Katherine Johnson

describes the sophisticated surveillance devices used to expose the secret lives of sharks.

Tagging along with sharks

In blue waters off Western Australia's Ningaloo Reef, divers approach the broad head and speckled body of a whale shark, the world's largest living fish.

A large eye the size of a human fist follows the divers' movements as they pause a few metres from the shark's back. Minutes later, the job is done. The divers move away and the submarine-like mass glides past. Trailing above and behind its dorsal fin is a satellite tag.

As the 10-metre shark surfaces, the tag begins transmitting its position via satellite to a computer. For 13 days and 420 kilometres, the movements of the whale shark are no longer secret.

The shark travels south along the reef before turning north and moving offshore. Then the signal changes. The transmission becomes more regular and frequent, indicating the tag has come off the shark and is now drifting in currents. It is eventually recovered 800 km to the south.

Dr John Stevens of CSIRO Marine Research is not surprised by the outcome. 'These are early days,' he says. 'We are tracking the largest fish in the world with one of the most sophisticated tagging methods available. There are bound to be glitches.'

With further refinements to the tagging system, the researchers hope to learn about the behaviour and migratory patterns of whale sharks.

'As with other species we are studying, this will help us understand the extent of their population, and help determine their vulnerability to fishing and other pressures,' Stevens says. 'Ultimately the goal is better conservation and management.'

Left: A whale shark with an attached acoustic tag. Diving alongside these gentle giants is the kind of job marine scientists would give their right arm for.

Whale sharks can reach lengths of up to 12 metres. In some countries, such as Taiwan, they are hunted for food. In Western Australia, ecotourism operators take people to snorkel with the whale sharks which eat only plankton and small fish.

Flaked out

Another species of shark being tracked by CSIRO marine researchers is the school shark, the ubiquitous flake sold in fish and chip shops of southern Australia.

School sharks are fished commercially in Australia's south eastern waters and make up about 30% of the value of the southern shark fishery, worth $15 million each year. But the species is considered to be overfished and management plans are in place to rebuild the population.

To learn about the travels of this species, researchers are using a data-logging tag that records depth, water temperature and light levels every four minutes for up to two years. The sharks are tagged and released by researchers aboard commercial fishing boats. When the shark is recaptured by fishers, the tags are sent back to CSIRO for analysis.

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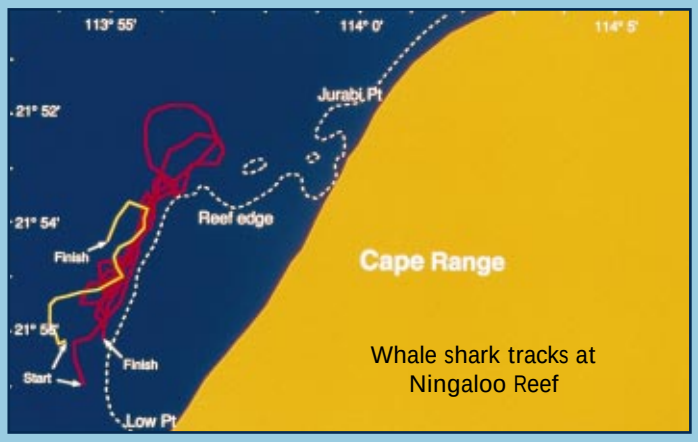
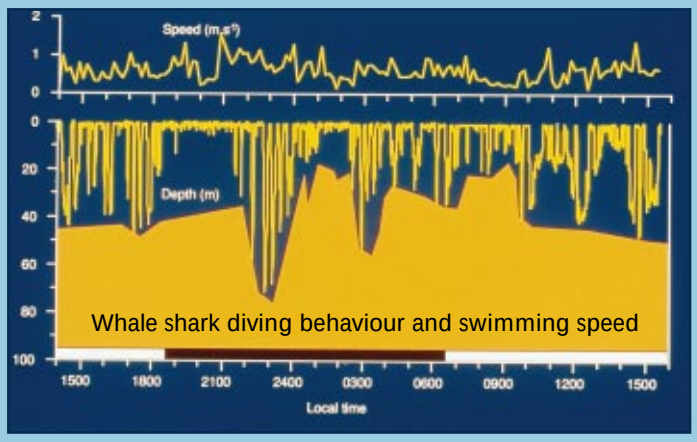
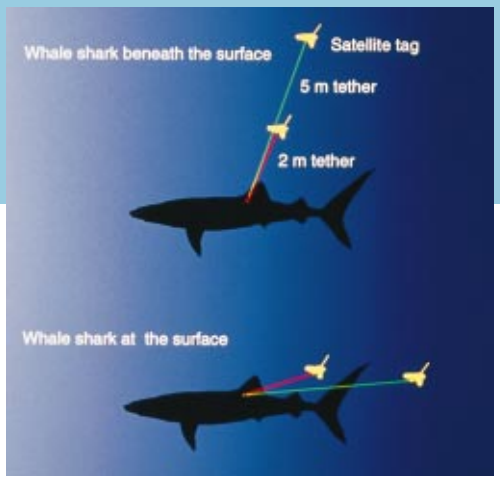




Above: The track of a whale shark off Ningaloo Reef. The shark was followed using an acoustic tag.

Above right: The diving behaviour and swimming speed of a whale shark tracked with an acoustic tag for 24 hours.

Right: This diagram represents a whale shark towing a satellite tag. The tag, which is towed above the shark, only transmits when it is on the surface.



The research aims to understand the detailed movement patterns of school sharks. It is funded jointly by the Fisheries Research and Development Corporation and CSIRO, and is assisted by the fishing industry.

Barely the size of a cigarette lighter, these tags are testing the limits of electronics creativity. They must operate to depths of at least 800 m, detect low levels of light, and store large amounts of data for up to several years.

So far, 30 school sharks have been tagged with data-logging (or archival) tags in South Australian waters. Researchers can calculate the shark's daily position from patterns of light levels recorded and stored in the tags. The record extends from when the shark is tagged to its recapture, providing it remains at depths where the light signal is sufficiently strong.

'Without this technology, we simply cannot get the information we need on depth, behaviour and movement,' Stevens says.

'While we have known that school sharks can travel between Australia and New Zealand from the earlier tagging work using simple tags with an identification number and return address, we can now find out what happens in between the points of release and recapture.'

Last year, two school sharks fitted with archival tags were released within 10 minutes of each other in South Australia and were recaptured more than 100 nautical miles away.

The first shark, a female, was recaptured only seven days after its release in Victoria having travelled 150 nautical miles west. The second, a male, was recaptured three weeks later, 100 miles to the north-west.

'We are delighted to have received results so soon after release, and already have detected an interesting daily vertical migration of the sharks from near the surface to depths of 500 metres,' Stevens says.

Sound signals

Other tags used by CSIRO transmit acoustic signals that have been used to track whale sharks and the little understood but much maligned white shark. It is without a doubt the most labour intensive type of tagging work there is, says white shark researcher Barry Bruce.

'In one instance, we trolled a tuna bait behind a rubber Zodiac. It's almost comical when you picture it – researchers packed into a rubber zodiac trolling for a great white that is longer than the boat – but it's the only way of being able to get close enough,' he says.

Once tagged, the shark descends out of sight, but not out of range. Sound pulses emitted from the tag are detected by a hydrophone suspended in the water. By following the signal, the shark can be followed.

'The longest tracking we did was 36 hours,' Bruce says. 'All of that time, a researcher wore headphones and was concentrating on following the signal. It was very tiring.'

Later, in the comfort of an office, the shark's track is analysed and the swimming behaviour of the shark studied. Tracking carried out in collaboration with South Australian and overseas researchers has

A school shark tagged with an archival tag. Research using archival tags has revealed that school sharks swim up tp 150 nautical miles in a week.

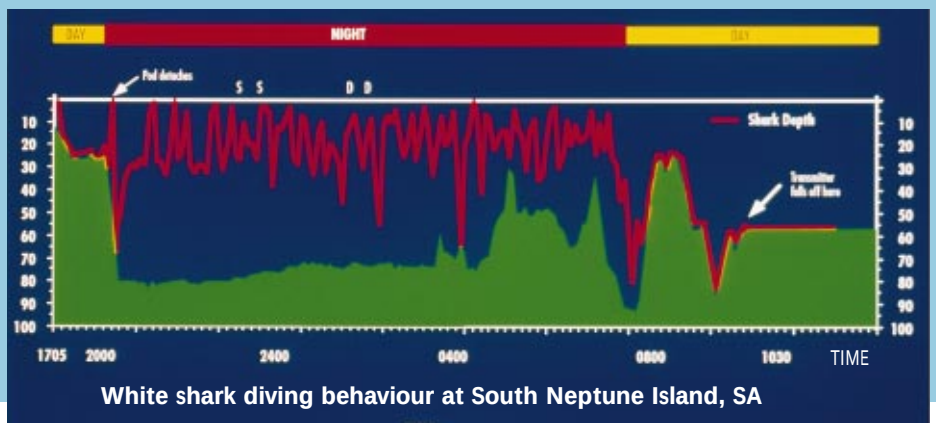
shown that, in the Port Lincoln area, these animals have a home range which may take in a number of different reefs or islands.

'These islands have seal colonies and seals are an important part of the diet of adult white sharks,' Bruce says. 'Tracked white sharks tend to swim near the seabed during the day and near the surface at night. They often patrol an island for an extended period, then move off in a directed course to another island.'

Vulnerable by nature

None of this information was known before the tagging research began a decade ago, and knowledge of many shark species is still

White shark track at South Neptune Island, SA



White shark diving behaviour at South Neptune Island, SA

Above: This white shark was tagged at Dangerous Reef, South Australia, in 1991, then recaught five years later inside a tuna farm cage nearby at Port Lincoln. A new research program funded by the Natural Heritage Trust will use a range of tag types to learn more about white shark movement patterns.

Left and above left: The track and diving behaviour of a white shark followed using an acoustic tag at South Neptune Island, South Australia during a 17-hour period. The maximum diving depth was about 80 m.

An evolving technology

Satellite tag.

WITH modern advances in electronics and communications, the amount that can be learned about fish movement has boomed. The following list charts the evolution of tag technology.

Conventional tags are simple plastic or metal tags that have an identification number and return address printed on them. Fishers who find these tags are asked to return them to the scientists so they can calculate how far (straight line distance) a fish had travelled from the point of tag and release to the point of recapture, and determine how much the fish has grown during this time. They are used in research on school, gummy, blue, and mako sharks.

Archival tags (or data-storage tags) are attached to the dorsal fin and are programmed to record information such as light, depth, water temperature, and fish temperature every few minutes for up to several years. They are returned to researchers, where the data is downloaded and analysed. They are used in research on school sharks.

Acoustic tags provide information on location by transmitting acoustic signals that are received by a hydrophone suspended in the water from a research boat. By following the signal, researchers can track the movements of the fish. These are used in research on white sharks and whale sharks.

Satellite tags transmit to satellites when the tag is on the surface. Signals are processed by the ARGOS satellite to determine the shark's position, relayed to ground stations and from there to computer. They can transmit data on other parameters, although the version used by CSIRO on whale sharks only gives information on location.

Pop-up archival tags are not yet on the market. They will record the same information as regular archival tags, but are programmed to disengage from the fish and float to the surface where they transmit information as a satellite signal to the ARGOS satellite.

poor. Part of the problem is the highly mobile and oceanic nature of many sharks, which makes them difficult and expensive to study. Their extensive range also poses problems for management.

But with slow growth rates, late sexual maturity, and few offspring, sharks (and their cartilagenous relatives the rays) are particularly vulnerable to over-fishing. Once over-fished, their populations can take decades to recover.

The reported world catch of sharks and rays is about 750 000 tonnes. In most cases, sharks are not targeted but caught accidentally as bycatch. As a result, these catches are poorly documented. The actual catch is probably closer to 1.5 million tonnes.

The conservation and management of shark stocks is receiving attention from a number of international organisations such as Convention on International Trade in Endangered Species, the World Conservation Union and the United Nations Food and Agriculture Organisation.

It is the hope of researchers involved in shark tagging projects at CSIRO that information from tagging research will go part of the way to filling the gaps in knowledge, and ensuring the future of sharks.