The Truth about Sharks by Rowan Byrne & Alessendro de Madellena www.marinecreatures.com © 2004

Introduction

Shark: Any of various usually ferocious fishes, with a long body, two dorsal fins, and rows of sharp teeth. The word "shark" can clear a beach or fill a movie theatre. For many people it conjures up a picture of a vicious "man-eating" fish armed with a fearsome array of teeth and of dimensions akin to that of a mini-bus. The truth of the matter is that of approximately 425 species of shark so far discovered, only a fraction conforms to this stereotype. They vary from the great white shark *(Carcharodon carcharias)* of 21 feet, to *Etmopterus perryl* a new species, which is probably the world's smallest shark of 160mm! Most sharks are a far cry from being a voracious predator; they are mostly harmless creatures displaying a great variety of form, size, lifestyle, and feeding habits.

The aim of this book is to reveal to the reader what sharks really are - fascinating and highly evolved creatures of great complexity and sophistication. Sharks have been called primitive creatures, and although this maybe accurate in some ways, it is misleading in others. Sharks first began to appear on the earth about 425 million years ago and, the earliest complete skeleton was that of *Cladoselache* dating from around 400 million years ago. Even at this primitive stage the resemblance to modern day sharks was striking. They roamed the seas 200 million years before the dinosaurs, and preceded humans by some 399 million years! The reason they have survived so long is, in the opinion of many authorities, a gradual evolution that has refined them to near perfection. Over the millennia, many species of shark have passed into extinction. The 375 or so species alive today represent the best evolutionary design; "sharks really are the worlds most perfect aquatic predator".

Shark Taxonomy

Sharks can be separated into the higher taxonomic level of order by observation of basic anatomical features. For example the order *Squatinformes,* (Angel sharks), *Pristiophoriformes,* (Saw sharks) and the *Squaliformes,* (Dogfish sharks), can be identified by their lack of anal fin. It can be relatively easy to differentiate between the three orders by the shape of the body and head. The number of gill slits is another important identifying factor and the presence or absence of dorsal fin spines, as well as the position of the mouth and the presence or absence of a nictitating membrane. For identification purposes, shark taxonomists have developed a list of external features and standard measurements. These include descriptive features such as the presence or absence of spiracles, dorsal fin spines, and anal fin, an interdorsal ridge, caudal keels, and nictitating membranes. Total body length interdorsal distance, head length and width, fin length and height, or size and the number of teeth, must also be measured and counted. Collectively these features provide enough information to make a positive identification.

The most primitive order is considered to be the *Hexanchiformes,* easily identified by their six or seven gill slits as compared to the normal compliment of five. These are primarily deep – water benthic sharks with a worldwide distribution. They bear live young and generally eat teleost fish. The *Squaliformes,* or dogfish sharks, number over eighty species in three families. These again are deep-water species distributed worldwide and are fished commercially. The five members of the *Pristiophoriformes* are unmistakable as they possess a saw like rostrum, and are collectively known as the saw sharks. These are generally easily recognisable and they inhabit warm temperate and tropical waters. The *Squatiniformes* or Angel sharks is a small order comprising a single genus in which all thirteen members are markedly flattened dorsoventrally and superficially resemble rays. They are normally found on the continental shelves and upper slopes of cold temperate and tropical seas. They have awl - like teeth that they use to impale bony fish, and crustaceans. The eight species that make up the *Heterodontiformes*, the bullhead, or hornsharks, are easily recognisable by their blunt heads and characteristic ridges over the eyes. These sharks generally live on rocky reefs, where there are plenty of cracks and crevices. To - date they have been found in the eastern and western Pacific Ocean and they generally feed on invertebrates such as urchins and molluscs.

The *Oretolobiformes*, comprises many sharks, mostly benthic species, and also the Whale shark (*Rhiniodon typus)*, which is more of a pelagic species. All species in this order possess a pair of barbels on the underside of the snout, and two dorsal fins. These sharks normally are flattened and feed most of the time on invertebrates and bony fish, except for the Whale shark, which feeds primarily on plankton or nekton. They are found in warm temperate and tropical seas. The *Lamniformes* are made up of seven families containing only sixteen species, including the basking shark *(Cetorhinus maximus),* the great white shark (*Carcharodon carcharias),* and the thresher shark (*Alopias vulpinus*). They are a small diverse order, the members of which are usually found in tropical and temperate seas, and even in Arctic waters. Some are pelagic while others are coastal. They feed mainly on bony fish and marine mammals and sometimes have been known to attack humans. The plankton feeders in this order are the megamouth, and Basking sharks. The last Order, *Carcharhiniformes,* is the largest containing one hundred and ninety three species in eight families. They are found around the world in

temperate and tropical seas. Most members of this order are fished for commercially and predate on other sharks, squid, and bony fish.

<u>Morphology & Anatomy.</u>

The body of the shark is usually strongly hydrodynamic, spindle shaped, having a rounded transversal section. In most sharks, the body is narrow at the level of the snout and, becomes progressively larger towards the first dorsal fin, and then resides to becoming gradually narrower again towards the caudal fin. There are some exceptions to this rule, the angle sharks *(Squaltinidae),* wobbegongs *(Orectolobidae),* both having flattened bodies (similar to rays), and are mainly adapted to benthic life on the seabed.

The snout is often dorso-ventrally depressed. The dorsal lobe of the caudal fin is much more developed then the lower lobe, so a pushing action from the sharks tail depress the head in a down wards motion, and this is counter balanced by large flat pectoral fins and moreover the shape of the head which is slightly flattened. In some species such as the mackerel sharks *(Lamnidae)* the upper and lower lodes of the caudal fins are similar in size and appearance, so the snout doesn't need to be flattened, and is in fact conical shaped with a pointed tip. This is best illustrated in the mako shark *(Isurus oxyrinchus).*

The head of some species can have a very peculiar shape, which is very evident in the hammerhead sharks *(Sphyrnidae)*. It has been suggested that is has any number of functions, ranging from hydrodynamics, to enlargement of special prey locating receptors located all across the sharks head, enabling it to locate prey especially buried on the seabed. Powerful swimming sharks possess strong caudal keels on their caudal preduncle, and its lateral expansions of the caudal preduncle which aid the hydrodynamics of the shark. This can be observed quite easily in the whale shark *(Rhincodon typus)* while in the porbegle shark *(Lamna nasus)* there are two pairs of caudal keels, the second is less pronounced and it is not on the caudal preducle but on the tail's side. Often, on the caudal preduncle there are precaudal pits, which are two notches located above and below the caudal preduncle.

All fish have well-developed fins as locomotory organs, but a sharks fins are different to that of normal bony fish such as cod, tuna, and mackerel to name a few. The shark possess inner rays that sustain the fins and are not externally visible, while in bony fish they are clearly visible, thus illustrating that shark skin is much thicker. Size, position, shape and the number of fins can vary from species to species. Its these varying characteristics that help scientists classify and recognise sharks for observatory and taxonomic reasons.Usually most sharks possess eight fins, a pair of pectoral, a pair of pelvic, two dorsal fins, and anal fin and a caudal fin. All the fins play a vital role in the shark propulsion and movement, and in particular the pectorals, the first dorsal and caudal fin. The pectoral fins aided by the pelvic fins sustain and stabilise the shark, as do the dorsal; and anal fins, while the caudal fin gives propulsion. Depending on the shark's way of life and the type of prey it feeds on the fins will vary from species to species, and can have varying shapes from apex rounded to possessing a short or long base to often being indented near the tips.

In benthic species pectoral fins are quite enlarged which is best demonstrated in the angel shark *(Squatinldae)* which has a flattened body and rests for long periods on the sea floor. When swimming they use their large pectorals like wings to glide like avians. The Oceanic white tip shark *(Carcharhinus longmanus)* possesses pectoral fins, which are well developed more noticeably in length rather then width. This distinguished variation is due to the type of prey they feed on, as the large white tipped fins having dark marks gives the impression of a school of small fish from a distance which in turn attracts prey on which the shark feeds.

In most cases the first dorsal fin is larger then the second, but there can be an exception to the rule! such as the pigmy shark *(Euprotomicrus bispinatus),* where the second dorsal fin is considerably larger then the first. In the sand tiger *(Carcharias tauras)* also known as "ragged tooth" and "grey nurse" depending where you are in the world, the first is larger, but only slightly. In the frilled and cow sharks *(Hexanchiformes)* there is only one dorsal fin and in relation to the caudal preduncle it is very backward on the body. In some species such as the port jackson shark *(Heterodontus portjacksoni)* there is a small dorsal spine, which can be long or short, straight or grooved. It is purely a defence mechanism and in some cases can be venomous. The anal fin is often small but in some sharks it has a long base as seen in many species of cat sharks *(Scyliorhinidae)* and is absent in dogfish sharks *(Squaliformes)* and sawsharks *(Pristiophoriformes).*

A shark's caudal fin is vertically orientated as in all fishes (except cetaceans in which their caudal fin is horizontal) which possess an upper and lower lobe. This is why a shark's caudal fin is heterocercal as the vertebral column extends up into the caudal lobe, as apposed to homeocercal of normal fish. The two lobes in most sharks are very different in length, the upper being longer then the lower. The Thresher shark *(Alopiidae)* has an extensive upper lobe, and can be as long as the rest of the sharks body in some cases! The reason for this morphological adaptation is that the shark uses its tail to predate on schools of small fish, using it to stun the fish before predating upon them. The mackerel sharks *(Lamnidae)* caudal fin lobes are nearly the same lengths as each other, the reason being as they are powerful fast swimming sharks they need this speed to chase fast moving prey items such as tuna and sailfish. Sharks are different to normal bony fish as they do not possess a swim bladder, instead they have a very large oily liver containing unsaturated oil with a low specific gravity, and this is paired with a light cartilaginous skeleton. The liver's weight can reach 25% of the shark's total weight, and the oil can constitute 90% of the total liver's mass. With oil having a lighter density then water this is one of the tools a shark uses to stay afloat and afford neutral buoyancy, aided by continued movement. Some other species have developed other mechanisms for in order to reduce their body's density, such as the blue shark *(Prionace glauca)* which has a long conical snout containing low-density gelatinous material. The Sand tiger *(Carcharias tauras)* literally gulps air at the surface intermittently and traps it in its body cavity, thus aiding its neutral buoyancy. The position of a shark's mouth is nearly always in a ventral position, as apposed to most bony fish where it is in a terminal position. The reason for the varying mouth positions is to do with the type prey they feed upon and the habitats they live in. Rarely as observed in the megamouth shark *(Megachasma pelagios)* is the position of the mouth frontal.

Located near the corner of the mouth are labial furrows, as they sometimes are an important feature in species identification as in the case of smooth-hounds *(Mustelus),* and are very pronounced in the Tiger shark *(Galeocerdo cuiver)*. The upper jaw of all sharks is not fixed to the brain case, ligaments suspend it, and this is quite spectacular in large sharks such as the great white shark *(Carcharodon carcharias).*
Shark teeth are present in there hundreds ranging from rows of 6 to 20 depending on the species. In most species it's the first and second rows are functional, but as they are loosely attached to the jaw and are easily lost, and are constantly being replaced by the developed tooth behind. The teeth in general consist of three parts internal pulp, dentine, and external vitrodentine, and vary from species to species depending on diet. The teeth principally have three designs, in the mako shark *(Isurus oxyrinchus)* they are narrow and elongated for to tear and grasp prey items, where as the tiger shark *(Galeocerdo cuvier)* has serrated margins for to specifically cut through prey items and finally as apposed to the grey smooth hound *(Mustelus californicus)* If we look closely at the teeth of a Tiger shark we can appreciate how highly developed they are, as they predate on hard literally unbreakable prey such as marine turtles. The teeth are similar to a tin opener on some respects, nearly to every little point of serration. The shape of the teeth change with growth from juvenile to adulthood, and sometimes this is quite evident in young tiger sharks. The wide variety of teeth shapes makes the teeth an important diagnostical character, which can aid in attack identification, while also helping us to age a shark. Usually examining dead specimens can only see the shape of teeth, but in a few species, such as in the sand

tiger sharks *(Odontaspididae)* and mackerel sharks *(Lamnidae)* the first row of teeth remain ever visible in the lower jaw, as they constantly swim with their mouth agape. Unfortunately, this natural appearance presents a vicious evil looking shark to the untrained eye when in reality they are not dangerous to humans, or don't deserve this stereotype.

Small teeth called dermal denticles (sometimes called placiod scales) cover sharkskin. They are smaller versions of their teeth, and consist of an internal pulp, dentine and external vitrodentine, while consisting of a basal plate, a pedicel and a crown. These differ from species to species and also on different parts of the body. In some case the denticles are very much enlarged, best illustrated in the bramble shark *(Echinorhinus brucus),* it has multiple denticles reaching 2.5cm each in diameter. Pelagic species, which swim faster, possess smaller denticles then benthic species, and are closer together. It is fascinating to the observer to see the arrangement of these denticles under a microscope, and literally you can be in awe to the minute perfection they illustrate. It is the scales of the shark which give it the rough feel when rubbed from tail to head, so now you know you should always rub a shark from head first!

Sharks in general swallow their prey whole, and require large stomachs to cope with this adaptation, not because they are always hungry. Many sharks do not feed all of the time and in some case can go without food for a number of weeks, such as the white shark *(Carcharadon carcharias).* So it is for this reason for when food is plentiful that shark will gorge itself, this being the main reason for the size to the stomach required, not because they "voracious and insatiable predators". Sharks in aquaria eat very little and are only fed once if not twice a week and it's not out of the ordinary for a shark not to eat for a couple of weeks.

A shark's intestine is very short, this is because it has a higher surface absorption and retains food for longer periods, and this is mainly due to an elichoidal structure called the spiral valve. Any hard parts of food that cannot pass through the spiral valve are regurgitated, while digestive systems then terminates at a small cavity called the cloaca. Sharks extract oxygen from the water by the use of their gills. The water enters the mouth and exists through the gills, (a process ram ventilation), and it's the gills where gaseous exchange takes place. Each gill has well-vascularized gill lamellae, and it's through these lamellae that oxygen enters the body. The gills are located on each side of a shark just before the pectoral fins, and behind the head. Sharks usually possess 5 pairs but in some species they have 6 pairs, such as the six-gill *(Hexanchus),* and even 7 pairs in the seven-gill shark *(Heptranchias).* Unlike bony fish sharks do not have a protective covering called the operculum. The gills vary from species to species depending on the environment and food types they predate upon.

The gills are usually vertical, and are parallel to one another; often the fifth gill is more oblique and slightly shorter. The gills play a fundamental role in feeding particular in the whale shark *(Rhincodon typus)* and the basking shark *(Cetorhinus maximus)* as they are filter feeders, and use their gills to sieve out plankton, while also regulating the amount of dissolved salts in the blood in association with the kidney, rectal gland, and liver. The gills are located below and behind the eye, and there is an opening called the spiracle, which is used mainly in benthic species, as it lets water enter and flow towards the gills, when the shark is resting on the sea bottom, such as the angel shark *(Squatinidae*). It is a rudimentary gill opening, and is not present in more pelagic species such as the blue shark *(Prionace gluaca),* but is found mostly in species that spend most of their time on the seabed.

A shark's heart is divided into two parts, the auricle and the ventricle. The blood goes from the ventricle to the ventral aorta, onto the aortic arches or branchial arteries, then to the capillaries located in the gills (where the blood becomes oxygenated). The sequence then continues onto the efferent arteries, to the dorsal aorta, and continues to the rest of the body through a network of capillaries and arteries. After the oxygen has been delivered to the different organs it is then collected by the venous system, and returned to the heart, passing through the sinous venosus to the auricle.

The majorities of sharks are cold-blooded, and don't have any mechanisms to maintain a constant body temperature; their body temperature is only slightly above the surrounding waters. There are a few species that are an exception to this rule, such as the mackerel sharks *(Lamnidae),* and thresher sharks *(Alopiidae).* These possess a body temperature that is 3-11 degrees Celsius higher then the surrounding waters. The reason for this is that they possess a conspicuous amount of red muscles located near the vertebral columns (and not externally near the skin like in other sharks), which is closely connected to the circulatory system by a well developed capillary network, constituting a heat exchanger that reduces heat loss, its really the red muscles that heat the blood. This heat conservation mechanism permits the shark to have more energy at its disposal, as this even aids digestion rates, and consequently increasing growth rates. It is not surprising that the fastest of all sharks the short fin mako *(Lamnidae)* can reach a speed of 35 to possibly 50 Km/hr!

Identification of a male and female sharks is usually quite easy, especially in mature specimens. Males possess two cylindrical copulatory organs called claspers, which are present in the pelvic region, at the base of the pelvic fins, from which they take origin. The claspers are very evident in adult males, in which they become long and highly calcified. In new born, or juvenile specimens there can be some difficulty in recognising the sex, as its possible that the claspers don't exceed the pelvic fin near the rear tip, being again short. During copulatory activities one clasper is inserted in the females cloaca and the male keeps the female still by biting and seizing her pectoral fins. It is for this reason that a females skin is up to 3 times thicker then the male's skin, which is best seen in the blue shark *(Prionace gluaca).* In some species once the clasper has been inserted, the extremity of the clasper spreads out, anchoring it and holding the oviduct open permitting passage of the sperm.

Sharks have three types of embryo development: oviparity, ovovivparity, and viviparity. In oviparity, eggs are laid in which the embryos develop and gain nourishment from a yolk. These eggs vary from species to species. The bullhead sharks *(Heterodontidae)* lay spiral – shaped eggs inserting them into crevices of rocky habitat, while the small spotted catshark *(Scyliorhinus canicula),* lays its eggs by fixing it to long algal substrates. In ovoviviparity (also called aplacentla viviparity), the eggs are retained in the oviducts until further development, and are usually nourished by a yolk sac. In some groups such as the mackerel, thresher, sand sandtiger sharks, the first fully developed young consume their underdeveloped siblings, a process called oophagy or uterine cannibalism, and it is mostly documented in these species. In viviparity (placental viviparity) also seen in mammals, the embryo's are retained in the oviducts until full development and are nourished by the mother through a placenta formed by attachment of a yolk sac to the oviduct wall. The gestation period for many sharks is very long, 24 months in some cases, such as the spiny dogfish *(Squalus acanthias).* The size of individual pups ranges from species to species, and can be related to the adult's size. Shark's growth in general is very slow. The best examples of this are seen in the sandbar shark *(Carcharhinus plumbeus)* as they require 12 to 14 years to attain a weight of 90-100 pounds, where in comparison to the short fin mako *(Isurus oxyrinchus)* it has a relatively high growth rate and only need 4 to 5 years to reach a sizeable weight of 300 pounds! In some species the age of reaching sexual maturity is even independent of the sex and the geographical location of the opoulation considered. In the male white shark *(Carcharadon carcharias)* maturity is suggested top be about 8 to 10 years where as in the female white shark it is 12 to 13 years. In the same context it is unknown to science as to how much time is required for a whale shark *(Rhincodon typus)* to attain 14 metres in length! Most sharks will have a life span of 20 to 30 years, and there is even a wide variety in that, as the Atlantic sharpnose shark *(Rhizoprion odonterranovae)* life span is I the region of 10 years where as the school shark *(Galeorhinus galeus)* approaches 100 years!

If sharks were uniform in their coloration, in many cases it is possible to observe a wide variety of colour patterns from species to species. Sharks are usually darker, often grey, and sometimes brown or blue, and the dorsal surfaces are lighter or whiter then the ventral surfaces. This type of coloration permits the shark to be invisible from above and below. The boundary between the dorsal and ventral surfaces is usually evident on the sides of the body, and can be soft or abrupt. Usually this limit is part of the tip of the snout which passes immediately under the eyes, where it reaches the lower limit of the first gill slit, and goes on to reach the anterior insertion of the pectoral fin. It then descends to the anterior insertion of the pelvic fin, and cross in the middle of the caudal preduncle. There is often another limit in the dark coloration of the dorsal surface, more indistinct, separating the sides from the upper part, passing above the eyes and gill slits.

Some species possess spots on their dorsal surface, which are evident in the sand tiger *(Carcharias tauras),* and in some cases elegant or complex coloration's can be observed such as spots, patches or stripes as seen in the swell shark *(Cephaloscyllium ventriosum).* The whale shark illustrates spectacular array of colorations and in some cases it can be described as a living painting. Its enormous surface varies from brownish, greyish, to bluish with a pattern of creamy white yellowish spots between pale and vertical strips becoming horizontal on the head. Often young whale sharks have varying coloration's compared to the adults. One of these differences is often constituted by the colour of the fin posterior margins and tips that can be lighter and darker in the adult then in the young.
As the reader hopefully understood reading this chapter, there are no single rules in the world of sharks: the "shark" is a well-defined animal in the minds of many people, but in reality these majestic creatures include a surprising amount of variations for almost all their characters.

Super Senses.

It was February the 16th 1998 and I found myself on an isolated beach on the coast of Northern Mexico, in a small fishing village, waiting for local fisherman to come in with the previous night's catch. It was when the catch had arrived on the beach it was one of the first times that I was able to observe in detail large pelagic sharks sensory biology. I examined the ampullae, the lateral line, and nictitating membranes to name a few and appreciated how spectacular these super senses really are.

Research as early as 1961 proved that sharks are in fact the most perceptive of all aquatic creatures. Sharks have always been renowned for their keen sense of smell and in some cases has been aptly named "nose of the sea", having a detection range of about 500 metres. The sense of smell, is its principal source of chemical sensitivity.

This sense is seated in the olfactory sacs located just in front of the eyes, near the tip of the snout, while the nostrils are located on the underside of the snout. These specially shaped membranes are located in the interior of the shark's snares and aid to make the sense of smell extremely acute. When an odour is located the head moves in the direction of the side that receives the strongest sensory impulse. This directionality is augmented in the course of swimming by the horizontal balancing movement of the head, which allows the nostrils to test a wider sense of smell. This is especially illustrated in the hammerhead sharks *(Sphrynaidae),* where the head is much wider then in other sharks. It is the forward motion of this type of swimming that brings water through the funnel - shaped nostrils into sacs where it passes over a series of sensory lamellae before leaving via a second aperature. "flaps of schneider" extend across the opening of each sac, which separate water flowing in from water flowing out. These olfactory lamellae are situated very close to the large and highly developed olfactory lobe of the forebrain, thus minimising the time interval between the stimulus and its detection by the shark giving it rapid response behaviour.

This is proven as a shark can detect 1 part of blood in 100 million parts of water, and under conditions of progressive starvation the sense of smell can be increased to a magnitude of 1 part in 10 billion.
The acute sense of smell also aids in sexual segregation, as it has been suggested that female sharks release pheromones, which in ordinary language lets the male shark know that she is interested in copulatory activities. This explains as to why male sharks follow female sharks sometimes as close as 30cm from the lead sharks tail! The male sharks olfactory senses would have to be extremely acute once again to interpret these signals, another example of how spectacular their sense of smell really is. In conclusion, a shark can be attracted by a multitude of odours literally from any source and this will in turn incite the shark's curiosity leading it to inspect the odour at closer quarters, so now you know!

The hearing spectrum of sharks extends from 10 Hertz in the low frequencies to approximately 1000 Hertz in the high frequencies. In comparison man's range is from 25 to 16000 Hertz, and it is obvious that man that are not heard by sharks can hear a lot of high-pitched sounds. Its this small difference between 25 and 10 in the low frequency register that indicates a shark can discern more bass tones then can man, and it is believed that this small difference compensates for the difference in high pitched frequencies.

The “ears” of a shark - one per side – are enclosed in its cartilaginous brain case and are composed of the same basic components found in the vertebrate ear, these being the three semicircular canals, the utriculus, the sacculus, and related structures. Recent research suggests that sharks pick up low frequency sounds by detecting the movement of water particles, which carry vibration, rather than by detecting changes in sound pressure. Organs in the saculus and macula neglecta contain otoliths, which are tiny granules of calcium carbonate which move with the shark and send signals to the brain which provides among others information on the shark’s attitude in the water. The macula neglecta is especially sensitive to vertical movements and can pick up vibrations from the roof of the shark’s skull. The endolympahtic duct which is unique to sharks extends from the saculus of both ears to small pores on the shark’s head. The precise function of the duct is as yet unknown, it maybe associated with acute definition of sound as well as the pinpointing the location of the sound.

Modern research has shown that low frequency sounds attract sharks. When the shark is in the vicinity of a low frequency sound source, and this sound is suddenly unexpectedly increased (by 20 decibels or so) the shark displays a reaction called a “retreat or startle response”. This is a rapid flight behaviour which has shown to repel juvenile lemon sharks *(Negaprion brevirostis)* and adult silky sharks *(Carcharhinus falciformis).* The same stimuli produced mixed results in oceanic white tip sharks *(Carcharhinus longimanus),* suggesting species variability in this regard, but it still remains to be investigated as a possibly means of repelling sharks. Acoustic senses, as acute as they are demonstrate that it is on of the first sensory adaptations a shark uses in locating its prey even if the distance is of the order of several thousand yards!

The lateral line is involved in mechanoreception being sensitive to vibration and pressure changes. The lateralis system is found on the shark’s head and body, and acts in the manner of a movement detector by picking up the smallest movement in the water and the vibrations resulting from it. This system seems to take the place of the ear for perception of low frequencies and in addition plays a determinant role in the fish’s balance.
The system consists of several small canals, which open at intervals to the surface, through tubes to pores in the skin. Each canal is filled with seawater, and contains clusters of sensory cells called neuromasts*,* whose vibratile cilia record pressures from the ambient fluid. From each neuromast several hair like projections, enclosed in a gelatinous dome, stick out into the interior of the fluid – filled canal. Vibrations that reach the shark are transmitted to the neuromasts and this causes the hair like projections to move very slightly, thereby triggering a nerve impulse to the brain initiating a behavioural response.

The lateralis also plays a role of stabiliser by recording differential pressures. If the shark is in an oblique position, one of the two lateral lines will record a higher (or lower) pressure on one side than the other. Reflex circuit action, in co-ordination with the cerebral structures, will order the actions necessary to the fins to re-establish identical pressures on each side, thus re-establishing the fish's balance.

In conclusion, the lateral line system should play a major role in locating prey, predator avoidance and social encounters, but the complete role of this system in determining behavioural responses is, as yet, unclear.

Sharks possess one other sensory organ, which is still little understood. This consists of a large number of "pit organs" (or free neuromasts) which are scattered along the shark's body and the lower jaw. Each pit is protected by modified denticles, which are different from the normal denticles. These denticles overlap in such a fashion that they create a small pit or cavity. These cavities form a clear visible ridge, which is best observed in young sharks, and tends to be more concealed in adult sharks. These pits are more numerous in pelagic species.

Inside each pit are papillae and a large sensitive cell. What is found to be remarkable about these pit organs is that they are totally analogous with papillae and cells which make up the taste organs on the tongue of man and other vertebrates. Even if analogy of function does not necessarily follow analogy of structure, the similarity in the present case is so absolute that we may with some justification make presumptions on a very probably role of these organs. It maybe argued that to have taste organs on the flanks is very odd, but experiments have shown that these structures are sensitive to chemical stimuli. This also distinguishes the pits from other mechanoreceptors, such as the lateralis system (previous mentioned) and the electroreception of the ampullae of lorenzini. The pits situated on the shark's back have a deciding importance in relation to shark attacks. As sharks have been known to brush off bathers with their bodies as an initial step in attack behaviour. The skin of the shark is so abrasive that it causes blood to be drawn from the bather, and thus it could be said that the shark physically tastes its intended prey to satisfy its curiosity. This type of behaviour also gives credence to sharks bumping or rubbing off boats, again trying to satisfy is curiosity.

Opinions on the function of these pits remain divided but from the evidence provided the taste function is the more plausible. Other functions such as the pits being used for to pick up vibrations in the surrounding waters, or even sensing movements in the sharks body, which would be useful at the termination of gestation for example, are also credible. It could even be that this one sensory organ carries out all these functions but a full understanding of the role of these fascinating structures awaits further research.

It has been considered that sharks have poor vision, but research carried out in 1961 has now dispelled this widely held notion. In 1960 research conducted at Bimini in the Bahamas on the Lemon shark *(Negaprion brevirostris)* showed that sharks with discs placed over their eyes were temporarily incapable of locating food when placed back into a tank with other sharks. The sharks which didn't have discs placed over their eyes were easily able to locate the food quickly; suggesting that sharks with impaired vision had difficulty in locating the food and depended very much on their vision to locate food at close quarters. Other experiments conducted by at Bimini illustrated that sharks were attracted to bright objects, while non-reflective dull colours were generally avoided.

In 1972 research confirmed that bull sharks *(Carcharhinus leucas)* and the sand tiger *(Carhcarias taurus)* could discriminate between different colours of underwater mesh netting. Bull sharks tended to avoid the brighter yellow nets. Further research in 1962 reported the attraction of oceanic sharks to fluorescent orange objects, and noted that sharks were attracted to bright yellow survival gear (sometimes loosely called "yum, yum yellow"), but ignored the same gear when it was painted black. This suggests that further research should be conducted into the "best" colour for mariners survival suits and whether a coloration which is noticeable to would be rescuers and inconspicuous to sharks as a would be deterrent. So with bright colours conclusively attracting shark's attention, why are life jackets and buoyancy aids still brightly coloured, and not a dull non-reflective coloration? Understandably these aids are brightly coloured so as to enable them to be detected by man enabling survivors to be spotted from a plane etc but, surely some colour scheme could be devised as to lower the possibility of shark attack, while still being visually prominent to a would be rescuer.

A shark's eye is a flattened version of the vertebrate eye, with an iris, lens and retina, and three fluid - filled chambers contained within a tough envelope of cartilage, the sclera. The sclera determines the external shape of the eye and this is due mainly to its tough outer layer. In sharks the aperture of the iris (pupil) varies in shape, and can open and close quite rapidly. There are two groups of contractile fibers, one radially and the other circularly arranged, and these regulate the size of the pupil, and thus regulate the amount of light which reaches the retina. The nurse shark *(Ginglymostoma cirratum)* can dilate its pupil to its maximum size 24 to 30 seconds after entering the dark and can constrict to its minimum size 5 to 13 seconds after emerging into the light again. This means that a shark charging at a fish which it catches sight of 15 metres away at the surface will, even though emerging from the depths, have time to adjust to the varying degrees of light.

The shark's retina contains many light sensitive photoreceptor cells, called rods and cones, with many more rods than cones present. The cones serve for visual acuity and colour perception, in photopic conditions, while the rods are more for vision in the dark, as in scotopic conditions, also seen in humans. The rods enhance the shark's ability to distinguish between objects, especially if moving and in very dim light.
The sensitivity of the sharks eye in dim light is greatly enhanced by a structure called the tapetum lucidum which is a kind of mirror located behind the retina and composed of silvery platelets containing a pigment called guanine, a crystal based substance. Cells found at the base of these platelets are called melanoblasts, which contain black pigments. The tapetum reflects incoming light back through the retina to re-stimulate the light sensitive rods and cones. This enhances a shark's nocturnal ability for feeding, while making the best use of what little light may be available.
The tapetum has an even more remarkable function in that it prevents bright light from reaching and damaging the retina in sharks that feed during the daylight or

crepuscular hours. This is not only achieved by reducing the size of the opening in the pupil, but also by a curtain of pigment that temporarily screens each of the tiny platelets of the tapetum. Each platelet is covered by cells that contain black granules (melanoblasts) which temporarily fill the cells in bright light, thus preventing light from being reflected back into the retina. As the shark's eye becomes conversely accustomed to the dark, these black granules withdraw to the base of the cells to expose the reflective surface of the platelets again. A shark's lens is almost spherical and rigid, unlike the ellipse- shaped elastic lens of mammals. A muscle, the protractor lentis, which helps sharks to focus on moving objects, controls the movement of the lens. Sharks have the visual capabilities to see above the surface water of the extent of 2.5 to 3 metres. This is best seen in the white shark *(Carcharodon carcharias)*. As for close range vision, shark's sight is highly impressive. At close range, the lens system moves backwards and forwards like a magnifying – glass, and it is not just the crystalline lens that alters it curvature, as seen in mammals.
Certain shark's posses a third eyelid called the nictitating membrane. When a shark is approaching its prey item, the membrane slips over the eye to protect it from damage. Not all species possess this third eyelid, for example the short fin mako *(Isurus oxyrinchus*) and the white shark *(Carcharodon carcharias)*, roll their eyes backwards before attacking so that the whites of their eyeball replaces the black pupil. So in conclusion, it can be said that shark's ability is outstanding in the sphere of vision, no matter what the environmental conditions maybe.

Sharks have a unique and highly specialised bioelectrical sensory system called the ampullae of lorenzini. These ampullae are called after the Italian anatomist Stefano Lorenzini who first described these organs in 1678. The ampullae are small, elaborate gelatinous organs that are linked to pores in the shark's skin through long canals, and are situated underneath the snout. The properties, which the shark is endowed with, are found to be unique in the animal kingdom. They have several unique roles: detection of variations in temperature and vibrations, as well as variations in salinity and in contact pressures and infinitesimal variations in electric fields.

Sharks have been able to locate prey in the open sea by detection of minute electrical fields generated by a struggling fish for example. At close quarters the movement of muscles and gill arches of aquatic animals have been shown to produce a direct current (D.C.) and low frequency voltage gradients in water. Sharks are highly responsive to D.C. frequencies below 8 Hz, (cycles per second), and can detect frequencies as low as 0.1Hz and of only a few microvolts in amplitude. Blue and dogfish sharks can detect fields as weak as 0.005u Vcm –1, twice the sensitivity required to locate prey fishes as Kalmijn documented in 1982.

Sven Dijgraaf, working at the University of Utrecht, more then 45 years ago was one of the first people to suspect that sharks may be sensitive to tiny electrical currents. He blindfolded small spotted catsharks (*Scyliorhinus canicula)* and found that they would rapidly turn away from a rusty steel wire located a few centimetres from their snouts. But when a glass rod was held at the same distance it did not produce the same effect. It was Dijgraaf's graduate students who found out the function of the ampullae. They severed the nerves to the ampullae and found that the sharks were able no longer to detect the electrical currents.

Kalmijn (1971) demonstrated the ability of the lesser spotted dogfish (Squalis acanthias*);* leopard shark *(Triakis semifasciata*) lemon shark *(Negaprion brevirostris*) and catsharks to locate buried fish in the absence of visual, mechanical, and chemical cues. Buried flounder and plaice were confined in an agar chamber which concealed them but which allowed an electrical current to flow through. On all occasions, the sharks were able to home directly in on these concealed prey items. When the prey was enclosed in an electrically insulated polyethylene film, the sharks were able to detect them. When the experiments were repeated using electrodes to stimulate the flounder's bioelectrical field, the sharks repeatedly attacked the buried electrodes. The shark's displayed the same feeding behaviour in response to the electrodes as they did to the actual prey. In fact, the sharks often ignored a piece of baitfish on the substrate to dig at buried electrodes. Kalmijn research concluded from these observations that the electrical fields provided a much stronger feeding stimulus, than the sight or odour of the bait.

Again Kalmijn in 1977 found that during experiments within the frequency range of direct current up to 8 Hz sharks responded to fields of voltage gradients as low as a hundred – millionth of a volt per centimetre. This is the equivalent to the field of a flashlight battery connected to electrodes spaced 100 miles (1600 km) apart in the ocean. This phenomenal electrical sensitivity is greater than that possessed by any other animal known to date!

It is this remarkable electrical sensitivity that has led to suggestions that sharks attack boats and humans, as well as divers in steel cages because of the electrical currents they produce. Divers in shark cages have noted that a shark initially attracted to fish bait will often mistakenly bite the cage rather then the bait at the last minute. This is due to the strong galvanic current or corrosion current produced by the metal in seawater. This is seen in documentaries the world over, and is not the case that the shark is trying to at the divers inside, it is merely confused by all the corrosion currents in the water around the cage. Sharks have also been known to attack the metal hulls of boats as well as "mouthing" propellers and outboard motors, giving more credence to the electrical sensitivity theory. Current research has suggested that the electrical fields that resemble those of a shark's regular prey may elicit attacks on underwater equipment. This fact perhaps can explain damage to sonar arrays by the cookie cutter shark (*Isistius brasiliensis).* Attacks were also observed on submerged fibre – optic telecommunication cables in the Canary Islands in 1985, which were attributed to deep sea species such as the goblin shark (*Mitsukurina owstoni)* and shallow water carcharinids. Designing a "bite proof" cable, consisting of a double layer of helical steel tape coated with a polyethylene shell has alleviated these problems.

Seasonal migrations play an important role in the life histories of many shark species. It has been suggested that some species use the earth's magnetic fields, along with the ocean currents to navigate the world's oceans. The shark creates such fields when it swims at speeds of 2 centimetres per second. When we realise that such currents have gradients of 0.05 to 0.5 volts\ cm, which are dependant of the direction of movement, it can be said that sharks posses the necessary sensory capabilities to receive their “bearings” in relation to these currents, in the manner of a standard electric compass. It has been suggested that some animals might sense changes in magnetic fields through minute movements of particles of “magnetite” embedded within their tissues. Although no one has yet looked for magnetite in sharks, chains of these particles have been found in the tissues of salmonids, another ocean migrator. The port jackson shark *(Heterodontus portusjacksoni)* has been observed returning with pinpoint accuracy to specific reef locations after several years absence and after travelling hundreds of kilometres.

Clearly there is scope for more research on the ampullae as it is an area of great interest and potential. Resent research conducted at the University Of Queensland by Darryl Whitehead has documented that there are in fact three different types of ampullae organs, where previously for a number of years their was thought only to be one type. Electrical senses are so well developed in sharks, that a better understanding of these extensive organs would clearly define and extenuate how remarkable these fish really are.
Sharks have an extremely acute sense of taste, and can be very selective. There are taste receptor cells located inside of the mouth cavity. These are best stimulated by direct contact with a food source. Sharks normally use taste to decide if an item is palatable or not, by mouthing the object or just simply having an investigative bite.

The “Moses Sole” *(Paradachirus marmoratus)* fish relies on the shark’s remarkable sense of taste for its survival. When the fish is snared in the shark’s jaws it secretes a chemical toxin which makes the shark “spit or cough” the fish out, as the shark finds the toxin unpleasant. This is possibly the only fish that living sharks cannot eat. So in conclusion shark’s sensory biology really is directly related to their behaviour, and how they behave is of interest of scientists and humans alike. If we had a better understanding of their sensory biology, it would reveal a valuable insight into their behavioural repertoire, as for most species this is alarmingly incomplete.

Research.

The Animal Kingdom possess a great many secrets that humans are constantly trying to divulge, particularly the underwater kingdom, which has its own inherit difficulties to study. There are many details about sharks that are as yet still undiscovered, and even in today’s world we still are finding more information about their secret life. Scientific researchers are based in many countries around the world, and its through collation of information from these parties that the “shark picture” is slowly coming together.

But how is it possible to study sharks? and what kinds of studies are being conducted by researchers? In the past the only method researchers had available of studying sharks was examining dead specimens. In most cases a naturalist had to examine specimens that were held in natural history museums, that had been dead for an extended period, and this could cause problems if the taxidermist didn’t preserve the shark in its original state. So it’s not strange to see many illustrations in books of bygone years to show sharks with “strange appendages” or modified limbs. The best way to preserve shark specimens is in liquid, such as alcohol (concentrated), or formalin, this way the appearance of the shark stays as it was when first caught.

Over the years, scientists have learned more about sharks through the development of photography, and being able to freeze specimens. Observing specific characters now became much easier, and researchers were now able to select characters that differentiated orders, families and species, hence the basis for classifying sharks, taxonomically. It is through this work that over the last number of decades we have begun to present a more accurate picture of each individual species. To date there is still links in the chain missing, as there are still species that remain “undiscovered” and poorly understood.
Captured specimens present the opportunity to collect data mostly about morphology, anatomy, size, diet, abundance, not to mention geographical distribution, and habitat. Some research is conducted on specimens caught in active fisheries, while others are caught on specific research exhibitions, but the main problem of studying sharks from active fisheries is that you cannot locate the exact position where the shark was caught, and often specimens arrive at fish markets already eviscerated. This way you cannot study internal anatomy, such as stomach contents, and reproductive organs, and in most cases the sharks are devoid of fins, skin, and heads.

The development of Aquaria has aided the study of live specimens, but this has inherent problems of its own. The shark’s behaviour is often dramatically altered, when kept in captivity, and research has shown that not all species can be kept in aquaria. The natural movement of sharks has been greatly aided by the development of tagging specimens. When the shark is tagged, raw and environmental data is recorded, and a tag with a specific number relating to the data is inserted through the skin near the base of the first dorsal fin, and then shark is released. When the shark is captured again the tag will be returned to the institute who first initially tagged the shark, and hopefully some raw data as well. This information then can present a picture of how long the shark has travelled, migration pattern, growth rate etc, and give a better understanding of that particular species biology. Another type of tag is sonic tag and this is used to track sharks on diurnal and nocturnal activities. The tag emits a sonic pulse in different patterns for different sharks tracked, and the tracking vessel receives this by use of an underwater microphone, called a “hydorphone”. This way you can tell when a shark will be more active, its swimming speed, and the depth it swims at certain times of the day. Another important method of relaying information about predatory and attacks is observations from fishing and research vessels. This is feasible with populations of some species that are restricted to certain areas, such as nursery grounds of juvenile lemon sharks, as seen in the Bimini lagoons of the Bahamas. This way you can recognise different specimens, by distinguishing characteristics, such as scars and bites, this being aided by photo identification. It is studies like this that teach us more about population dynamics and social behaviour of sharks. Today most researchers conduct underwater studies, where they can directly encounter sharks. It is through this type of study that we can distinguish between dangerous and non-dangerous species, and take appropriate action to reduce any dangers when studying them. This has lead to such innovations such as the anti shark cage, and the neptunic dive chain mail suit. When studying shark behaviour, divers presence can alter their behaviour patterns, as in some cases the shark can see the diver as another predator, and will be on its guard, thus altering its natural behaviour patterns. Shark attacks are a particular area of interest for researchers and the circumstances that surround them, for example the particular species that can and do attack humans, and how to reduce the possibility of shark attacks in general. The mechanisms that are in use today to reduce attacks are chemical repellents, netting, screens, and electrical barriers; thus all designed with protection of beaches and divers in mind.

The remains of extinct sharks, and in particular their teeth, (the part of the body that fossilises the best) are extremely abundant, and give palaeontologists the detail they require to place together their evolutionary history. In some circumstances the dental morphology of some genera has been accurately reconstructed to reflect the ancient history of these animals. Genetical studies have recently shed light on the mitrochondrial DNA sequences related to sharks phylogenetic tree's and they also give the opportunity to study the evidence that separates the different groups.

It is beyond the scope of this book to illustrate a complete list of all shark researchers working around the world at present (as their numbers go into hundreds). Below you will find a completed and up to date list of all scientific institutes and associations that are conducting research on sharks and other elasmobranchs at present.

Sharks for millions of years have played a pivotal role in maintaining the oceans gene pool and balance, and with certain species their biology is still little understood. What is definite is that sharks are under a constant threat from overfishing, and especially some of the more pelagic species, which migrate over foreign fishery boundaries. One of the best known sharks who's story started with the film jaws is of course the white shark *(Carcharadon carcharias).* The white shark is now a very rare fish indeed, so rare that it has been proposed for inclusion on CITES Appendix 1, and international convention which prohibits its capture world-wide. This species has never been plentiful by nature, being the ultimate predator, and by definition it is less abundant then its prey. In a recent statistic generally only 27 white sharks are caught for every 100,000 sharks, and any unnecessary pressure on this 0.027% could lead to extinction of this majestic predator.

In the north Atlantic the Basking shark *(Cetorhinus maximus)* has been hunted for centuries to obtain the vast quantities of unsaturated oil it possess. An average sized shark can provide up to 200 gallons of oil, just from its liver alone! Probably the best known example of overfishing of sharks was in Achill Island (see figure 1), off the west coast of Ireland, where basking sharks were caught in extremely strong sisal nets, or directly harpooned from fishermen's boats. When the shark was dead, this leviathan of the deep was towed or dragged to the shore, for processing. The first detail was to heat the massive liver, which in some circumstances can be a third of the shark's length. After World War Two the demand for vitamin D (which is found in sharks liver soured), and with the basking shark being easy prey due to its surface feeding technique, their overall numbers plummeted, (again see figure 1). They were being killed faster then they could reproduce, and man's ignorance once again was overshadowed by greed.

***Figure 1.* Achill Island Fishery Statistics 1950 – 1975**

Year	Number of sharks taken.
1950	905
1951	1630
1952	1808
1953	1068
1954	1162
1955	1708
1956	977
1957	468
1958	500
1959	280
1960	219
1961	258
1962	116
1963	75
1964	39
1965	47
1966	46
1967	41
1968	75
1969	113
1970	42
1971	29
1972	62
1973	85
1974	33
1975	38

As can be seen from the statistics, it was not long before the fishery collapsed. What the author found was that even today, the Irish government has sold its Basking shark fishery off to the Norwegians in return for a share in the whitefish market. So they overexploited the shark fishery to the point of collapse, and have done nothing to try to save the population, if there is one left at all. This is why the general population should support the proposed UK listing of the Basking shark on the endangered species list on CITES Appendix 1.

In the last 20 years with the explosion of the Chinese \ Asian economy's there is a new threat to sharks that being the unprecedented demand for shark fins, in preparation for shark fin soup. The fins have such a high value that in many cases if not all the rest of the shark is often discarded at sea. The most appalling thing is that the shark, still alive is pulled in, and the fins are cut off and then the shark dumped back still alive, where it dies a slow and merciless death, while sinking to the ocean floor, if not eaten by other sharks.

It is without doubt the most senseless and wasteful act in fisheries. 90% of the shark is totally wasted, when the rest of the body could be used for human consumption in many countries the world over, not to mention the production of other products such as skin “shagreen” (sharkskin with denticles removed). So why does this fishery continue to practice such a wasteful technique when many third world countries are wanting for food? What kind of world do we really live in? that we can waste such a valuable resource.

Not many consumers are aware that when they visit the fish’n’chip shop and order the “fish” in most cases they are actually eating shark. Shark, it could be said is not a user friendly name especially when it comes to human foods, so in many cases they are given more attractive names, such as “rock salmon” or “hake” (depending on where you are in the world). Another good example is the short fin mako and porbeagle sharks when caught in the north – east Atlantic, and shipped to the Italian fish markets are sometimes sold as smooth hound *(Mustelus asterias)*. The spiny dogfish *(Squalus acanthias*), is caught by anglers from the shore, to large fishing vessels at sea and is without doubt either knowingly or not the most consumed shark in developed countries fish’n’chip shops. So believe it or not people eat more sharks then they think, so next time you go into a chip shop check and see what you’re eating is really what you think it is! This way its you the consumers who can help scientists save sharks and make a real difference, maintaining the ocean balance for future generations.

So wouldn’t the ocean be a better place without sharks, seen as how they attack people, and eat commercial stocks we eat? the answer is no. If sharks didn’t exist the whole ecology of the global oceans would be devastated. As mentioned previously sharks regulate and maintain natural populations in a beneficial way. They are the top of the food chain, and stabilise other populations that for example prey on our own commercial species, such as seals, dolphins, and walrus’s etc, and without the regulation natural populations of these predators would grow out of all proportion. A shark fishery in Tasmania collapsed after two years of over fishing, which in turn caused the collapsed of spiny lobsters, and local fishermen began to observe large numbers of octopus in their nets. Octopus prey on spiny lobsters, and are predated upon by sharks, thus controlling the octopus populations, but when the sharks were removed there was a population explosion, causing adverse effects. It makes no sense economically to fish out shark populations, not only from a fisherman’s point of view, but also from an ecotourism perspective. Divers pay thousands of dollars the world over to dive and see sharks and to interact in their natural environment. No longer is the shark a feared and deadly adversary, but a creature to be respected and treated with awe, for its natural beauty.

So why is it that sharks fishery’s collapse so quickly if not managed properly? the main reasons are that sharks reproduce few young, and take up to 12 to 15 years to mature. Some species produce as little as two pups biannually, so if a population is over fished or nursery areas destroyed, it will take years for the population to recover. Finally from public perspective sharks often get bad press, and are not seen as cuddly or attractive like their mammal counterparts such as dolphins, whales, and seals. Since most of these species possess blowholes, they don’t have to expose their formidable array of teeth, unlike sharks, and are not seen as dangerous, or more to the point ravenous. With the insatiable demand for shark fins increasing some countries are resorting to capturing dolphins, and slaughtering them for to use as shark bait, who is to know where will all of this end? It just goes to show what a pivotal part sharks play in the oceans balance.

THE TIGER SHARK.

The Tiger shark, *Galeocerado cuvier* belongs to the Order Carcharhiniformes and to the wide family Carcharhinidae, the requiem sharks. The tiger shark is actually the only living species of the genus *Galeocerdo.* The latin name comes from the Greek "gale" or weasel, and "kerdo" which is weasel of fox, and the rest comes from the French naturalist George Cuvier. The origin of the English name is quite evident if you have ever seen a picture of a tiger shark, as they possess black strips along both flanks which is similar to tigers found in the forests of India. The strips fade with age, but are particularly evident on juvenile sharks, these sometimes being the most curious and aggressive.

The tiger possess a large, broad flattened head, with a short snout nearly truncate in a dorsoventral view, while possessing a large mouth, and low caudal keels on a slender body. The eyes are rounded and large, possessing a third eyelid or nictitating membrane. The teeth are the same in the upper and lower jaws, and are large, broad flattened and oblique. They have strong serrated margins, while also having serrations on the serrated margins. The tiger possess five medium sized gill slits, three located in front of the pectoral fins and two behind, and small spiracles. The upper lobe of the caudal fin is long and slender, and the lower lobe being much smaller. The pectoral fins are not particular large, while between the dorsal fins there is an interdorsal ridge. The tiger is dark grey on its back, and has large dark bands having a vertical disposition, while the ventral surface is white, and the boundary between the two layers is quite evident, and rather distinct.

The tiger can reach what is thought to be a maximum length of 6 metres, but scientists are still not sure that this is their maximum length. Some cases have reported 7 to 9 metres in length, some 30 feet!, now that would be a sight. Males mature at 3.1 metres, while females mature at 3.2 metres, possessing aplacental viviparity reproduction. After a gestation period of more then a year, in early spring - summer the female gives birth to varying numbers of shark pups from 10 to 82 depending on the females size. The pups vary in size from 51 to 86 cm.

The tiger is more of a coastal species in distribution as opposed to other pelagic species, and is generally found in all areas such as coral reefs, estuarine, and continental shelves to name s a few. The tiger can be usually found in tropical, sub tropical, and warm temperate sea's and has a wide geographical distribution, but is largely present in the Pacific, Atlantic, and Indian Oceans. The tiger is a nocturnal species, and come particularly close to the shore and shallow water at night, these being mostly adults, and diurnally retreat to deeper water offshore of varying depths. Like the white shark the tiger feeds upon varying prey, such as sea turtles, abatros seabirds, seals, other sharks and rays, and finally whales and jellyfish. More over the Tiger is known to eat more unpalatable items produced by man, and attribute stereotyped to all sharks, as this most certainly is not the case.

The tiger does have a deserved reputation of being a dangerous adversary, only second to the white shark, and has been know to attack small boat. It literally has no fear, and with a large well equipped mouth full of serrated teeth, who can blame it. It is usually unselective in attacks and its ability to swim in shallow waters makes this one shark to be taken serious note of. With its resemblance to other sharks within the Carcharhinidae family it is sure that many attacks are attributed to the tiger when in actual fact other sharks would be responsible such as the bull, blacktip, and bronze whalers to name a few.

It is fair to say that not all encounters result in attacks, as many divers have swam along with a tiger and no aggressive behaviour has been initiated. But this is an activity that should not be exercised, when a tiger is spotted by a diver, in all circumstances, divers should leave or retreat slowly from the water, or move away from the shark in a slow relaxed manner, not bringing attention to oneself. Sharks are complex animals, and there are no hard and fast rules to document their behaviour, so caution should always be exercised. In shark fisheries the tiger is never really targeted as such but is often a major by-catch of smaller fisheries, due to its investigative behaviour. In Tropical fisheries the tiger is usually consumed for its meat, and fins processed for soup, while the liver is abundant in vitamins and unsaturated oils, thus the whole shark is used and little wasted. What is detrimental to the tigers existence and its counterpart the white shark is sport fishing. What is the real purpose of this activity humans are the only creatures that hunt for sport, a shark doesn't, not to mention the wastage if the shark is handled improperly as part of a tag or release project, thus damaging the shark. Why is it that humans are seen to be "macho" if they catch an animal that is bigger stronger, and more fearsome then them. Sharks are only trying to survive, and in most cases would avoid humans given half the chance, so is sport fishing really a sport, as a sport is a game of two equals, and is this really the case in this circumstance? I think not.

The Mako Shark

The two well known mako sharks are the shortfin mako *(Isurus oxyrinchus)* and the lesser known long fin mako *(Isurus paucus)* both belonging to the family Lamnidae, the same family as its cousin the white shark *(Carcharodon carcharias)* and the porbegle *(Lamna nasus)* and finally the salmon shark *(Lamna ditropis)*.The name mako has a unknown origin and is thought to have come from the Moari in New Zealand.

The mako one of the most beautiful of all sharks, is easily recognisable. They are extremely spindle – shaped with a narrow snout, this being conical and pointed, aiding their hydrodynamics. They also have a strong caudal keel and the caudal fin is lunate in shape. Their mouth has a fearsome appearance, possessing several long narrow curved teeth that protrude from the lower jaw to the exterior, with points curved inwards towards the inside of the mouth. The eyes are large, dark and rounded, and are similar to that of the white shark, while spiracles are very small. The five slits gills are located in front of the pectoral fins, while the dorsal fin is large while also being very tall. The second dorsal fin is very small as are the anal, and pelvic fins.

The mako has a intense blue coloration, darker on the dorsal side while the ventral side is white and the boundary line between the two is quite evident. The two species of mako have similar dimensions, the maximum total length of the short fin is 3.94 metres, and 4.17 for the long fin. The male short fin mako reaches sexual maturity around 2 metres while the female matures at 2.8 metres and has aplacental viviparity with oophagy. Paturation occurs between the end of winter and the middle of spring, and gestation can last up to 18 months. The litter size varies from 4 to 25 young, and at birth measure about 70 cm. The reproductive biology of the long fin is shrouded in mystery as very little is known, it is thought that the litter is composed of two young and at birth measure 92-97 cm. The mako sharks are capable of extreme swimming speeds and are in fact one of the fastest fish in the sea's. This obtainable high speed facilitates incredible leaps out of the water, sometimes up to 6 metres in height, this is a behaviour only demonstrated by this species, making them prize catches for sports fishermen. The migration of the short fin mako is astonishing to say the least, some specimens have been known to travel 2700 kilometres across the Atlantic Ocean and 2050 kilometres across the Pacific! During these migrations the shark maintains a speed of 28 kilometres a day. This is only permitted as with other members of the lamniods, as the mako has a physiological mechanism to keep its body temperature above that of the surrounding water, and consequently has a high level of energy at its disposal. The short fin mako is cosmopolitan in its distribution but generally prefers cold temperate waters, and can be found between the surface and 152 metres below, while in tropical waters it can be found at a greater depth of 200 to 400 metres. The long fin mako on the other hand has a distribution, which is little understood. The diet of this species varies from small sharks, and rays to bony fish and sea turtles, as well as cetaceans and cephalopods. A classic prey for mako's is the swordfish, and surprisingly enough the shark does not seam to be deterred by the presence of its large sword, and in some cases swords of the swordfish have been found inside dead or still living mako's.

The mako is a considerable adversary, being dangerous at the best of times, for its size, teeth, and their behaviour being idiosyncratic. But in reality, this species prefers to live far offshore, and it is because of this that it very rarely encounters bathers or divers. The mako shark has a high commercial value, as does its counter part the porbegle, and is often caught as a bycatch of tuna and swordfish fisheries, though in some parts of the world its meat being low in chloroestorol is considered delectable. Unfortunately, the teeth of the mako are like porcelain and are often used as an excuse to hunt these majestic predators just for the souvenirs, as with the tiger and white shark. The author knows of one company that makes replica teeth to the finest of detail, with plummeting populations of wild sharks, is it not about time the souvenir trade took stock of what it is really is doing and sell replica teeth and jaws instead of real teeth? It's up to the consumer to demand replica teeth and not real ones, or better still not to purchase any teeth or jaws at all, that would have to be in the long run replaced.