Sawfish

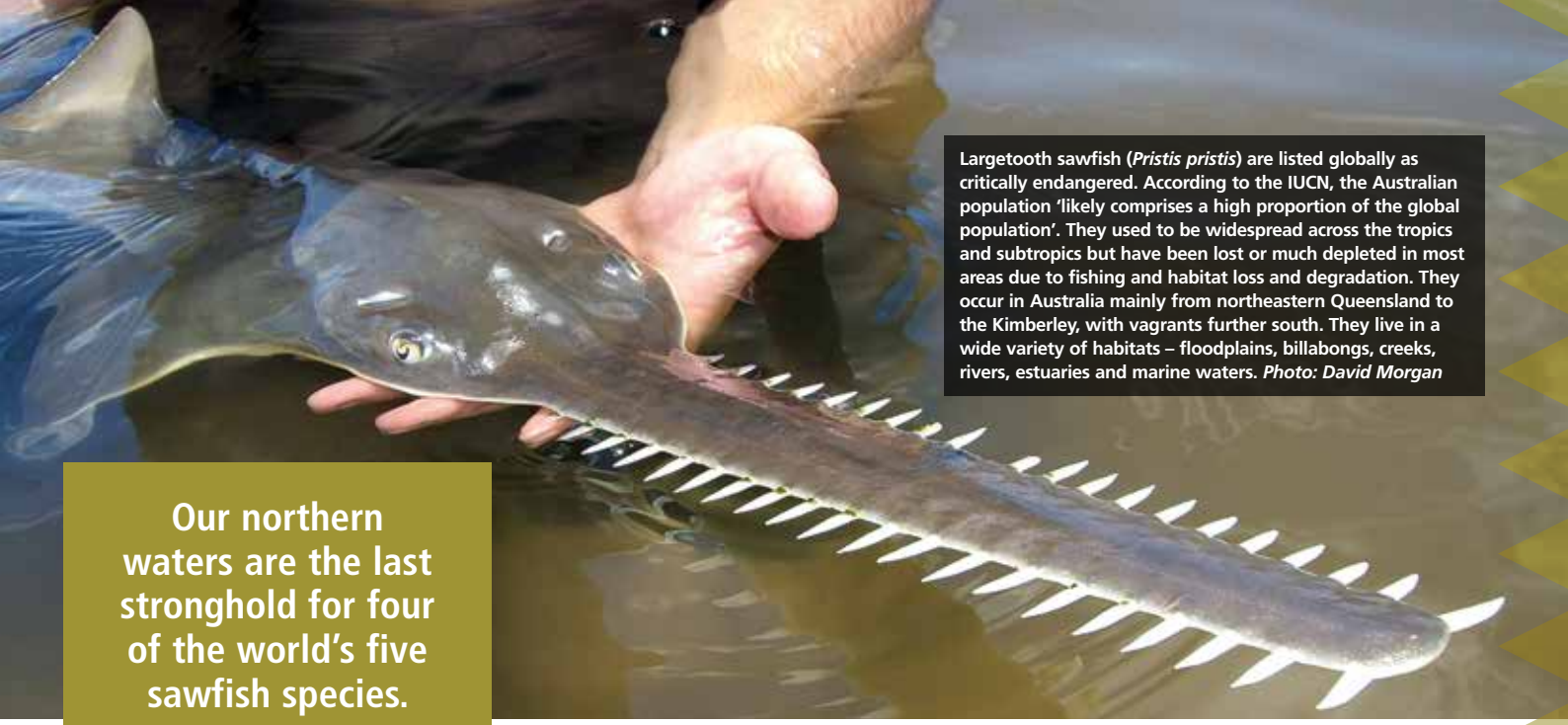
ANCIENT PREDATORS IN NEED OF MODERN CONSERVATION TOOLS

Conservation geneticist **Nicole Phillips** and zoologist **Barbara Wueringer** reveal how vital northern Australia is to the future of sawfish.

Sensitive detector and lethal weapon combined, there are few implements in nature as versatile as the snout of a sawfish. With it, they home in on weak electrical pulses and eddies created by fish and crustaceans, then stun or impale them. But this magnificent saw is also their achilles heel as it makes them terribly prone to entanglement in fishing nets and is prized as a trophy. Sawfish are fast disappearing from most of the world.

Few Australians ever see a wild sawfish – for they are rare, well camouflaged and often live in murky waters – but Australia is critical to their future. Our northern waters are the last stronghold for four of the world's five species. So, it is important that Australians recognise them as part of their iconic natural heritage to ensure that resources are dedicated to safeguarding their future. We have been studying their population genetics (Nicole), sensory adaptations and feeding behaviours (Barbara) to better understand how to achieve this.

Green sawfish (*Pristis zijsron*) are listed globally as critically endangered. According to the IUCN, Australia has 'some of the last remaining viable populations … albeit at significantly reduced levels'. They were once widespread in the Indo-West Pacific region but have disappeared from much of their range due to inshore gillnet and trawl fishing. In Australia they used to occur as far south as Sydney but are now extinct in NSW. Juveniles use inshore waters and mangroves, and adults use marine and estuarine waters. ***Photo: Jeff Whitty***



Largetooth sawfish (*Pristis pristis*) are listed globally as critically endangered. According to the IUCN, the Australian population 'likely comprises a high proportion of the global population'. They used to be widespread across the tropics and subtropics but have been lost or much depleted in most areas due to fishing and habitat loss and degradation. They occur in Australia mainly from northeastern Queensland to the Kimberley, with vagrants further south. They live in a wide variety of habitats – floodplains, billabongs, creeks, rivers, estuaries and marine waters. *Photo: David Morgan*

Our northern waters are the last stronghold for four of the world's five sawfish species.

Ancient predators

Sawfish are a family (Pristidae) in the class of fish with cartilage skeletons (the Chondrichthyes) that includes sharks, rays, skates and chimaeras. Although their bodies and manner of swimming are shark-like, sawfish belong to the shark's closest relatives, the rays. They emerged around 60 million years ago.

Historically, many sawfish species have been described, but recent genetic analyses have reduced the number of living species to just five. Northern Australia is a sawfish hotspot, with more species than any other region: the largetooth, green and dwarf sawfishes (genus *Pristis*) and the narrow sawfish (genus *Anoxypristis*).

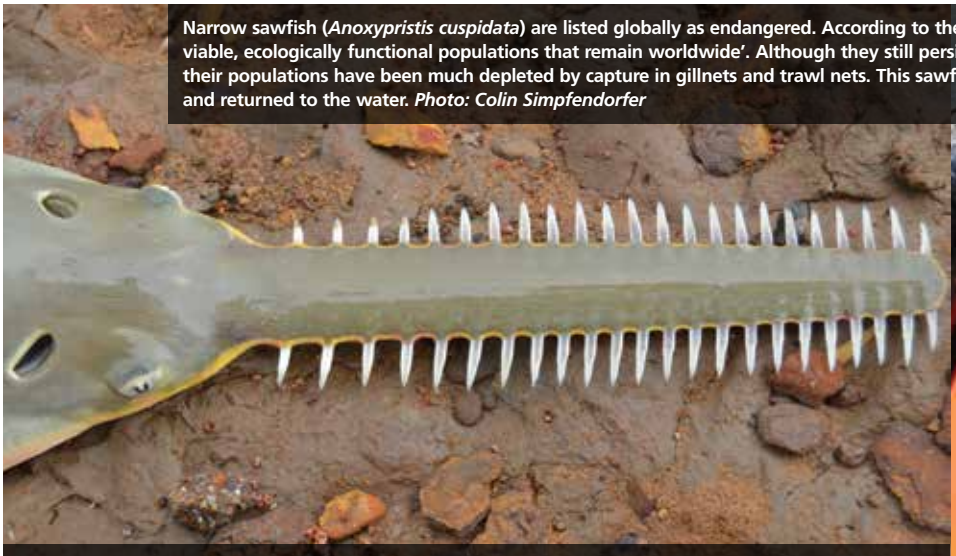
A versatile implement

The defining feature of sawfishes, their saw (or rostrum), is an extension of the skull, and can make up over a fifth of their body length. The saw 'teeth' are actually modified dermal denticles, the microscopic scale-like structures on the skin of sharks and rays. Unlike shark teeth, the sawfish saw teeth are not replaced as they wear or break, but grow continuously from their base, like the incisors of rodents.

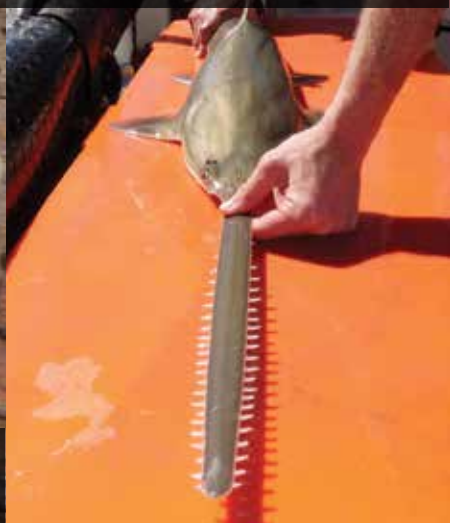
Swordfish and marlin can use their rostrum to stun or kill prey, and the snouts of animals like platypus and northern hemisphere paddlefish can detect the weak electric fields of hidden prey, but the sawfish rostrum is unique in combining these attributes. Captive sawfish have been observed also using their saw to fight over food and establish social hierarchies.

The sawfish's saw is covered in two types of receptors: mechanoreceptors that detect nearby water movements and electroreceptors (known as the ampullae of Lorenzini) that detect weak electric fields. As all living beings are surrounded by a weak electric field, and any slight movement of animals in water creates micro-currents, these two senses enable sawfish to detect prey in the dark and in highly turbid waters. Largetooth sawfish, whose young live in often-turbid rivers where visibility can fall below 10 centimetres, have the most electroreceptors, providing them with the highest resolution.

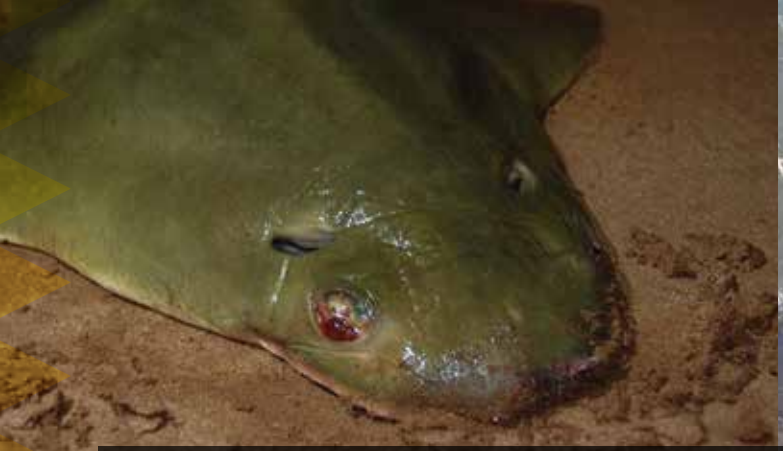
Barbara's studies on captive young largetooth sawfish have challenged the reputation of sawfish as sluggish bottom-dwellers that search for food by raking their saw through sediments. They are in fact active and agile hunters. As well as sometimes sitting and waiting for prey to pass, they prowl on the bottom and in the water column, holding their saw up at a slight angle. When a fish is detected they rapidly swipe the saw from side to side to stun or impale it. They then pin it under their saw, turn it around (to prevent scales

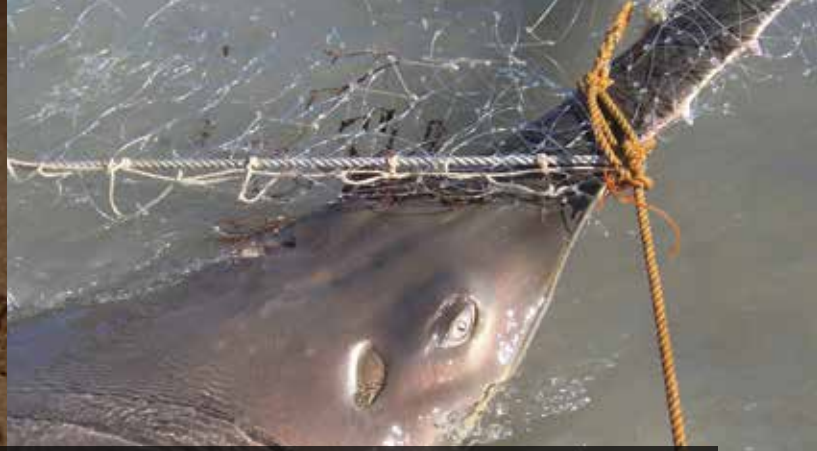


Narrow sawfish (*Anoxypristis cuspidata*) are listed globally as endangered. According to the IUCN, northern Australia 'contains the most viable, ecologically functional populations that remain worldwide'. Although they still persist across most of their Indo-West Pacific range, their populations have been much depleted by capture in gillnets and trawl nets. This sawfish was captured in Cleveland Bay for research and returned to the water. *Photo: Colin Simpfendorfer*

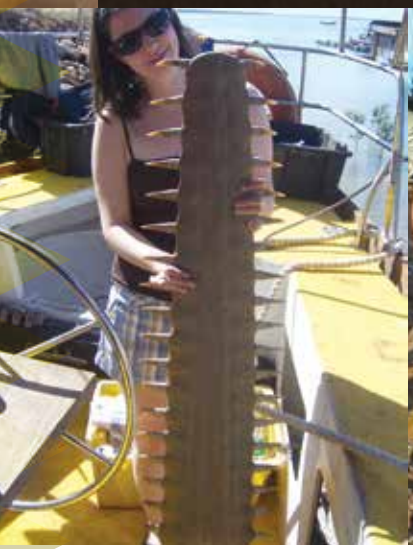


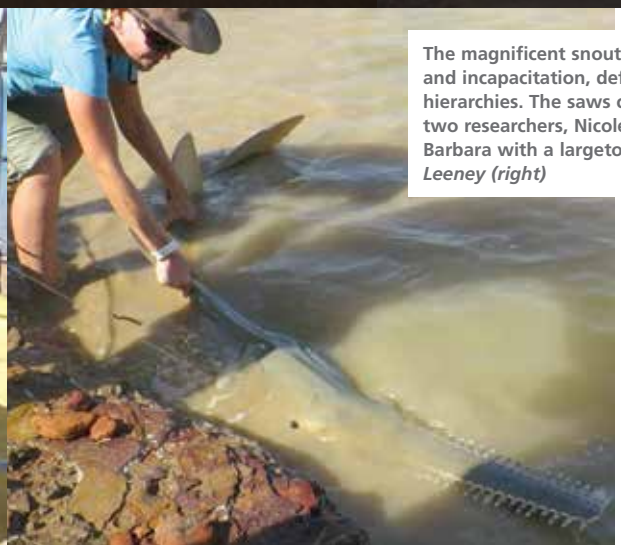
Dwarf sawfish (Pristis clavata) are listed globally as endangered. According to the IUCN, they are 'possibly now restricted to tropical waters of northern Australia', from the Pilbara coast to the Gulf of Carpentaria. They may have once occurred in the Indian Ocean region and Southeast Asia. *Photo: David Morgan*





Commercial and recreational fishing threaten sawfish in multiple ways. Their saw easily becomes entangled in nets and lines (as shown here for a green sawfish in the Gulf of Carpentaria), and they are often unintentionally captured by fishers using prawn or fish trawls, gillnets or long lines (Australian law requires fishers to quickly return them to the water unharmed). Sawfish are sometimes illegally targeted for their high value fins or for trophy saws, even though their international trade is now illegal under the Convention for the International Trade in Endangered Species of Wild Flora and Fauna. Recreational fishers are known to sometimes cut off the saw before returning them to the water, as is shown here for a green sawfish. *Photos: Barbara Wueringer (right), David Morgan (left)*





The magnificent snouts of sawfish serve many purposes: prey detection and incapacitation, defence and probably fighting and establishing social hierarchies. The saws can grow well over 1 metre long. Shown are the two researchers, Nicole with the rostrum of a largetooth sawfish and Barbara with a largetooth sawfish. *Photos: James Tweedley (left), Ruth Leeney (right)*

In some regions, the only clues to the former presence of sawfish are saws displayed in restaurants and bars.

and fins from getting caught in their gullet) and swallow it. Sawfish can tackle large prey – a 33 centimetre-long catfish was found in the stomach of a 1.3 metre largetooth sawfish.

Declines

Sawfish were once abundant in coastal tropical and subtropical waters around the world, but declines have been so severe they are now considered the most endangered of all the sharks and rays. Their coastal habitats are among the most densely populated with humans and heavily exploited, an overlap creating many problems for sawfish. All five species appear on the IUCN (International Union for Conservation of Nature) Red List, three as critically endangered and two as endangered. The largetooth sawfish was recently listed by the IUCN as one of the 100 most endangered species on the planet.

In some regions, the only clues to the former presence of sawfish are saws displayed in restaurants and bars. The best-documented decline was the loss of largetooth sawfish from Lake Nicaragua in Central America, where in the 1970s some 60,000 to 100,000 were fished in five years. Not one was found during a 1992 survey. Nicaragua's 2006 ban on sawfish fishing was likely decades too late.

Like many species susceptible to over-exploitation, sawfish grow large, live long, mature late, and produce few offspring. Largetooth sawfish, the best-studied species in Australia, can grow to over 5 metres. They become sexually mature when they are 2.5–3 metres long, at roughly eight years of age. They may breed annually, and give birth to up to 12 pups after a gestation of about five months. Other sawfish species are probably similar, except for the narrow sawfish, which reaches maturity after three to six years.

Sawfish face their greatest threats in Australia and elsewhere from commercial and recreational fishing. Their rostrum all too easily becomes entangled in fishing nets and lines. It is illegal to directly target sawfish in Australian waters, but they are often caught accidentally (as bycatch) by commercial and recreational fishers. Although Australian law requires that they be quickly returned unharmed to the water, recreational fishers sometimes remove the saw as a trophy. Despite reports of sawfish surviving the loss of their saw, they are likely to be much weaker and less able to reproduce or defend themselves without it. Sawfish fins are among the most valuable in the illegal international fin trade, and have been targeted in Australian waters by foreign fishing vessels, but the extent of this is unknown.

Northern Australian stronghold

Although Australian sawfish populations have suffered substantial declines, leading to the listing of the three P*ristis* species as threatened under national laws, the losses here have probably not been as severe as elsewhere, probably because northern Australian waters are still relatively pristine. The Australian populations of largetooth, dwarf, green and narrow sawfishes are thought to be the last viable populations of these species, and therefore central to global conservation efforts.

We cannot assume that the future of Australian sawfishes is secure. Essential for conservation is a better understanding of their biology, including whether the regional populations of each species are interconnected or isolated. Conserving small, isolated populations can be difficult because they are not replenished by animals migrating from elsewhere. The management of larger populations also has its challenges for it requires cooperative management across state or international borders.

Genetic revelations

It is a tough job to study rare animals that live in murky waters in remote regions and do not come to the surface to breathe (like marine mammals). Fortunately, modern genetic techniques using small tissue samples (a biopsy from a live animal or skin from a rostrum) have made it much easier to study the population biology of sawfishes. Nicole has analysed patterns of mating and dispersal in northern Australian populations of largetooth, green and dwarf sawfishes, using two types of genetic markers to distinguish patterns for males and females. This work has revealed contrasting population structures in species that use different habitats.

Largetooth sawfish live in freshwater as juveniles and marine waters as adults, a segregation unique among shark and ray species living today. Their genes show there is a flow of paternal genes between regional populations but not of maternal genes, which implies that males and females have different patterns of dispersal. It appears that female largetooth sawfish give birth in the same region, perhaps the same river mouth, that they themselves were born in. Known as philopatry, this strategy enhances the chances of the young being born at the entrance to a suitable river, from where they travel upstream to spend the first eight years of life. Female philopatry is advantageous in northern Australia, where high quality freshwater nursery habitats are sparse. Male largetooth sawfish differ from females in not being tied to particular river mouths for breeding. A male from the west coast, for example, may mate with females from as far away as the Gulf of Carpentaria.

This dual dispersal pattern – of females with small reproductive ranges and wider-ranging males – is common in the animal kingdom but challenging for conservation. Protecting females, pupping grounds, and nursery areas need to be high priorities, for if a population of largetooth sawfish is lost from a river or group of rivers, the species may not re-establish there naturally, at least not for some time. This is especially so for the west coast, where the Fitzroy River has the only known large population of largetooth sawfish. A decline in one location could be to the detriment of populations elsewhere that are linked by male dispersal.

In contrast, there is little to no gene flow between regional populations of green or dwarf sawfishes. Like many coastal rays, they live in marine and estuarine waters their entire lives, and use inshore and mangrove areas as nurseries. Their genes reveal that the dispersal and mating of both males and females is highly restricted in northern Australian, although we don't know where the boundaries between regional populations lie. Because the risk of localised extinctions for these species is high, conserving both males and females, as well as pupping grounds and nursery areas, all need to be priorities.

These genetic insights are part of the information being used by the Australian government to develop recovery plans for the largetooth, green and dwarf sawfishes. Because the north is relatively undeveloped, the prognosis for sawfishes in Australia could be good, so long as they are kept safe from fishing, and the habitats they use during key life stages are protected. Proposed mines in the Cape York and Fitzroy River regions could harm sawfish populations.

There is still much more we need to learn about these magnificent creatures. Once they leave their nursery areas, virtually nothing is known about their adult lives, a large gap in the knowledge needed to conserve them. ■

READING: For the latest on sawfish research and conservation, go to sawfishconservationsociety.org ■ Phillips N. 2012. *Conservation genetics of Pristis sawfishes in Australian waters*. Doctor of Philosophy thesis. Murdoch University ■ Phillips N, Chaplin J, Morgan D, Peverell S. 2011. Population genetic structure and genetic diversity of three critically endangered *Pristis* sawfishes in Australian waters. *Marine Biology* 158: 903–15 ■ Whitty J, Phillips N, Morgan D, *et al.* 2014. Utility of rostra for the identification of Australian sawfishes. *Aquatic Conservation: Marine and Freshwater Ecosystems* 24: 791–804 ■ Wueringer B, Squire L, Kajiura S, et al. 2012. The function of the sawfish's saw. *Current Biology* 22(5): R150–5 ■ Wueringer B, Peverell S, Seymour J, *et al.* 2011. Sensory systems in sawfishes. 1. The ampullae of Lorenzini. *Brain, Behavior and Evolution* 78(2): 139–49 ■ Wueringer B, Peverell S, Seymour J, *et al.* 2011. Sensory systems in sawfishes. 2. The lateral line. *Brain, Behavior and Evolution* 78(2): 150–61.

DR NICOLE PHILLIPS is a conservation geneticist who has been studying sawfish for nearly 10 years. The genetic research described here was conducted at Murdoch University. She is currently working at the Cooperative Institute for Marine and Atmospheric Studies, University of Miami, on the population genetics of bottlenose dolphins in the Gulf of Mexico.

DR BARBARA WUERINGER is a zoologist who has been studying the behaviour of sawfishes for over nine years. The research described here on how sawfish capture their food was conducted at the University of Queensland and the University of Western Australia. Barbara is an Adjunct Senior Research Fellow at James Cook University.

Virtually nothing is known about their adult lives, a large gap in the knowledge needed to conserve them.

This green sawfish was caught off Picnic Point at Maroochydore, Queensland in about 1940. They are no longer found in those waters. Their current distribution is thought to be from about Mackay (Queensland) across northern Australian waters to Shark Bay (Western Australia).