Sharks

Looking beyond the bite

***Chris Viney** reports on research aimed at making the water a safer place, for sharks.*

***Pristis microdon*, Australia's largest freshwater fish, inhabits Top End, Indonesian and New Guinean waterways. It noses about on the muddy river bottom, vulnerable to gillnets set for barramundi.**

Quick! Before you read the next paragraph, can you name Australia's largest freshwater fish?

The Murray cod perhaps? It's a lightweight compared to the freshwater sawfish (*Pristis microdon*). This astonishing creature, which inhabits Top End, Indonesian and New Guinean rivers, can grow to seven metres, with almost a third of its length being a sharp-toothed saw-blade.

Pristis microdon belongs to the wide-ranging family of cartilaginous fishes called elasmobranchs (from the Greek words *elasmos*, meaning beaten metal and *bragkhia*, meaning gills) which includes sharks, rays and chimaeras or ghost sharks. Their lineage is ancient, the oldest shark fossils dating back 425 million years. Today's elasmobranchs live in all the world's oceans, from inshore waters to the high seas, and also in major freshwater river systems. They range from the top of the food chain to lower-level predators. But despite having survived so long, their future is in danger, and freshwater species are among the most threatened.

The sawfish, which occupies the same river habitats as barramundi, is a classic example. According to Dr Peter Last from CSIRO's Division of Marine Research, rivers are sometimes netted to catch barramundi. 'The sawfish nose about on the muddy river bottom, stunning and killing fish with their saws,' Last says. It's hard to imagine anything more likely to get inextricably tangled in a nylon monofilament gillnet.'

Compounding their misfortune, the sawfish also taste good. In the past, Indonesian fishers have killed unsustainable numbers of this and other sawfish species in their waters. Now they are rare.

Another elasmobrach in danger is the freshwater whipray (*Himantura chaophraya*), which grows to two metres across and can weigh 600 kilograms. A smaller form of the whipray lives in the rivers of the Kimberleys, where the extreme tidal range results in two-metre bore waves sweeping up the estuaries. Dolphins and even whales sometimes surf upstream on the tidal bore.

Top End residents have gone to amazing lengths to aid the study of this elusive whipray. A joint CSIRO-Tokyo University field trip to the Pentecost River area in the early 1990s failed to locate one, but soon after the scientists had left, a woman on a remote cattle property did. Knowing of CSIRO's research, she loaded the fish in the back of her 4WD and drove a few hundred kilometres to Kununurra, located a Frigmobile, and sent the fish south for CSIRO scientists to study.

Another research specimen was delivered by Gordon Stables, a Top End tropical fish collector who was also aware of CSIRO's interest in whiprays. Having captured alive a small whipray, he put it in his truck-mounted tank, and continued his collecting expedition. By the time Gordon contacted Last, the whipray had killed and eaten more than half the valuable stock of aquarium fish sharing the tank.

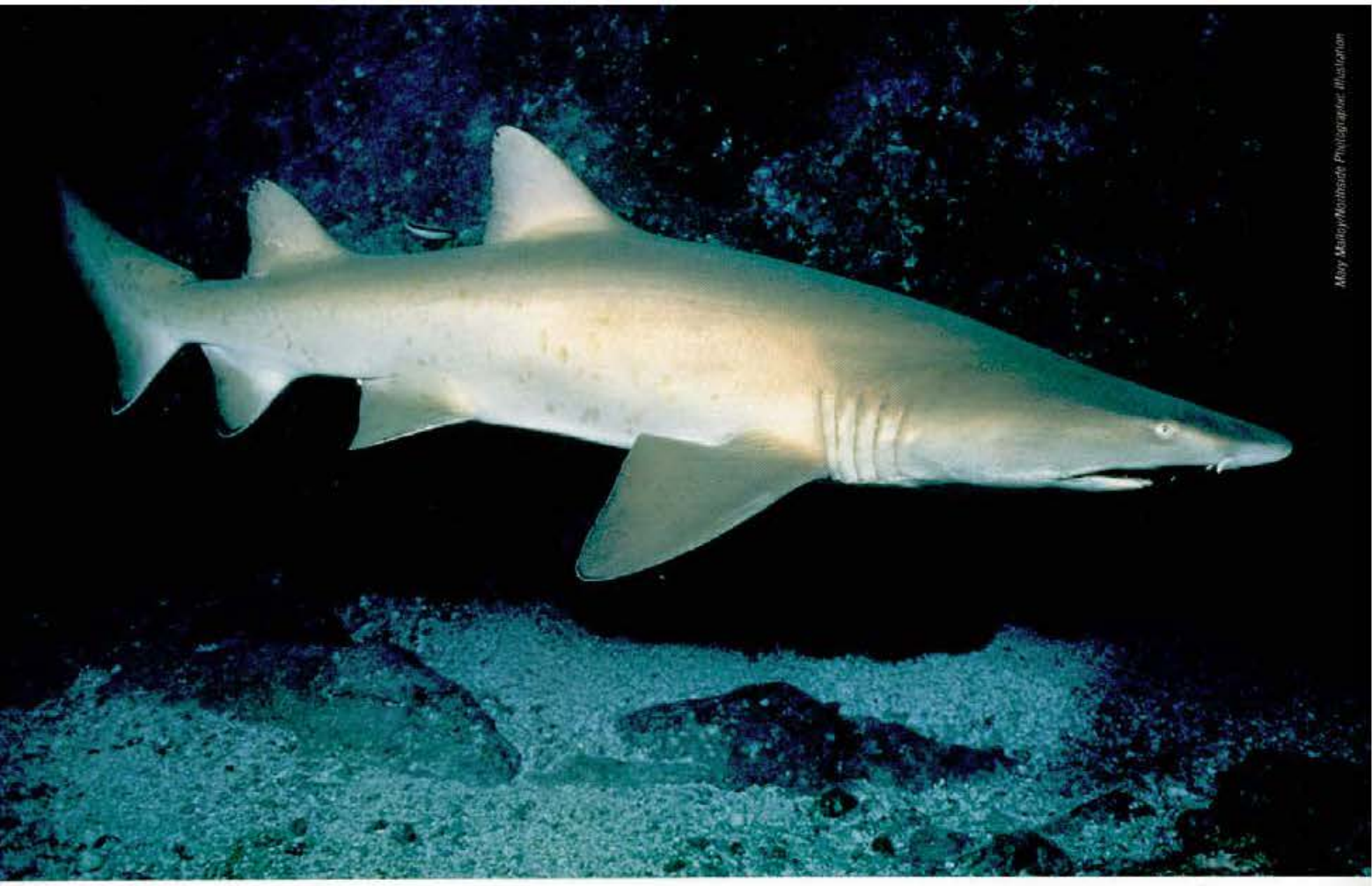
Sharks too are threatened by disturbance in Top End waterways, yet frustratingly little is known about their distribution and biology. A 1.5 m shark, hooked last year by a recreational angler in Kakadu's Alligator River, proved to be a rare freshwater shark of the genus *Glyphis*, also known as the Ganges shark. Only three other specimens have ever been identified in our waters, and this individual may be a new species.

'These remarkable fish aren't in the distant reaches of the oceans, or deep below the surface of the sea, but under bridges crossed by cattle trains, and in the brown wetland waters cut by tourist boats,' Last says.

Little time remains to learn learn more about these freshwater species, because too many sawfish, sharks and rays in Australia's tropical rivers meet the same fate as the *Gyphis* shark caught by the Kakadu angler. . . He ate it.

Learning to play fair

A similar fate is facing marine sharks, which are under threat in many of the world's oceans. The reported commercial fishing catch of sharks and rays is about



Mary Malloy/Northside Photographic Illustration

The grey nurse, like many sharks, produces small numbers of well-developed young. It gives birth to two pups, one from each uterus. This low productivity makes sharks vulnerable to overfishing.

700 000 tonnes a year. But sharks taken as the by-catch of other target fisheries are not represented in this figure.

Few countries have management plans for their shark fisheries, and are unable or unwilling to tackle unsustainable, unregulated catch levels. In Australia, however, CSIRO scientists are working with fishers and agencies such as the Australian Fisheries Management Authority (AFMA) to expand our knowledge of vital role played by sharks in the ecosystem.

The issue is of concern to marine scientists, because pressure from overfishing and habitat degradation is threatening the survival of creatures that have been part of the marine ecosystems for hundreds of millions of years. Australia's marine system is one of the world's few remaining mega-diverse environments, with one of the richest shark and ray faunas on Earth. Maintaining this biodiversity is important, because environments with a broad range of species in balance with each other are more able to recover from natural or human-created stresses. Reduced biodiversity can disrupt ecological balance, taking away the natural checks and balances that keep ecosystems healthy.

Last says the diversity of our marine ecosystems puts Australian scientists in a key strategic position to take the lead in shark research programs and conservation measures. And the scope for research is broad. 'We rarely understand even the basic ecological implications when a top level predator, such as a shark, is seriously depleted.' Last says.

Last and his colleague Dr John Stevens are co-authors of the definitive text, *Sharks and Rays of Australia*, published in 1994. Stevens says the fact that sharks have survived for so many millions of years is proof of their adaptability and evolutionary success. But for many species, aspects of their biology make them poorly adapted to survive large-scale exploitation by humans.

'In most bony fish species, females produce millions of eggs each year, and only a small percentage need to survive to maintain population stocks,' Stevens says. 'Because of their high reproductive potential, some species can maintain numbers even under heavy levels of exploitation.'

But sharks are different. Most produce small numbers of well-developed young, and this low productivity makes them vulnerable to over-fishing. Even the most prolific breeder, the blue shark, *Prionace glauca*, may only produce an average of 35 young a year, while the grey nurse shark, *Carcharias taurus*, breeds more like a mammal than a fish, giving birth to two pups, one from each uterus.

'Many species are also restricted in their distribution, and as well, most sharks tend to be long-lived and slow-maturing, all characteristics that put them at further risk, Stevens says. 'For a whole spectrum of reasons, a heavily-exploited shark population is slow to replenish.'

Great white in danger

If there's one shark that stirs the public's imagination, it's the white shark, *Carcharodon carcharias*. When sensationalist media preys on people's sometimes deep-seated fears of sharks, this species usually is the target.

Peter Benchley chose the great white as his villain in *Jaws*, but this species is responsible for few of the relatively small number of shark attacks in this country. Of some 500 registered attacks in Australian waters, only 44 are attributed to white sharks. Most are by species of the whaler family or tiger sharks. In any

case, it's an exaggerated risk. The frequency of attacks on swimmers is low. The chances are twice as high of dying from a bee sting or lightning strike.

CSIRO scientist Dr Barry Bruce has been working with white sharks since 1987. He says factors leading to a slow replenishment rate for this species include their lower numbers, position at the top of the food chain, slow maturity and limited reproductive potential. All combine to make the white shark vulnerable to exploitation, and although it's not a major commercial species, many white sharks die in the nets and on the long-lines of professional fishers.

'Incidental capture as a by-catch of commercial operations is undoubtedly more significant than targeted fishing of white sharks, although the actual number taken is unknown,' Bruce says.

'Another significant point may be that most white sharks taken are juveniles. This can have a dramatic impact on the adult population, and is cause for serious concern.'

In Australia and overseas, moves have been made to protect the white shark. South Africa and California both have protective legislation, and Tasmania and New South Wales passed similar measures in 1995. Other Australian states are considering protection laws, and a national conference in 1996 resolved that some form of conservation management was needed, but could not reach

The reproductive method of the whale shark is a mystery. No pregnant females have been recorded.

Geoff Taylor/Lochman Transparencies

Inside or out?

ONE of the delights of beachcombing is discovering the leathery 'purses' that are the egg cases of certain shark species. Ribbed or smooth, often with curling tendrils to anchor them to seaweeds and grasses, they can litter the beaches in their thousands after stormy weather. Each one has protected and nourished its embryo over a period of several months before the pups hatch. Sharks that produce their young this way are described as oviparous (from the Latin words *ovum*, meaning egg, and *parere*, to bring forth).

In some species, cellophane-thin egg cases are retained inside the uterus of the female. Viviparous sharks (*vivere* meaning live) give birth to active young after a gestation period that can range from five to 22 months, depending on the species.

The embryos of grey nurse, mako, thresher and some other sharks are cannibalistic: successive ovulations occur, and the eggs are eaten by the first-hatching batch of embryos. In the grey nurse shark, only one large pup survives from each uterus. This unusual process is called oophagy (from the Greek *oion*, meaning egg and *phagy*, eat).

Breeding cycles show wide variety across shark species. Some breed throughout the year, while others follow a seasonal cycle.

Claspers

Female bony fishes produce eggs that are fertilised in the water by sperm from the males. The high mortality rate of eggs and larvae means that large numbers of eggs must be spawned. Sharks have evolved a different reproductive method, fertilising the eggs within the female's body, and producing fewer, but better-protected young.

Mature male sharks have paired claspers, which are modified pelvic fins, sometimes with hooks or spreading tips. During mating, one clasper pivots forwards to enter the female's genital opening and guide the sperm, which runs along a groove in the clasper, helped on its way by seawater pumped from muscular sacs under the skin of the belly.

Whale shark

Oviparous or viviparous? The reproductive method of the world's largest species, the whale shark, is a mystery. No pregnant females have been recorded. A massive egg case measuring 30 cm by 14 cm that may have come from this species has been found, but it was so thin that it may have been an aborted internal egg case.

agreement on appropriate measures. The conference formed a white shark working group to evaluate the issue, and to produce a strategic research plan for white shark management in Australia.

Flake and chips

Australians have always been big shark eaters. In Melbourne, flake capital of the nation, tonnes of shark are consumed every year. Most comes from the long-established southern shark fishery in Bass Strait, eastern Victorian, South Australian and Tasmanian waters. Here, two species - school sharks and gummy sharks - have been fished since the 1920s.

'While gummy shark levels are holding their own, overfishing of school sharks has become a serious problem,' Stevens says. 'School shark numbers in the fishery may have declined by 55-85% since commercial fishing began.'

Fishing is by gill net or long line, and because the two species are taken together, it's difficult to target one and avoid the other. But as Stevens points out, even if this were possible, making gummy sharks the target would put increasing pressure on the population stocks of this species, and would have to be carefully regulated.

But the picture for the fishery is not all bleak. CSIRO, AFMA and other marine research agencies along with fishers and environmental groups are working together to provide a realistic assessment of stocks and to develop practical methods to put management of the species on a sustainable basis.

By-catch blues

Today's ocean is a dangerous place . . . for sharks.

Being the deliberate target of large and small-scale commercial fisheries is risky enough, but that's only part of the story. Netting and settlings to protect popular beaches against the chance of shark attack kills about 1500 sharks in Australia each year, most of which are harmless. The program also kills large numbers of rays, and is a threat to protected species such as turtles, dugong and dolphins.

Recreational fishing and habitat destruction through ocean pollution also put pressure on shark populations. But most serious is the number of sharks killed as by-catch in other fishing operations. Tuna and squid fleets catch millions of sharks each year, especially the widely-distributed open-ocean blue shark, whose range coincides with these high seas fisheries. The exact numbers are unknown, but it is believed that around six million blues are taken annually. Worldwide, it is believed that the unreported shark catch is at least equal to reported numbers.

In Tasmania, a company called Beku is using the livers of the already-caught sharks to produce squalene oil (see 'Good oils and fishy tales', *Ecos* 87). Scientists from CSIRO Marine Research have worked with the company for six years to help develop this versatile product.

In Third World countries, however, the by-catch shark trade is large, expanding and unregulated, driven by lucrative markets for shark fins and cartilage. Dried shark fins, a culinary delicacy in high demand in Asian markets, are quick and easy to process and can fetch up to $220 a kilogram. And shark cartilage, which is used in medical science as cancer treatment and to manufacture artificial skin, is worth $A180 000 a tonne.

No-one knows what the ecological impacts are likely to be when the marine food chain is unbalanced by large-scale interference. What we do know is that first and second-level predators cull fish populations of their weaker members, maintaining the strength of the ocean's gene pool. Any major decrease in predator numbers must upset the delicate ecological balance.

Graphic examples of this imbalance have been recorded on land. A Colorado study on the balance between mountain lions, wolves and deer found that in the absence of the primary predators, the deer population increased rapidly, then starved.

Less is known of such complex interactions in the marine environment,

School sharks (pictured) and gummy sharks have been fished in southern Australian waters since the 1920s. CSIRO scientists are working to locate the pupping grounds of school sharks which may have declined by 55-85% during this period.

Mary Nalsey/Australic Photographic Illustration

although some scientists in South Africa theorise that a successful beach meshing program that removed numbers of large sharks may have led to a rapid increase in the numbers of juvenile sharks, which caused problems for fisheries operations.

Seeking nursery schools

Gathering data on shark populations, biology and habitat, is critical to the effective management of commercial fisheries, and to protecting species at risk. Stevens says that even with well-observed species, much remains to be learned.

'For example, one of our projects on the southern shark fishery is to locate the pupping grounds of school sharks,' Stevens says. 'Proof of the amount of information that needs to be discovered is the discrepancy of opinion on just where the major pupping grounds are located.

'Some researchers believe they are in the shallow bays of Australia's east coast, while others point to South Australia. Another view is that the sharks migrate off the continental shelf, and pup across the Tasman Sea in New Zealand waters.'

An archival tagging project funded by AFMA and the Fisheries Research and Development Corporation may help to solve this and other mysteries relating to shark populations, movements and behaviour. The tags, developed for tuna research programs, are electronic data loggers with sensors for time, temperature, depth and light.

The light sensor and timer enables scientists to determine dawn, solar noon and sunset, day-by-day, on the shark's travels. By comparing this data with Greenwich Mean Time, they can plot longitude, just as early navigators did. (Solar noon advances from GMT by four minutes for every degree of longitude). Day length gives the latitude, and by crossing the two lines, the shark's position can be plotted.

To yield their data, the tags must be recovered. Recovery rate is only 10%, but work is progressing on a tag that automatically releases after a certain period, and then bobs to the surface, downloading its data via satellite to a CSIRO computer.

This and other CSIRO research is a vital to increasing our knowledge of sharks, to shaping public awareness of the conservation issues, to maintain sustainable fisheries, and to national and international efforts to identify and protect threatened shark species.

Eric Bolgaard/Lochman Transparencies

Manta rays feed on plankton, which they filter through their gills.

Cartilaginous curiosities

SHARKS, rays and chimaera are all members of the family of elasmobranchs, or cartilaginous fishes. This wide-ranging and diverse group includes creatures both large and small, gentle and dangerous, graceful and sinister. Here are three.

Cookie-cutter shark

It's luminous. It swallows its own teeth. It attacks nuclear submarines.

Cookie-cutter sharks earned their curious name for an unusual feeding habit. After attaching themselves to large fish and marine mammals with fleshy, sucking lips, they spin, boring out a plug of flesh. Crater-shaped marks from cookie-cutters' teeth have even been found on the rubber sonar domes of submarines!

The shark's large, oily liver allows it to hang motionless in the water, its strong luminescence luring prey. Cookie-cutters swallow their large lower teeth during replacement, perhaps to maintain calcium levels. This remarkable shark grows to a length of 50 cm, and is widespread in temperate and tropical oceans.

Manta ray

Largest of all the rays, these graceful giants can reach a wingtip to wingtip span of more than nine metres. Preferring tropical waters, manta rays are common off Australia's northern coastline, and occasionally venture as far south as Rottnest Island in Western Australia, or Montague Island, off New South Wales.

Mantas are inquisitive creatures, and divers sometimes are able to ride on their broad 'wings'. The manta's slow, rippling glide can quickly become high-speed flight. They sometimes leap clear of the water, landing with a loud slap.

Like other devilrays, the manta feeds on plankton, which it sieves through its filtering gills.

Giant chimaera

Purplish-blue in colour, and growing to well over a metre in length, giant chimaeras live in deep water, on the mid-continental slopes and abyssal plains off New Zealand and Tasmania, and on seamounts further south.

Like other species of chimaeras, mature males of this species carry their sexual organs on their heads. The thumb-shaped, bristly appendages called 'head claspers' are used for transferring sperm to the female.

Giant chimaera's are rarely-caught, and little is known of their biology.