great whites (*C. carcharias*), and threshers (*Alopias* spp.) have all declined by over 75% in the North-west Atlantic Ocean[98], as seen in Figure 4. Another study demonstrated that oceanic

X About 600 elasmobranch species have yet to be evaluated.

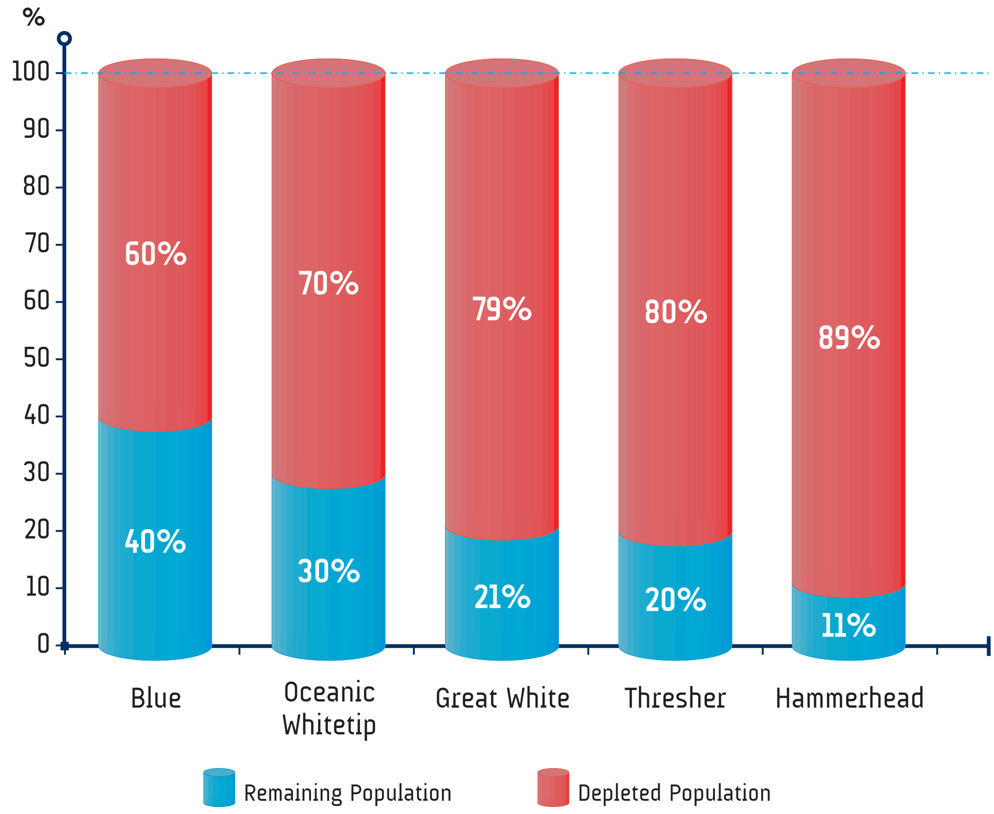
whitetips (*C. longimanus*) have all but disappeared from the Gulf of Mexico since the 1950´s, their population having diminished by more than 99%[99]. Still another study revealed that over 76% of the large pelagic sharks and rays assessed, species such as the shortfin mako (*I. oxyrinchus*) that were previously considered too robust and mobile to become threatened by fisheries, have a heightened risk of extinction.[100]

In Europe, the most endangered sharks are those targeted for industrial food production. Both the porbeagle (*L. nasus*) and spurdog (*S. acanthias*), highly valued in Europe for their meat and fins, are *Critically Endangered* in the Northeast Atlantic Ocean according to the IUCN. Other elasmobranches found in Europe such as the angel shark (*S. squatina*) and blue skate (*Dipturus batis*) are also *Critically Endangered*. Indeed, skates currently represent one of the most threatened groups of all marine species[101].

Auction for rays in the fish market of San Carlos de la Rápita, Spain, with data on the fishing vessel, weight and price.
© OCEANA/ LX.

Ironically, the species that were historically named for being the most common are no longer so. The common thresher shark (*A. vulpinus*), common sawfish (*Pristis pristis*), common guitarfish (*Rhinobatos rhinobatos*) and blue skate (*D. batis*), also known as the common skate, are all threatened with extinction. Those species more recently thought of as being the most abundant and “common”, such as the blue shark (*P. glauca*) and spurdog (*S. acanthias*), are now going in the way of the others.

Figure 4: Population trends of five Northwest Atlantic shark species over the last two decades.[102]



The following are the major threats today to elasmobranch populations all around the world:

Fishing out of control

The number one threat to the future of elasmobranch populations is fisheries exploitation. Sharks and other elasmobranches have suffered serious declines in recent decades due to overfishing. According to the 2006 catch statistics from the United Nations Food and Agriculture Organization (FAO), 758,498 tons of sharks, rays, skates and other elasmobranches were reported caught around the world[103], although estimates based on the shark fin market reveal that catches may in fact be three to four times higher[104]. India, Indonesia, Taiwan Province, Mexico and Spain have been the top five elasmobranch-catching nations in recent years. And when taken as a whole, the European Union is the second elasmobranch catching state in the world[105]. Within the European Union (EU), Spain is undoubtedly the top shark (and elasmobranch in general) catching nation. In 2006, this country caught 56,175 tons of elasmobranches worldwide[106]. Other important European elasmobranch fishing nations are Portugal, France and the United Kingdom.

Blue sharks in Ondarroa, Spain. © OCEANA/ LX.

The freshmarket auction in Vigo, Spain, the centre of the European shark trade. © OCEANA/ LX.

Sharks and other elasmobranches are caught both by giant industrial vessels and small artisanal boats, especially in targeted fisheries that have been expanding rapidly since the 1980´s[107] as the demand for shark fins increased. Elasmobranches are also often caught as by-catch in nearly all fishing gears. Sometimes, sharks have become the targeted species in fisheries in which they were historically considered by-catch, as stocks of the traditionally targeted species declined and new markets for shark products opened. For example, the nearly 200 industrial EU surface longliners that overwhelmingly target sharks in the Atlantic (up to 70% of their total catch is comprised of these animals) originally targeted swordfish and tuna and considered sharks a by-catch[108].

Fins drying at a trader's storehouse in Lima, Peru, 2007. © OCEANA/ LX.

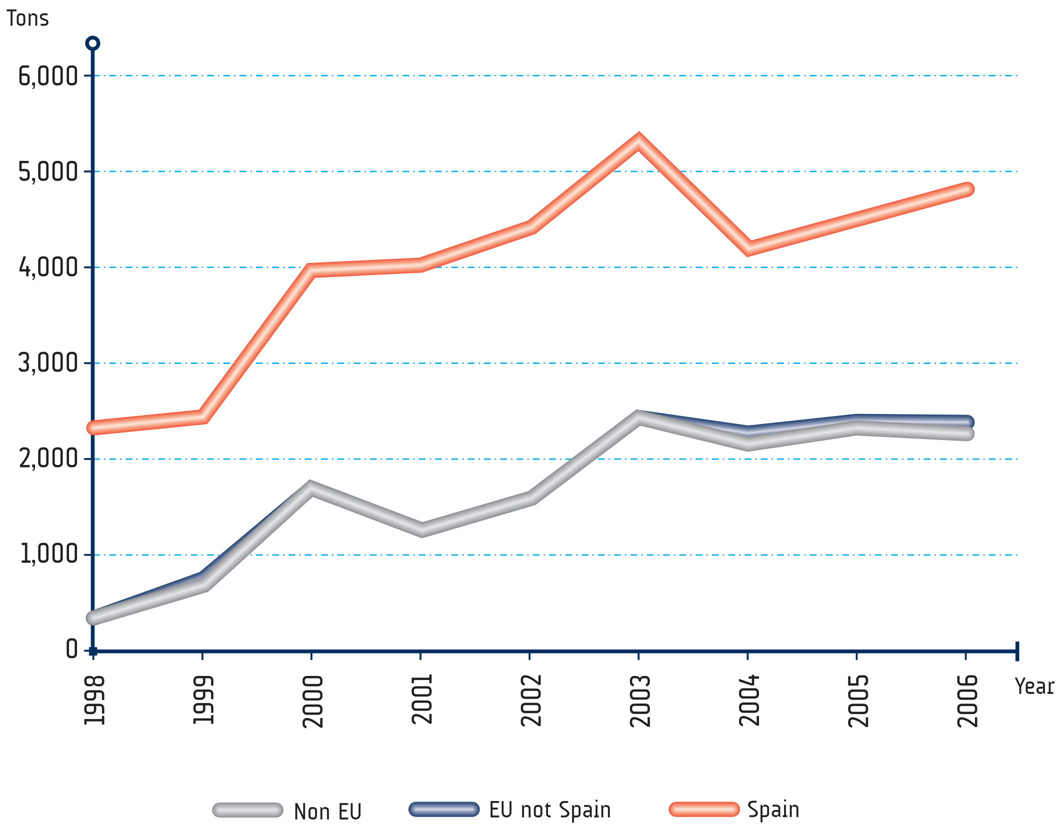
Different fishing gears and fisheries tend to target different species of sharks. Longliners are indeed the main culprits for shark catches; Spanish and Portuguese longline vessels caught 43,000 tons of sharks and related species in 2005 alone[109]. These vessels use hundreds or thousands of baited hooks hanging from a single fishing line to mostly catch pelagic sharks such as blue (*P. glauca*) and shortfin mako (*I. oxyrinchus*).

Driftnets, prohibited in the EU since 2002, are nets that can reach up to 25 km (15.5 miles) long and float vertically in the water to drift with the current. They typically catch pelagic and coastal elasmobranches, such as basking shark (*C. maximus*), common thresher (*A. vulpinus*), devil ray (*M. mobular*) and pelagic stingray (*Pteroplatytrygon violacea).* Purse seines are another vertical net whose ends are pulled tight to enclose the catch; this gear also catches pelagic and coastal elasmobranches including hammerheads (*Sphyrna* spp.), silky (*C. falciformis*) and oceanic whitetip (*C. longimanus*). Bottom trawlers, a destructive gear that uses weights to actively drag nets across the seabed, and gillnets, nets placed in the water to snare fish as they swim through, predominantly catch demersal species such as tope shark (*Galeorhinus galeus*) and spurdog (*S. acanthias*), and deep-sea sharks like Portuguese dogfish (*C. coelolepis*) and kitefin (*Dalatias licha*).

Fishery practices that utilise only certain parts of sharks' bodies are extremely wasteful. The cruel and wasteful practice of shark finning, in which a shark's fins are sliced off and the dead or dying body is tossed back to sea, utilises only 2 to 5% of the animal, throwing away sources of protein and potential commercial or pharmaceutical products. Shark finning threatens already overexploited shark populations, and a recent study estimates that up to 73 million sharks are killed annually to supply the international fin market[110]. Spain is Europe's largest exporter of shark fins, and in 2006 this country provided nearly half of the frozen fins sold on the Hong Kong market. Figure 5 shows the weight of Spain in the frozen shark fin market compared to that of the rest of the European Union and the world.

A finned shark is dumped onto an otherwise healthy reef in Raja Ampat, Indonesia, 2007. © Justin Ebert.

Figure 5: Origin of unprocessed, frozen shark fins imported to Hong Kong from 1998-2006.[111]



Fisheries management concerns

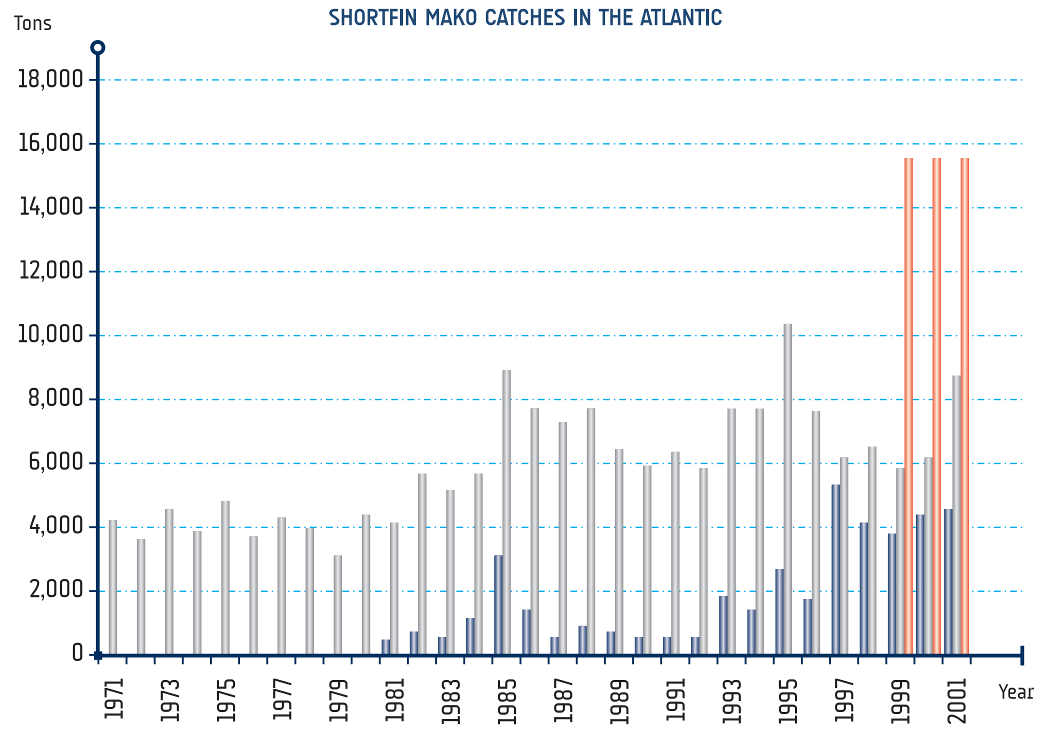
Shark fisheries management in the EU is either nonexistent or little effective. The vast majority of shark species caught by EU vessels lack fishing quotas or other control measures employed for commercialised fish, such as closed areas or minimum catch sizes. European fishermen are, for the most part, free to catch as many sharks as they want. This fishing without limit has been devastating to shark populations around the world since once overfished, many populations take several decades to recover[112]. Since many shark species aggregate by sex and size, focusing fishery efforts on a stock of sexually mature or even pregnant females can have devastating effects on a population. Without catch limits and other regulations, European shark fisheries can never be sustainable and shark populations will continue to decline.

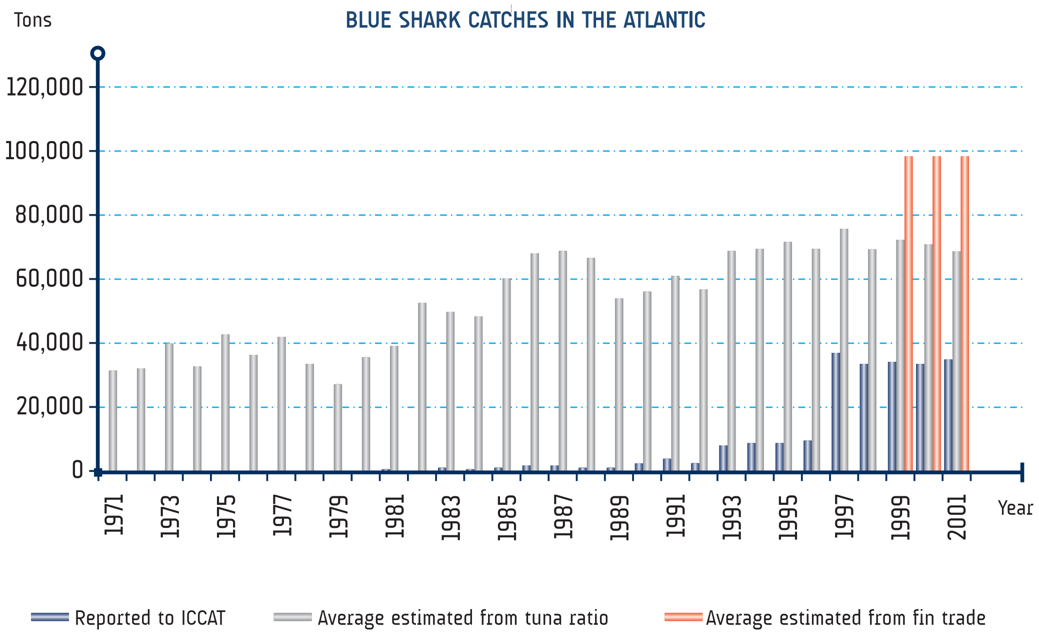
Despite awareness of excessive shark and ray catches, problems exist with accurately knowing the real magnitude of these catches. One difficulty is that sharks are often grouped together upon landing under general categories such as "deep-sea sharks", "elasmobranches", "rays" or even "other", making it difficult to determine the diversity of species involved in each fishery. This lack of data and detail on the actual species landed complicates stock assessments and other scientific studies.

Undulate ray (*R. undulata*) gliding over a kelp forest in the Cedeira ría (drowned river valley), Galicia, Spain. © OCEANA/ Carlos Suárez.

Another difficulty arises with the discrepancies between officially reported catches and real catches. Numerous fleets do not report their shark catches to the relevant fishery management organisations, indicating that real catches are much higher than those reflected in official databases. In fact, studies of the quantities of shark fins on the Hong Kong market reveal that sharks and fins are traded up to four times higher than what is officially reported[113]. Figure 6 shows the discrepancy between catches officially reported to the International Commission for the Conservation of Atlantic Tunas (ICCAT), estimated real catches for non-reporting ICCAT fleets, and estimated real catches based on Hong Kong fin trade data for blue (*P. glauca*) and shortfin mako (*I. oxyrinchus*) sharks in the Atlantic Ocean. Of note is that official ICCAT data only represent about 50% of the likely blue and mako shark catches in the Atlantic Ocean, demonstrating that there are vast gaps in catch reporting.

Figure 6: Comparison between shark catches reported to ICCAT and estimated shark catches based on sharks:tuna catch ratios and Hong Kong trade data.[114]





Moreover, because fish stocks in European waters are widely overfished and European fish consumption is on the rise, EU vessels today travel further and further to find new fishing grounds. EU fleets are catching sharks outside of Europe under various frameworks with which they can escape EU fisheries regulation. Some fleets operate create Joint Ventures between EU-based companies and third-countries. Other vessels fish under foreign flags, known as "flags of convenience", so that they can reduce operating costs and fish under nations with more lenient fisheries regulations. Another way to fish in foreign waters is under "Fisheries Partnership Agreements" (FPAs). In 2007, 357 EU surface longliners operated under FPAs to fish in the waters of African, Caribbean and Pacific countries. The majority of FPAs have been established for the catch of tuna, although many of the vessels are overwhelmingly targeting sharks.

Most shark fisheries undertaken via these various legal frameworks are poorly managed or not managed at all[115]. The shark catches from the vessels fishing under FPAs are not managed or limited. And shark fishing on the high seas (in international waters outside the 200-mile Exclusive Economic Zone (EEZ) of any country) is virtually totally unmanaged.

Shark fins at the Jakarta International Airport, Indonesia, 2006. © OCEANA.

Japanese longliners in the port of Las Palmas, Spain. The large Japanese longliner fleet fishing in the Atlantic often unloads frozen shark carcasses along with frozen and dried shark fins here. © OCEANA/ LX.

Shark product trade

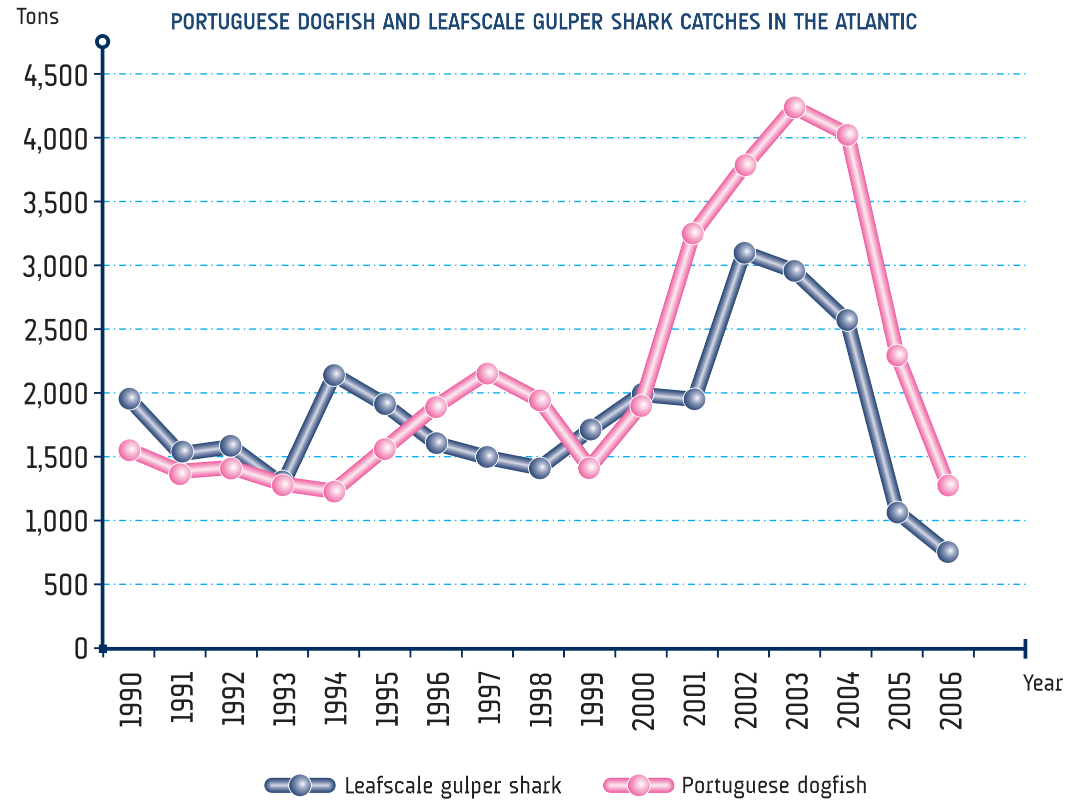
The use of shark and ray parts for commercial purposes is another great threat to their survival. Most elasmobranches are caught in Europe for their fins, but the increasing market demand for meat and other shark products worldwide is leading to wasteful fisheries and the decimation of shark populations. Although many countries indeed trade shark products, much data is left out of official statistics or not recorded on a product-level basis (for example, shark meat vs. shark fins).

Consumption and trade of shark meat has increased in recent years, partly due to the development of new fisheries and the depletion of traditionally targeted species. Spurdog (*S. acanthias)* and porbeagle (*L. nasus)* are both species whose meat is highly valued in Europe, and increased fishing and trade have landed their Northeast Atlantic populations in the IUCN Red List's *Critically Endangered* category. Spurdog in particular is imported into the EU to satisfy the demand for fish and chips in the U.K. and smoked belly flaps, known as schillerlocken, in Germany. In Italy, blue shark (*P. glauca*) steaks are commonly replacing swordfish (*X. gladius)* steaks as overfishing is wiping out the swordfish populations of the Mediterranean and Atlantic. The tope shark (*G. galeus)* is another highly traded and consumed species, particularly sold as cazón in Spain. Shark meat markets are continually opening up. For example demand is increasing in Poland[116] and other eastern European countries as well.

Shark steak (blue shark) on a menu in a local restaurant in Le Grau-du-Roi, France, 2008. © OCEANA/ LX.

Shark liver oil is another globally traded shark product. Liver oil from deep-sea sharks was commonly used as a source of Vitamin A in the early to mid-1900s. However, developments in the synthetic vitamin industry led to a virtual collapse of this market[117]. Today, components of shark liver oil are used as a folk medicine for curing general ailments, healing wounds and reducing pain. Livers are also widely harvested for their squalene, an organic compound used as an emollient in some cosmetic products such as creams, lotions and glosses. The world market for this product is estimated to be between 1,000 and 2,000 tons. Deep-sea sharks in particular are favourites for this trade, as these species have very large livers (weighing up to one-third of the entire shark) with a high oil content. France is one of the largest importers of shark liver oil in the world: in 2005, French companies imported more than 9,000 tons of fish liver oil from Peru and Morocco[118], all of which likely came from sharks as no other species important to the liver oil market are caught in these countries. Two deep-sea sharks widely used to harvest squalene in European waters are the leafscale gulper shark (*C. squamosus*), and the Portuguese dogfish (*C. coelolepis*), both species whose European populations are classified as severely depleted by the International Council for the Exploration of the Seas (ICES).[119] Figure 7 shows the dramatic decrease in landings of these two species since 2003 when they were caught to supply a part of the liver oil market.

Figure 7: Catches of Portuguese dogfish and leafscale gulper shark were relatively stable for 10 years but recently crashed after the unsustainable increase in catches that began in 2000.[120]



Trade and uses for other shark products vary widely, although statistics are highly unknown or unavailable. Shark teeth and jaws are indeed traded worldwide for use as traditional weapons, trinkets and jewellery[121]. Teeth and jaws for certain species can reach very high prices- those for great whites (*C. carcharias*) can cost over €250 and €1,250 respectively[122]! Cartilage from deep-sea and tropical sharks is used today as a source of chondroitin, a molecule often added to dietary supplements and marketed as an alternative treatment for diseases such as osteoarthritis. Additional, but unfounded, claims that this product helps battle cancer and asthma have also made it popular in medicinal supplements. Shark skin, because of its rough texture, is sometimes used as sandpaper or as leather for luxury items such as shoes, handbags and wallets. Ray skin can also be used to cover furniture. Additionally, live elasmobranches themselves are traded for private and public aquaria. Rare and colourful species, like sawfish (Pristidae family) and freshwater stingrays (Potamotrygonidae family), which are among the most threatened species, are highly valuable for the aquarium market.

Shortfin mako (*I. oxyrinchus*) and blue shark (*P. glauca*) jaws for sale in São Vicente, Cape Verde, 2007. © OCEANA/ LX.

Shark jaws for sale in Pucusana, Peru, 2007. © OCEANA/ LX.

Waiter, there's a fin in my soup!

Shark fin soup, part of traditional Chinese culture, dates back thousands of years. The soup was once a rarity available only to the upper class, as shark fins were difficult to obtain and the soup was complicated to create. Prepared with heavily processed shark fins, the soup is flavoured with chicken or pork broth to add flavour to the mostly tasteless and gelatinous shark fin cartilage. Today, with improved fishing techniques and China's larger and wealthier middle class, demand for this product has skyrocketed. Shark fin soup is treated as a delicacy and served at wedding celebrations, business dinners and other high profile events to demonstrate wealth and prestige.

Sadly, the increasing demand for shark fins is driving one of the cruelest and most wasteful fishing techniques practised: shark finning. While finning is technically illegal in many parts of the world, including the European Union, the disparity between exceptionally valuable shark fins and less valuable shark meat creates an economic incentive for fishermen to catch sharks solely for their fins and throw away the bodies. The current EU regulation prohibiting shark finning is among the weakest in the world, and scientists agree that it is not effective in totally eliminating this illegal practice[123].

A cook prepares shark fin soup. © Rob Stewart/ Sharkwater.

Shark meat typically sells from between €1.50 and €2.50 per kilo, but fins can reach up to €500 per kilo on some markets and a bowl of shark fin soup can cost up to €250 in the most expensive restaurants in the United States. In general, the bigger the fin, the higher the price. The fins of some of the most protected sharks in the world, including the great white (*C. carcharias*) and the whale shark (*R. typus*), are among the most valued.

According to FAO statistics, 15,465 tons of dried and frozen shark fins were imported around the world in 2006[124]. However, a large amount of fins escape official trade statistics and according to market studies, between 26-73 million sharks are killed each year to satisfy the market's demand[125]. This would mean between 100 and 300 million fins. Spain leads European participation in the Hong Kong market, one of the largest in the world for this product, and the ports of Vigo in Galicia and Las Palmas in the Canary Islands are the European centres for the fin trade.

Waiter, there's a fin in my soup! (continuation)

While shark fin soup is touted for its curative and medicinal properties, it can actually be harmful for one's health. The drying, bleaching, and lengthy cooking process the fins go through reduces the water content of the fin, thus concentrating numerous heavy metals including mercury. Some studies have shown fins to have mercury levels many times higher than government-recommended limits[126]. Mercury is known to cause nervous system damage as well as more serious poisoning. And while shark fins are also touted as an aphrodisiac, the mercury in them can actually lead to sterility in men.

In 2005, Disney took a positive stance on this issue and announced that shark fin soup would not be served at wedding banquets and special events as planned in the Hong Kong Disneyland park, stating that an environmentally sustainable source for the product was not found[127]. But while awareness and condemnation of shark finning is growing around the world, a booming Chinese economy makes an additional increase in demand likely.

In today's world of increasingly environmentally friendly food products and health conscious consumers, perhaps one solution to this problem could be found in fake shark fins. One Japanese company is already bringing fake shark fins to China. The artificial fins, made out of pork gelatine, sell for one-tenth the price of real fins[128], but the benefits to global shark populations and the marine environment are priceless.

Shark fins for sale at a restaurant in Bangkok, Thailand. © OCEANA.

Others

Habitat destruction and degradation present additional threats to elasmobranches, and are actually considered to be the main causes of global species decline in general[129]. This phenomenon applies to both terrestrial and marine environments, and sharks living in coastal waters, the open ocean and on the sea floor are menaced by this dilemma. These environments can be degraded directly and indirectly through pollution, habitat degradation and changes in ocean characteristics, among other causes.

Pollution is degrading our oceans and threatening the sharks that live in it. Large, rapid catastrophic events, like major oil tanker spills, is one of the most recognisable types of ocean contamination. But hydrocarbon (including crude oil, fuel, petrol and oily waste) dumping can also be continual and occur over long periods of time as a result of ordinary maritime traffic, washing out the tanks of oil tankers, bilge water dumping or minor spillages at sea or in port. Up to three times more oil is intentionally poured into the ocean during routine, but sometimes illegal, cleaning procedures than spilled in accidents like the 2003 *Prestige* disaster in the north of Spain. The Mediterranean, now recognised as the most dangerous place in the world for elasmobranches, is the sea most affected by this type of dumping; approximately 490,000 tons of hydrocarbons are released there a year[130]. These hydrocarbons and other oil toxicants can contaminate the flesh of sharks and rays though direct contact or via the food web and also spoil their coastal habitats, including seagrass meadows and coral reefs[131].

A beach with an oil slick from the July 2007 Don Pedro fuel spill in Ibiza, Balearic Islands, Spain. Fences impeding the entrance to the water can be seen. © OCEANA/ Juan Cuetos.

Chemical pollutants are also threatening the health of sharks in the oceans. Urban and industrial waste is constantly flushed into rivers and land runoff brings organic material like fertilisers to the oceans. Sharks are among the most polluted animals on Earth and studies have shown that heavy metal (cadmium, mercury, lead) pollution in these animals can inhibit DNA synthesis, disrupt sperm production and alter heart function and blood parameters[132]. Sharks are so susceptible to chemical contamination because of a phenomenon known as bioaccumulation in which predators high on the food web tend to harbour more contaminants. The concentrations of substances gradually increase in the bodies of animals with each step up the food web. As sharks consume their prey they are consuming the combined contaminants from the trophic levels below them; the levels of pollutants in large shark species are orders of magnitude higher than those in many teleost species.

Dirty sharks

Sharks are full of marine pollutants such as mercury, lead, and polychlorinated biphenyls (PCBs). Greenland sharks (*S. microcephalus*), which inhabit Arctic waters and some of the least populated regions on Earth, have been found to contain high amounts of human-manufactured industrial waste. In one study, the main source of pollutants found in these sharks was PCBs, banned in the 1970s. These compounds can be extremely persistent in the natural environment and long-lived top predators like sharks may carry them for decades[133].

Another toxic chemical, hexabromocyclododecane (HBCD), has been found in shark liver oil from sharks captured around Japan. This flame retardant is found in everything from consumer electronics to furniture, and is contaminating Japanese waters and winding up in shark and other fish liver oils sold as nutritional supplements. The liver oils were found to contain relatively high levels of HBCD, which can disrupt thyroid and nervous system functioning in mammals[134].

Eating shark meat in general is also advised against due to high mercury levels; consumption of shark fin soup can be particularly dangerous as impurities are concentrated in the fins during the production process. Mercury accumulates in animals naturally from the environment, but concentrations can be elevated as the result of pollution from outdated chlorine factories. Investigations conducted at the University of Hong Kong discovered that shark fins contained 5.84 parts per million (ppm) of mercury, compared to a maximum permitted level of 0.5 ppm. Other tests of fresh shark meat in Texas, USA, revealed mercury levels up to 15 ppm[135].

Mercury contamination is not only a problem for sharks; it also threatens human health by attacking the central nervous system and causing neurological damage if ingested in sufficient quantities. In fact, the Australia and New Zealand Food Standards Agency, the U.S. Food and Drug Administration, the U.K. Food Standards Agency, the European Food Safety Authority and the European Commission Health and Consumer Protection Directorate General have all recommended that young children and women of child bearing age limit their consumption of shark due to high levels of mercury in its meat. While some EU Member States make this advisory readily available to the public, in others it is not so transparent. British health authorities have made the advisory available on their official website, but in Spain mercury alerts are only available via healthcare professionals.

Habitat degradation from coastal development is also threatening shark survival. The alteration of coastlines, from the construction of coastal engineering structures like jetties or seawalls to activities like dredging, mining and the establishment of aquaculture facilities, is eliminating or damaging critical pupping and nursery areas where coastal sharks are born and juveniles spend the first part of their life. Freshwater habitats like rivers, estuaries and coastal areas are often even more susceptible to exploitation and degradation than marine waters as they lay on the edge of large and expanding human populations. Some of the most endangered elasmobranch families such as sawfish (Pristidae family) and guitarfish (Rhinobatidae family) live in these areas. Seafloor habitats are also destroyed by destructive fishing practices such as bottom trawling, which drags huge nets along the ocean floor and carries with it anything in their path. This is threatening the habitats of demersal and coral reef elasmobranches.

Bottom trawl scar in a seagrass bed in Santanyi, Majorca, Balearic Islands, Spain, 2005. © OCEANA/ Mar Mas.

4/ The threats faced by sharks

Climate change and changes in water temperature, weather, currents and tidal levels may also present threats to sharks. Although much about migratory sharks is unknown, it is likely that they use temperature or seasonal cues in the water for feeding or breeding migrations. Water temperature changes due to climate change or other causes may alter these migration patterns as well as food supply and habitats.

Recreational fishing, beach meshing and marine debris (such as fishing gear lost at sea and left to "ghost fish" for many years) represent other threats to the survival of elasmobranches around the world.

School of manta rays (*Mobula thurstoni*) in Coiba Island, Panama. © Houssine Kaddachi.

5/ Looking forward towards change

How do we improve this seemingly dire situation for sharks? The answer is that we need something sharks have resisted doing for millions of years... We need change. Legislative reform is one of the most straightforward and steadfast ways to protect sharks and other elasmobranches. This may be achieved through fisheries management regimes and regional and international environmental conventions.

Fisheries management regimes

Targeted and by-catch fisheries represent the single greatest threat to sharks and rays. The biological difficulty these animals have in recovering from overfishing is magnified by the fact that there are very few regimes for managing shark fisheries around the world. For example, no international catch limits exist for sharks despite their having been commercialised for decades.

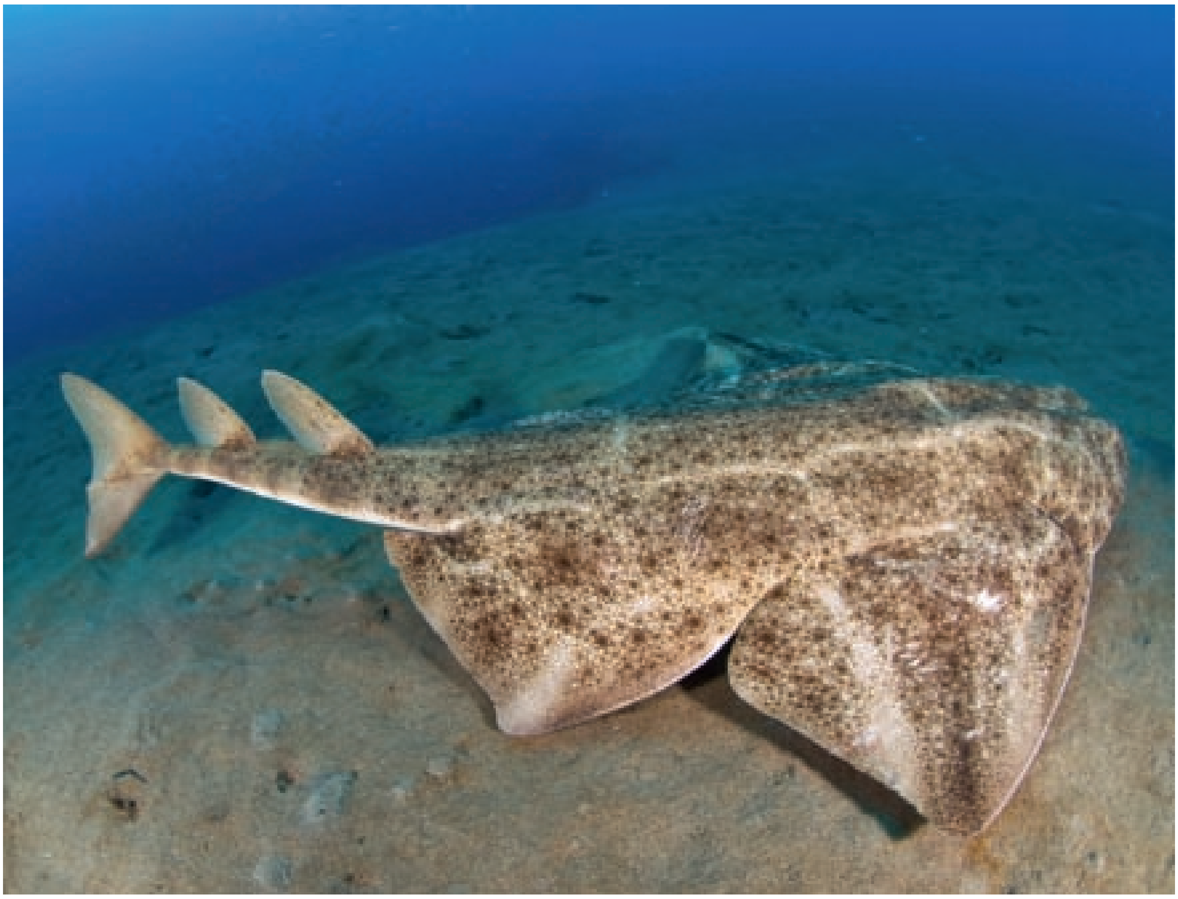
Figure 8. Top 20 Endangered Elasmobranches in European Waters[136] according to IUCN regional Red List status

Sand tiger shark *Carcharias taurus*	Critically Endangered in Med.
Blue skate *Dipturus batis*	Critically Endangered in Med.
Spiny butterfly ray *Gymnura altavela*	Critically Endangered in Med.
Shortfin mako *Isurus oxyrinchus*	Critically Endangered in Med.
Porbeagle shark *Lamna nasus*	Critically Endangered in NE Atlantic & Med.
Maltese ray *Leucoraja melitensis*	Critically Endangered in Med.
Angular roughshark *Oxynotus centrina*	Critically Endangered in Med.
Smalltooth sawfish *Pristis pectinata*	Critically Endangered in Med.
Common sawfish *Pristis pristis*	Critically Endangered in Med.
Bottlenosed skate *Rostroraja alba*	Critically Endangered in Med.
Spiny dogfish *Squalus acanthias*	Critically Endangered in NE Atlantic
Sawback angelshark *Squatina aculeata*	Critically Endangered in Med.
Smoothback angelshark *Squatina oculata*	Critically Endangered in Med.
Angelshark *Squatina squatina*	Critically Endangered in Med.
Sandbar shark *Carcharhinus plumbeus*	Endangered in Med.
Great white shark *Carcharodon carcharias*	Endangered in Med.
Basking shark *Cetorhinus maximus*	Endangered in NE Atlantic
Devil fish *Mobula mobular*	Endangered in Med.
Blackchin guitarfish *Rhinobatos cemiculus*	Endangered in Med.
Common guitarfish *Rhinobatos rhinobatos*	Endangered in Med.

5/ Looking forward towards change

In Europe, most sharks are “free to be caught”, as nearly all shark fisheries are virtually unregulated at both national and regional levels; because of this, one-third of European shark and ray species are now threatened with extinction according to the IUCN. This situation demands rectification, and indeed many of the more productive species of sharks and rays can be sustainably caught if properly managed.

The European Union, one of the largest shark catching states in the world, has a responsibility to lead shark management and work towards sustainable fisheries. A sound and comprehensive science-based Community Plan of Action for Sharks is necessary for their conservation and management inside and outside Community waters. In addition, there are a number of fisheries management regimes that the EU should establish either as part of, or complementary to, the Plan of Action. Specifically, all species suitable for commercialisation must have a management plan and be regulated with science-based fishing quotas (Total Allowable Catches, or TACs). Further, catch and landing data must be recorded on a species-specific level and the shark finning ban must be strengthened.[XI]



The angelshark (*S. squatina*) is *Critically Endangered* all around the world according to the IUCN. This one was photographed in Puerto del Carmen, Lanzarote in the Canary Islands, Spain, in 2006. © Carlos Suárez.

XI See Appendix III for a full description of the fisheries management regimes the EU should establish relevant to elasmobranches.

Environmental convention protection

While some elasmobranches can be caught sustainably if appropriately managed with the regimes mentioned above, others require stricter protection due to their poor conservation status and threat of extinction. These endangered sharks and rays should be protected via international conventions and regional agreements that protect the environment. These agreements can serve to limit catches, regulate trade, protect habitats and outline recuperation plans for threatened species.

In the EU, there are several international and regional conventions in force for the conservation of threatened European flora and fauna species. However, only few elasmobranches are currently protected under them. Among them, the blue shark (*P. glauca*) and devil fish (*M. mobular*) are partially protected under the Bern Convention on the Conservation of European Wildlife and Natural Habitats and the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. However, many other species listed as Critically Endangered on the IUCN Red List are not protected at all, including the smoothback angelshark (*Squatina oculata*) and the Maltese ray (*Leucoraja melitensis*). The legislation of these conventions is in urgent need of revision and improvement to protect all threatened European elasmobranches before they become locally extinct.[XII]

An ocellated electric ray (*Diplobatis ommata*) in Cabo Pulmo, Mexico. © Houssine Kaddachi.

XII See Appendix III for a full description of the international and regional environmental conventions relevant to European elasmobranches.

6/ Conclusion

Sharks and rays are incredibly diverse and complex animals that have survived and evolved over millennia to become efficient and integral ocean inhabitants. However today's uncontrolled fishing activities are threatening their very survival and putting entire ecosystem functions at risk. Achieving legislative changes for elasmobranch fisheries management and threatened species protection is necessary to safeguard these animals. This will require willpower and conviction from political decision-makers and compromise within many industrial sectors.

However, this is not the only area where we need change, because the negative images of sharks that mass media propagate inhibits political will and keeps research priorities low. The damaging stereotype of the shark as a ravenous and restless beast needs a makeover, and this can only be achieved through increased public awareness and environmental education. We can all work to learn more about the beauty and magnificence of these animals, and to teach younger generations to appreciate and understand them.

Despite the incredible vastness of the oceans, and even the immensity of the land, all organisms are linked in intricate and unexpected ways. If humans throw a kink into this magical web, we will undoubtedly throw parts of it, large and small, off balance. Sharks, whether for maintaining robust ecosystems, providing for a source of employment and nutrition, or enchanting the public with their awesome image, are much more valuable in our waters than out of them.

Saving sharks is the responsibility of all of us.

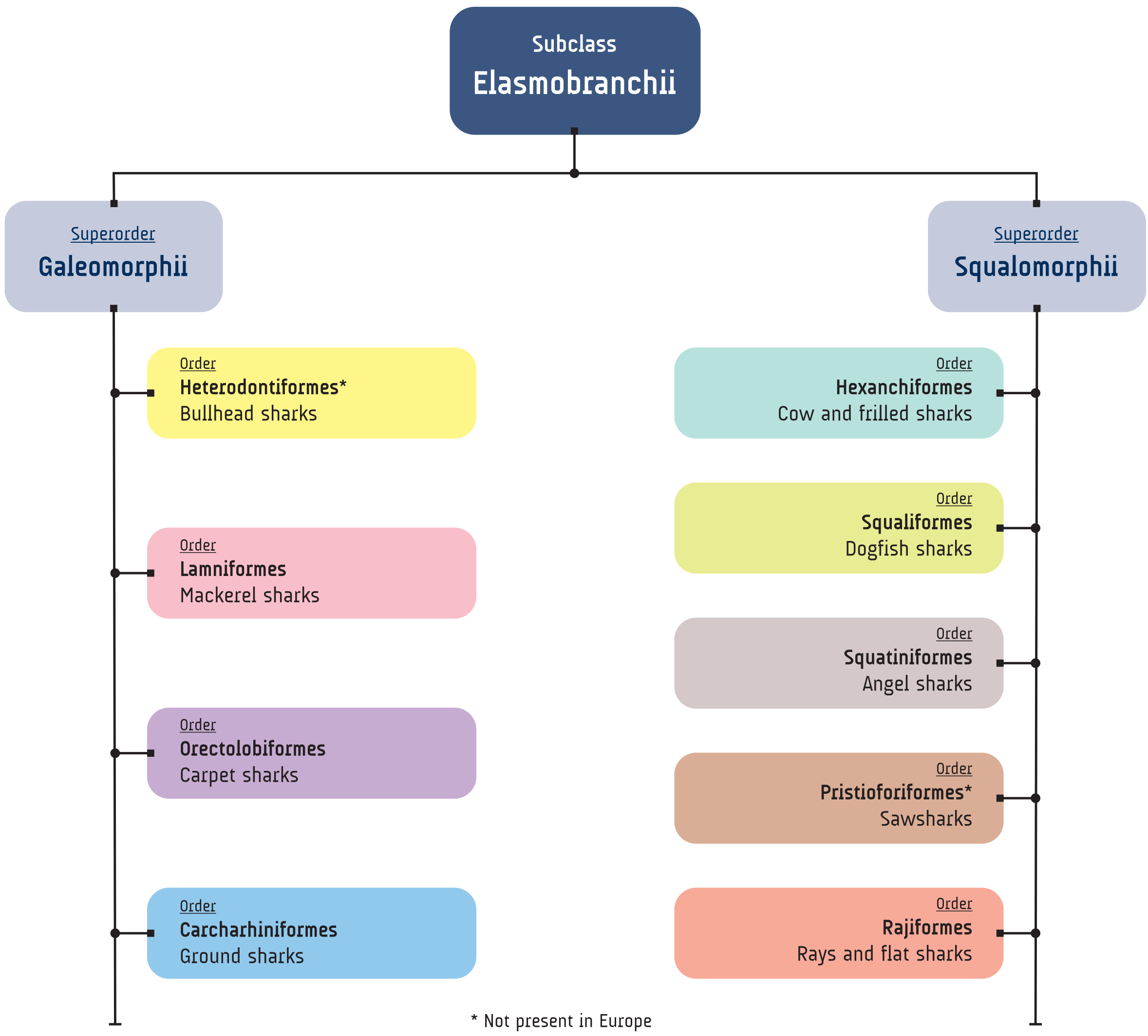
A shark in a Bahamas coral reef. © Willy Volk

Appendix I/ Elasmobranch taxonomy

Sharks and rays are classified according to the following system:

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Class: Chondrichthyes
Subclass: Elasmobranchii (elasmobranches), Holocephali (chimera)

The elasmobranches are further divided into two superorders, Galeomorphii (many of the species commonly thought of as typical sharks) and Squalomorphii, with 8 unique orders of sharks and 1 order of batoids:



* Not present in Europe

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Lamniformes – Mackerel sharks					
Bigeye thresher	*Alopias superciliosus*	Pelagic subtropical	Iberian Peninsula to Canary Islands and Madeira. Mediterranean.	VU	UNCLOS Annex I
Common thresher shark	*Alopias vulpinus*	Pelagic subtropical	Norway to Iberian Peninsula and Mediterranean.	VU	UNCLOS Annex I
Sand tiger shark/ Grey nurse shark	*Carcharias taurus*	Demersal subtropical	Mediterranean and Black Sea. Scarcer in North-east Atlantic, Canary Islands. More frequent in south.	VU	
Great white shark	*Carcharodon carcharias*	Pelagic subtropical	South European Atlantic (From France south) and Mediterranean. Canary Islands and Madeira.	VU	Barcelona Annex II Bern Appendix II[III] CMS Appendix I & II CITES II UNCLOS Annex I
Basking shark	*Cetorhinus maximus*	Pelagic temperate	Iceland to western Barents Sea to Iberian Peninsula and Mediterranean.	VU	Barcelona Annex II Bern Appendix II[III] CMS Appendix I & II CITES II UNCLOS Annex I All OSPAR regions
Shortfin mako	*Isurus oxyrinchus*	Pelagic subtropical	Norway to Canary Islands and Mediterranean.	VU	Barcelona Annex III Bern Appendix III[III] UNCLOS Annex I
Longfin mako	*Isurus paucus*	Pelagic subtropical	Canary Islands.	VU	UNCLOS Annex I
Porbeagle	*Lamna nasus*	Pelagic temperate	Iceland to Western Barents Sea to Iberian Peninsula and Mediterranean.	VU	Barcelona Annex II Bern Appendix II[III] UNCLOS Annex I All OSPAR regions
Goblin shark	*Mitsukurina owstoni*	Bathydemersal deep-waters	Bay of Biscay to Madeira, through Iberia	LC	
Smalltooth sand tiger	*Odontaspis ferox*	Bathydemersal deep-waters	From Gulf of Gascony to Madeira and Canary Island. Mediterranean.	DD	
Bigeye sandtiger	*Odontaspis noronhai*	Bathydemersal deep-waters	Madeira to west.	DD	

I Species found in European waters from the Arctic to the Canary Islands. Those species in EU overseas territories, such as French Polynesia or Bermuda, are not included.

II IUCN 2008. 2008 IUCN Red List of Threatened Species. <www.iucnredlist.org.>
CR: Critically Endangered/ EN: Endangered/ VU: Vulnerable/ LR: Lower Risk/ NT: Near Threatened/
LC: Least Concern/ DD: Data Deficient/- Those species not evaluated are left blank.

III Only in the Mediterranean

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Carcharhiniformes – Ground sharks					
White ghost catshark	*Apristurus aphyodes*	Bathypelagic deep-waters	North-east Atlantic.	DD	
Atlantic ghost catshark	*Apristurus atlanticus*	Bathydemersal deep-waters	Canary Islands	DD	
Iceland catshark	*Apristurus laurussonii*	Bathydemersal deep-waters	Iceland to Ireland to Canary Islands and Madeira.	DD	
Ghost catshark	*Apristurus manis*	Bathydemersal deep-waters	Ireland.	LC	
Smalleye catchark	*Apristurus microps*	Bathydemersal deep-waters	Iceland to Scotland.	LC	
Bignose shark	*Carcharhinus altimus*	Demersal subtropical	Spain to Mediterranean.		UNCLOS Annex I
Copper shark	*Carcharhinus brachyurus*	Pelagic subtropical	From the French Atlantic to the Mediterranean. Canary Islands.	NT	UNCLOS Annex I
Spinner shark	*Carcharhinus brevipinna*	Pelagic subtropical	French and Spanish Atlantic and Mediterranean.	NT	UNCLOS Annex I
Silky shark	*Carcharhinus falciformis*	Pelagic subtropical	Canary Islands and Madeira.	NT	UNCLOS Annex I
Galapagos shark	*Carcharhinus galapagensis*	Benthopelagic tropical	Canary Islands.	NT	UNCLOS Annex I
Blacktip shark	*Carcharhinus limbatus*	Pelagic subtropical	Canary Islands to Madeira and Mediterranean.	NT	UNCLOS Annex I
Oceanic whitetip shark	*Carcharhinus longimanus*	Pelagic subtropical	Portugal to Canary Islands, possibly Mediterranean.	VU	UNCLOS Annex I
Blacktip reef shark	*Carcharhinus melanopterus*	Subtropical	Eastern Mediterranean (through Suez canal).	NT	UNCLOS Annex I
Dusky shark	*Carcharhinus obscurus*	Pelagic subtropical	Canary Islands. Possibly Madeira and Mediterranean.	NT	UNCLOS Annex I
Sandbar shark	*Carcharhinus plumbeus*	Pelagic subtropical	Iberian Peninsula, Mediterranean and Canary Islands.	NT	UNCLOS Annex I

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Tiger shark	*Galeocerdo cuvier*	Pelagic subtropical	Iceland and Canary Islands.	NT	UNCLOS Annex I
Tope shark	*Galeorhinus galeus*	Benthopelagic subtropical	Iceland to Canary Islands and Mediterranean.	VU	
Blackmouth catshark	*Galeus melastomus*	Bathydemersal deep-waters	From Faroe Islands to Iberian Peninsula and Mediterranean.		
Atlantic catshark	*Galeus atlanticus*	Bathydemersal deep-waters	Northeast Atlantic and Mediterranean. Straights of Gibraltar to Italy.	NT	
Mouse catshark	*Galeus murinus*	Bathydemersal deep-waters	Iceland to Faroe Islands.		
Starry smooth-hound	*Mustelus asterias*	Demersal temperate	From North Sea to Canary Islands. Mediterranean.	LC	
Smooth-hound	*Mustelus mustelus*	Demersal subtropical	British Isles to France and Madeira-Canary Islands. Mediterranean.	LC	
Blackspotted smooth-hound	*Mustelus punctulatus*	Demersal subtropical	Mediterranean to Gibraltar.		
Blue shark	*Prionace glauca*	Pelagic subtropical	Norway to Canary Islands and Mediterranean.	NT	Barcelona Annex III Bern Appendix III[III] UNCLOS Annex I
False catshark	*Pseudotriakis microdon*	Bathydemersal deep-waters	From Iceland to Canary Islands and Azores.	DD	
Milk shark	*Rhizoprionodon acutus*	Benthopelagic tropical	Mediterranean and Madeira.	LC	UNCLOS Annex I
Small spotted catshark	*Scyliorhinus canicula*	Demersal subtropical	North Sea to Iberian Peninsula and Mediterranean.		
Nursehound	*Scyliorhinus stellaris*	Reef subtropical	South Scandinavia to Canary Islands and Mediterranean.		
Scalloped hammerhead	*Sphyrna lewini*	Pelagic subtropical	Mediterranean to Gibraltar. Azores, Madeira and Canary Islands.	EN	UNCLOS Annex I

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Great hammerhead	*Sphyrna mokarran*	Pelagic subtropical	Mediterranean to Gibraltar.	EN	UNCLOS Annex I
Smalleye hammerhead	*Sphyrna tudes*	Benthopelagic subtropical	Mediterranean.	VU	UNCLOS Annex I
Smooth hammerhead	*Sphyrna zygaena*	Benthopelagic subtropical	British Isles to Canary Islands and Mediterranean.	NT	UNCLOS Annex I
Orectolobiformes – Carpet sharks					
Nurse shark	*Ginglymostoma cirratum*	Reef subtropical	West African. Occasional up to France.	DD	
Whale shark	*Rhincodon typus*	Pelagic	Canary Islands.	VU	CMS Appendix II CITES II UNCLOS Annex I
Squaliformes –Dogfish sharks					
Gulper shark	*Centrophorus granulosus*	Bathydemersal deep-waters	From France to Canary Islands and Madeira. Mediterranean.	VU	OSPAR Regions IV, V
Lowfin gulper shark	*Centrophorus lusitanicus*	Bathydemersal deep-waters	Portugal to Canary Islands		
Leafscale gulper shark	*Centrophorus squamosus*	Benthopelagic deep-waters	Iceland to Iberian Peninsula and to Canary Island, Madeira and Azores.	VU	OSPAR Regions IV, V
Little gulper shark	*Centrophorus uyato*	Bathydemersal deep-waters	Western Mediterranean and Gibraltar.	DD	
Black dogfish	*Centroscyllium fabricii*	Bathydemersal deep-waters	Greenland to Iceland to France-Iberia and West Sahara.		
Portuguese dogfish	*Centroscymnus coelolepis*	Bathydemersal deep-waters	Iceland to Canary Islands. Mediterranean.	NT	All OSPAR regions
Shortnose velvet dogfish	*Centroscymnus cryptacanthus*	Bathydemersal deep-waters	Madeira.		
Longnose velvet dogfish	*Centroselachus crepidater*	Bathydemersal deep-waters	Iceland to Macronesia	LC	
Kitefin shark	*Dalatias licha*	Bathydemersal deep-waters	Iceland to Ireland and to Morocco. Western Mediterranean.	DD	

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Birdbeak dogfish	*Deania calcea*	Bathydemersal deep-waters	Iceland to Canary Islands.	LC	
Rough longnose dogfish	*Deania hystricosum*	Bathydemersal deep-waters	Madeira.		
Arrowhead dogfish	*Deania profundorum*	Benthopelagic deep-waters	Canary Islands.		
Bramble shark	*Echinorhinus brucus*	Bathydemersal deep-waters	North Sea to Mediterranean.	DD	
Smooth lantershark	*Etmopterus pusillus*	Bathydemersal deep-waters	Iberia to Azores and Canary Islands.		
Great lantrnshark	*Etmopterus princeps*	Bathydemersal deep-waters	Iceland to Bay of Biscay and Gibraltar. Possibly to Canary Islands.	DD	
Velvet belly lantern shark	*Etmopterus spinax*	Bathydemersal deep-waters	Iceland-Norway and western Mediterranean.		
Angular roughshark	*Oxynotus centrina*	Bathydemersal deep-waters	Cornwall to Bay of Biscay and Mediterranean.	VU	
Sailfin roghshark	*Oxynotus paradoxus*	Bathydemersal deep-waters	From Scotland to Iberian Peninsula and Sahara.		
Azores dogfish	*Scymnodalatias garricki*	Bathypelagic deep-waters	Azores.		
Smallmouth velvet dogfish	*Scymnodon obscurus*	Benthopelagic tropical	Iceland to Madeira.		
Knifetooth dogfish	*Scymnodon ringens*	Bathypelagic deep-waters	From Scotland to Iberian Peninsula and Gibraltar.		
Velvet dogfish	*Scymnodon squamulosus*	Benthopelagic deep-waters	Iceland to Canary Islands.		
Greenland shark	*Somniosus microcephalus*	Benthopelagic deep-waters	From White Sea to Greenland and France.	NT	
Little sleeper shark	*Somniosus rostratus*	Bathydemersal deep-waters	From France to Madeira and Mediterranean (mainly western).		
Spined pigmy shark	*Squaliolus laticaudus*	Bathypelagic deep-waters	From France to Madeira.	LC	

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Spiny dogfish	*Squalus acanthias*	Benthopelagic temperate	From Murmansk to Canary Islands. Mediterranean and Black Sea.	VU	All OSPAR regions
Longnose spurdog	*Squalus blainville*	Demersal subtropical	Bay of Biscay and Mediterranean. Possibly Canary Islands.		
Smallmouth velvet dogfish	*Zameus squamulosus*	Bathydemersal deep-waters	From Iceland down to Africa	DD	
Hexanchiformes –Cow and frilled sharks					
Frilled shark	*Chlamydoselachus anguineus*	Bathydemersal deep-waters	From Norway to Iberia and Madeira trough France-UK.	NT	
Sharpnose sevengill shark	*Heptranchias perlo*	Bathydemersal deep-waters	Mediterranean and Canary Islands.	NT	
Bigeye sixgill shark	*Hexanchus nakamurai*	Bathydemersal deep-waters	France to Gibraltar and Mediterranean.		
Bluntnose sixgill shark	*Hexanchus griseus*	Benthopelagic subtropical	Iceland to Canary-Madeira and Mediterranean.	NT	UNCLOS Annex I
Squatiniformes – Angel sharks					
Sawback angelshark	*Squatina aculeata*	Demersal subtropical	Mediterranean to Canary Islands.	CR	
Smoothback angelshark	*Squatina oculata*	Demersal subtropical	Mediterranean to Morocco.	CR	
Angelshark	*Squatina squatina*	Demersal temperate	Norway to Canary Islands and Mediterranean.	CR	Barcelona Annex III Bern Appendix III[III] OSPAR Regions II, II, IV
Rajiformes – Rays and flat sharks					
Arctic skate	*Amblyraja hyperborea*	Bathydemersal deep-waters	Svalbard to Greenland to Shetland.	LC	
Jensen's skate	*Amblyraja jenseni*	Bathydemersal deep-waters	Iceland.		
Thorny skate	*Amblyraja radiata*	Demersal temperate	Greenland to western Baltic and English Channel (except south north Sea).		

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Pale ray	*Bathyraja pallida*	Bathydemersal deep-waters	Bay of Biscay.	LC	
Richardson's ray	*Bathyraja richardsoni*	Bathydemersal deep-waters	Western Bay of Biscay.	LC	
Spinetail ray	*Bathyraja spinicauda*	Bathydemersal deep-waters	Barents Sea to Greenland.		
Roughtail stingray	*Dasyatis centroura*	Demersal subtropical	Bay of Biscay to Canary Islands and Madeira. Mediterranean.	LC	
Marbled stingray	*Dasyatis chrysonota marmorata*	Demersal tropical	Mediterranean to Gibraltar.		
Daisy stingray	*Dasyatis margarita*	Demersal tropical	Possibly in Canary Islands.		
Common stingray	*Dasyatis pastinaca*	Demersal subtropical	Norway to Canary Islands and Azores. Mediterranean.		
Tortonese's stingray	*Dasyatis tortonesi*	Demersal temperate	Mediterranean.		
Blue or common skate	*Dipturus batis*	Demersal subtropical	Norway to Canary Islands to west Baltic. Western Mediterranean.	CR	All OSPAR regions
Sailray	*Dipturus linteus*	Bathydemersal deep-waters	Skagerrak to Greenland.		
Norwegian skate	*Dipturus nidarosiensis*	Bathydemersal deep-waters	From Norway to Ireland and Mauritania.		
Longnosed skate	*Dipturus oxyrinchus*	Bathydemersal deep-waters	Norway to Skagerrak to Canary Islands and Madeira. Mediterranean.	NT	
Spiny butterfly ray	*Gymnura altavela*	Demersal subtropical	Portugal to Madeira and Canary Islands. Mediterranean and Black Sea.	VU	
Madeira butterfly ray	*Gymnura hirundo*	Demersal subtropical	Madeira.		
Honeycomb stingray	*Himantura uarnak*	Demersal subtropical	Mediterranean (through Suez canal).		

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Sandy ray	*Leucoraja circularis*	Bathydemersal deep-waters	Iceland to Skagerrak to Morocco. Mediterranean.		
Shagreen ray	*Leucoraja fullonica*	Bathydemersal deep-waters	Murmansk to Faroe Islands and Skagerrak to Mediterranean. Western Mediterranean.		
Maltese ray	*Leucoraja melitensis*	Bathydemersal deep-waters	Western Mediterranean.	CR	
Cuckoo ray	*Leucoraja naevus*	Demersal subtropical	Kattegat to British Isles to Gibraltar and Mediterranean.		
Krefft's ray	*Malacoraja kreffti*	Demersal temperate	Faroe Islands to Iceland.	LC	
Roughskin skate	*Malacoraja spinacidermis*	Bathydemersal deep-waters	Iceland to Faroe Islands to Sahara.	LC	
Giant manta	*Manta birostris*	Pelagic subtropical	Madeira and Canary Islands.	NT	
Devil fish	*Mobula mobular*	Pelagic subtropical	Ireland to Azores and Canary Islands. Mediterranean.	EN	Barcelona Annex II Bern Appendix II[III]
Common eagle ray	*Myliobatis aquila*	Benthopelagic subtropical	British Isles and southwest North Sea to Canary Islands. Mediterranean.		
Blue ray	*Neoraja caerulea*	Bathydemersal deep-waters	Between Iceland and Ireland.		
Smalltooth sawfish	*Pristis pectinata*	Demersal subtropical	Gibraltar to Canary Islands. Possibly Mediterranean.	CR	CITES I
Common sawfish	*Pristis pristis*	Demersal subtropical	Portugal to Canary Islands and western Mediterranean.	CR	CITES I
Bull ray	*Pteromylaeus bovinus*	Benthopelagic subtropical	Portugal to Madeira and Canary Islands. Mediterranean.	DD	
Pelagic stingray	*Pteroplatytrygon violacea*	Pelagic subtropical	Western Mediterranean.	LC	

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
African ray	*Raja africana*	Demersal subtropical	South Mediterranean to Mauritania.		
Starry ray	*Raja asterias*	Demersal subtropical	Mediterranean and Gibraltar.	LC	
Blonde ray	*Raja brachyura*	Demersal temperate	British Isles to Canary Islands and Madeira. Western Mediterranean.		
Thornback ray	*Raja clavata*	Demersal subtropical	Iceland to Canary Islands. Mediterranean.	NT	
Madeiran ray	*Raja maderensis*	Bathydemersal deep-waters	Madeira to Canary and possibly Azores.		
Small-eyed ray	*Raja microocellata*	Demersal temperate	West British Isles to Morocco.	NT	
Brown ray	*Raja miraletus*	Demersal subtropical	Portugal to Madeira and Mediterranean. Possibly Canary Islands.		
Spotted ray	*Raja montagui*	Demersal temperate	Shetland to western Baltic to Canary Islands. Mediterranean.	LC	OSPAR Regions II, III, IV, V
Speckled ray	*Raja polystigma*	Demersal subtropical	Mediterranean to Gibraltar.		
Rough ray	*Raja radula*	Demersal subtropical	Mediterranean to Gibraltar.		
Rondelet's ray	*Raja rondeleti*	Demersal subtropical	Western Mediterranean (excluding Spain).		
Undulate ray	*Raja undulata*	Demersal subtropical	British Isles to Canary Islands. Mediterranean.		
Deepwater ray	*Rajella bathyphila*	Bathydemersal deep-waters	Greenland to Denmark to Bay of Biscay to Sahara.		
Bigelow's ray	*Rajella bigelowi*	Bathydemersal deep-waters	British Isles to Bay of Biscay and Azores and Sahara.		
Round ray	*Rajella fyllae*	Bathydemersal deep-waters	Svalbarg to Greenland to Bay of Biscay		

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Mid-Atlantic skate	*Rajella kukujevi*	Bathydemersal deep-waters	49°50'N, 29°33'W.		
Blackchin guitarfish	*Rhinobatos cemiculus*	Demersal subtropical	Portugal to Canary Islands and Mediterranean	EN	
Common guitarfish	*Rhinobatos rhinobatos*	Demersal subtropical	Bay of Biscay to Canary Islands and Mediterranean	EN	
Lusitanian cownose ray	*Rhinoptera marginata*	Benthopelagic subtropical	Spain to Canary Islands. Mediterranean.		
Bottlenosed or white skate	*Rostroraja alba*	Demersal subtropical	Canary Islands to the Mediterranean.	EN	Barcelona Annex II Bern Appendix II[III]
Round stingray	*Taeniura grabata*	Demersal subtropical	Canary Islands to the Mediterranean.		
Common torpedo	*Torpedo torpedo*	Demersal deep-waters	Southern Bay of Biscay to Canary Islands and Mediterranean.		
Spotted torpedo	*Torpedo marmorata*	Demersal subtropical	From British Isle to Canary Island. Mediterranean.		
Atlantic torpedo	*Torpedo nobiliana*	Pelagic subtropical	Scotland to Canary Islands (rare in North Sea). Mediterranean.		
Chimaeriformes - Chimaeras					
Rabbit fish	*Chimaera monstrosa*	Bathydemersal deep-waters	Iceland to Azores and Madeira and Mediterranean (mainly west).	NT	
Smallspine spookfish	*Harriotta haeckeli*	Bathydemersal deep-waters	Canary Island to Gibraltar.	DD	
Narrownose chimaera	*Harriotta raleighana*	Bathydemersal deep-waters	Iceland to France to Canary Islands.	LC	
Large-eyed rabbitfish	*Hydrolagus mirabilis*	Bathydemersal deep-waters	Iceland to north of Spain to Morocco.	NT	
Smalleyed rabbitfish	*Hydrolagus affinis*	Bathydemersal deep-waters	Iceland to Bay of Biscay and Portugal.	LC	

Appendix II/ European Chondrichthyan Species[I]: range and conservation status

Common Name	Scientific Name	Habitat	Range in Europe	IUCN global Red List status[II]	Relevant instruments
Ghost shark	*Hydrolagus pallidus*	Bathydemersal deep-waters	Iceland.	LC	
Spearnose chimaera	*Rhinochimaera atlantica*	Bathydemersal deep-waters	Iceland to Bay of Biscay. Sahara.	LC	

Appendix III/ Recommended fisheries management regimes and environmental convention protection for elasmobranches in Europe

There are a number of fisheries management regimes that the European Union should establish either as part of, or complementary to, the European Plan of Action for Sharks to ensure shark fishery sustainability. These include:

- The EU's Common Fisheries Policy (CFP) outlines that catch and/or effort limits should be established for commercial fish stocks. Despite the fact that sharks have been commercialised for decades, this policy has not been applied to shark fisheries. All sharks targeted by European Union fisheries (for example, blue (*P. glauca*) and mako (*I. oxyrinchus*) sharks in the Atlantic longline fishery) should be recognised as commercially exploited species and the catches by EU vessels must be regulated with **management or recovery plans that include fishing limits** and quotas. Catches and landings must differentiated by species.

- Migratory shark species exploited on the high seas, like blue (*P. glauca*) and mako (*I. oxyrinchus*) sharks, must be added to the lists of **highly migratory species that are controlled and managed by Regional Fishery Management Organisations** (RFMO) such as ICCAT, IATTC, IOTC and WCPFC[I]. These RFMOs must manage sharks using the same standard management schemes, catch limits and quotas used for other targeted highly migratory species like swordfish (*X. gladius)*.

- In addition to commercially targeted stocks, major shark by-catches occur in several industrial European Union fisheries. Effective management measures to **reduce this shark by-catch** must be introduced, including improvement of fishing gear to increase selectivity and establishment of closed areas and/or periods when by-catch rates are excessive or to restrict fishing activities in shark spawning and nursery areas.

- By-catches often turn into discards, the portion of the animal catch that is thrown away at sea and ultimately wasted. This is also contributing to the decline of vulnerable marine populations. Sharks are often included in discards, and those caught by industrial fleets, including purse seiners, deep-sea gillneters, longliners and trawlers are never reported. Promoting all of the above measures to reduce by-catch will **decrease discards of those species**. Elasmobranches caught as by-catch that have a chance to survive must be released back into the water as quickly as possible.

- An **overhaul of the EU's shark finning ban** is also necessary so that sharks are required to be landed at port with their fins attached to their bodies. The current regulation, in effect since 2003, is over-complicated and unenforceable, leaving room for illegal finning practices to occur. In order to have a truly effective prohibition against shark finning, fins should not be permitted to be removed on board vessels for processing or any other purposes.

I ICCAT: International Commission for the Conservation of Atlantic Tunas; IATTC: Inter-American Tropical Tuna Commission; IOTC: Indian Ocean Tuna Commission; WCPFC: Western and Central Pacific Fisheries Commission.

Appendix III/ Recommended fisheries management regimes and environmental convention protection for elasmobranches in Europe

- **Shark catches of EU vessels outside of EU waters** must also be controlled. The European Union must take immediate efforts to bring the shark fisheries and catches of EU vessels that operate in international and third-Country waters, and of EU chartered vessels, under control. Further control measures must be taken to avoid illegal activities in foreign harbours and facilities connected to shark fisheries and trade around the world.

- Trade statistics for shark species, shark meat, shark liver oil and shark fins are often mixed in with those of other fish products. Developing **distinct trade statistics for shark products** can be a useful instrument to estimate real shark catches and to compile more specific trade-flow information.

- **Independent observer coverage** on board vessels taking sharks in targeted fisheries or with major shark by-catch is crucial to completely eliminate shark finning, collect detailed scientific information and guarantee that shark catches are fully retained and reported on a species-specific level.

The legislation of many international and regional conventions in force to protect the environment is in urgent need of revision and improvement to achieve the conservation of threatened European elasmobranch species. Among them are:

- The 1995 Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean, born out of the **Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean**[137], establishes conservation measures for the Mediterranean environment. Contracting parties include all countries with a Mediterranean shoreline as well as the European Union. Although more than 40% of Mediterranean elasmobranches are considered threatened with extinction, only eight are protected with this agreement. All threatened elasmobranches in the Mediterranean should be added to Annex II, listing endangered or threatened species, or Annex III, listing species whose exploitation is regulated.

- The **Convention on the Conservation of European Wildlife and Natural Habitats, known as the Bern Convention**[138], is another European regional agreement relevant to shark conservation. This convention aims to conserve wild flora and fauna and their natural habitats, with particular emphasis on vulnerable and endangered species. Contracting parties include the European Union and other member states of the Council of Europe. Over one-third of European elasmobranches are threatened with extinction, but only eight are protected with this agreement. All *Endangered* and *Critically Endangered* European elasmobranches should be listed under Appendix II for strictly protected fauna species and all other threatened elasmobranches under Appendix III for protected fauna species.

I See Appendix II of this report for species currently listed under each protocol.

Appendix III/ Recommended fisheries management regimes and environmental convention protection for elasmobranches in Europe

- The highly migratory nature of many shark species places them outside the responsibility of specific countries or regions, and thus shark conservation must be approached as a global issue. The **Convention on the Conservation of Migratory Species of Wild Animals[139] (CMS), also known as the Bonn convention**, is an environmental treaty that provides a global platform for the conservation and sustainable use of migratory animals and the places they live. The Convention brings together the states through which migratory animals pass; the EU and all of its Member states are contracting parties. Only three European elasmobranches, the basking shark (*C. maximus*), whale shark (*R. typus*) and the great white shark (*C. carcharias)*, are included in this convention. Many other pelagic sharks caught by European fleets are migratory and should be added to Appendix I, listing migratory species threatened with extinction or Appendix II, listing migratory species that need or would benefit from international cooperation.

- Regulating trade of endangered elasmobranch species is also crucial to their conservation. The **Convention on International Trade in Endangered Species of Wild Fauna and Flora[140] (CITES)** serves to protect wildlife against over-exploitation and prevents international trade from threatening species' survival. Although the European Union is not yet a party to the Convention, all of its Member states are, and the EU itself has been fully implementing CITES since 1984. Currently, only five European elasmobranches are listed on CITES. EU Member states should propose to add all IUCN Red Listed *Endangered* and *Critically Endangered* European elasmobranch species to Appendix I to prohibit open trade, and all other threatened elasmobranch species to Appendix II to regulate trade and ensure its continued sustainability.

- Equally important to protecting species is protecting the places they live. Habitat conservation is key to an ecosystem approach to management, and in the EU the **Habitats Directive[141]** is a cornerstone of the environmental conservation policy aimed at achieving this. This directive led to the establishment of Natura 2000, a network of protected areas that aims to assure the long-term survival of Europe's most valuable and threatened species and habitats. EU member states should propose to add all habitats that are crucial to shark conservation (e.g., breeding or nursery grounds) to Annex I of the Habitats Directive, which designates habitats as special areas of conservation. In addition, as there are currently no elasmobranch species included in this directive, all endangered elasmobranches should be added to Annex II, listing species that require special areas of conservation.

- Other international agreements also exist which should be revised to reflect the current threatened status of European elasmobranches, including the **United Nations Convention on the Law of the Sea**, which lists 25 oceanic sharks on Annex I, and the **OSPAR Convention for the Protection of the Marine Environment of the North-east Atlantic**, which notes regions where species are threatened or in decline.

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Appendix III_Recommended fisheries management regimes and environmental convention protection for elasmobranches in Europe

137 United Nations Environment Programme Mediterranean Action Plan for the Barcelona Convention http://www.unepmap.org/index.php

138 United Nations Environment Programme Regional Seas Programme http://www.unep.ch/regionalseas/legal/bern.htm

139 Convention on Migratory Species http://www.cms.int/

140 Convention on International Trade in Endangered Species of Wild Fauna and Flora http://www.cites.org/

141 Habitats Directive http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

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