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Sharks and rays

Summary

- Some 125 species of sharks, rays, skates and chimeras are found in the Great Barrier Reef (the Reef), and inhabit a wide variety of habitats.
- Sharks have very conservative life history traits and are generally unable to withstand the levels of fishing most bony (teleost) fishes are able to sustain. Many shark fisheries around the world have collapsed.
- As sharks are apex predators, they help to control populations of prey species. Consequently, reducing the number of sharks may have significant and unpredictable impacts on other parts of the ecosystem.
- There is very little information available about the sharks in the Reef, and their status is unknown. The basic biological characteristics of most species in the Reef have yet to be studied.
- Some sharks found in the Reef are listed as threatened species. Some of these sharks are protected under Great Barrier Reef Marine Park legislation, state legislation and the *Environmental Protection and Biodiversity Conservation Act 1999*. Recovery plans have also been developed for the great white shark and grey nurse shark, while recovery plans for the Bizant River shark and whale shark are in various stages of completion.
- The main pressure on sharks in the Reef is fishing, and this pressure is increasing. More than 90% of the Reef commercial shark harvest is taken by the gillnet fishery with the remainder taken by the line and trawl fisheries. However recreational fishermen catch and retain a significant number of sharks.
- The commercial harvest of shark has increased four fold between 1994 and 2003. It is unknown whether this level of fishing is sustainable.
- There is inadequate reporting of shark catch and there are no species specific catch and effort data. Further, bycatch and shark finning are significant issues but poorly documented. The practice of removing shark fins and discarding the body at sea is now banned in the Reef, and measures have been introduced to reduce bycatch in non-target fisheries.
- Some sharks are highly migratory and travel large distances. As a result, they are also subject to pressures from fisheries outside the Reef such as the Northern Shark Fishery, Eastern Tuna and Billfish Fishery, and fisheries throughout Australia and the wider Pacific.
- The existing fisheries research, stock assessment and management regimes for sharks in the Reef need to be improved if the shark fishery is to be managed sustainably. Research is currently underway to collect more robust data on the Reef shark catch, and these data will form the basis of future stock and species risk assessments.
- International and national initiatives such as the *National Plan of Action for the Conservation and Management of Sharks*, and assessments under the *Environment Protection and Biodiversity Conservation Act (1999)* are also driving new research and efforts to improve the sustainability of fisheries impacting sharks. Public education and awareness raising programs have also been implemented.
- Other pressures include the degradation of habitats such as seagrass meadows and estuarine systems from terrestrial runoff and coastal development. This is being addressed through coastal zone management initiatives and the *Reef Water Quality Protection Plan*.
- The rezoning of the Great Barrier Reef Marine Park has improved the level of protection of the biodiversity and ecological functions that support the various habitats of the Reef. The new Great Barrier Reef Marine Park Zoning Plan came into effect on 1 July 2004, and

will increase the resilience of the Reef ecosystem in the face of multiple pressures, as well as helping to sustain the ecological processes and habitats that support shark populations.

Condition

The diversity of sharks on the Great Barrier Reef

The Reef is home to approximately 122 species of sharks and rays (Elasmobranchii) and three species of chimera (Holocephalii). For simplicity, the term s*hark* is used throughout this chapter to include sharks, rays, skates and chimeras. The sharks of the Reef are very diverse in size, appearance and lifestyle. They range from small, cryptic species with limited home ranges such as the epaulette shark, to large, highly migratory species, such as the whale shark. All sharks are predatory and feed on a wide variety of prey. Small, bottom dwelling sharks may live on crustaceans and molluscs while reef sharks and open water sharks prey upon fishes. Some species, such as whale sharks and manta rays, are specialist feeders that live on plankton.

Sharks live in a variety of habitats, ranging from coral reefs to open water pelagic zones and benthic habitats of the inter-reefal and lagoonal regions of the continental shelf.[22] Many species move between these different habitats at various stages of their life cycle, using habitats such as estuaries and seagrass beds as nurseries or foraging grounds.[4,26,41]

There is a great diversity of sharks in the Great Barrier Reef, ranging from the small, home ranging epaulette shark (top) to the large, highly migratory whale shark (bottom)

Roles in marine ecosystems

Many sharks are considered to be top level predators and occupy ecological niches at the top of the food chain. Consequently, sharks are naturally less common than prey species lower down in the food chain, and they are thought to have a significant effect on prey populations.[35,39,52] Ecosystem models suggest that in this role, sharks help to regulate the populations of prey species and in doing so maintain the balance of the ecosystem. These models also suggest that depleting shark populations may have significant and unpredictable effects on marine food webs. In one scenario, the removal of tiger sharks resulted in a population explosion of sea birds. The increased bird numbers led to uncontrolled predation by seabirds on fishes to the extent that fish populations collapsed.[49]

Life history and biology

Sharks have very different life history traits compared to bony (teleost) fishes, and are often described as possessing “K-selected” life histories. This means that sharks have reproductive strategies geared towards producing a small number of young that have high survival rates. Compared to bony fishes, sharks:

- are slow growing and long lived;
- have fewer natural enemies and lower adult mortality rates;
- reproduce slowly and produce few young; and
- take a long time to reach sexual maturity compared to bony fishes.[6,19]

This means that the number of young produced is closely linked to the number of breeding adults. Thus, as the number of adult sharks declines, the number of new recruits (new individuals entering a population from birth or migration) entering the population may also quickly decline. This also means that once shark populations are depleted, they may take decades to recover. In this context, shark populations have characteristics similar to marine mammals such as dolphins,[6] and are especially vulnerable to human pressures.

In contrast, bony fishes such as coral trout have a much higher reproductive potential. A single female coral trout may produce millions of eggs every year. While very few of the resulting larvae survive, this high reproductive capacity provides these populations with a "buffer zone". A very small increase in larval survival may result in a large increase of juvenile and adult fish in later years. This influx of young may help to "buffer" the impacts of human pressures such as fishing.

Lemon sharks are often found in shallow reef lagoons throughout the Great Barrier Reef. Compared to bony fish, sharks live for a long time, grow slowly and produce few young. This means that shark populations are very sensitive to intense pressures, and once depleted, can take decades to recover.

Determining condition

Lack of critical information

Around the world, sharks have traditionally been low value fisheries and thus have received relatively little research, management or conservation attention. In the Reef, there is very little information available about the status of sharks and no stock assessments or population studies have been undertaken. For many species, basic biological characteristics such as size and age at maturity, growth rate, fecundity (the reproductive capacity of a species) and ecological relationships are unknown. This lack of information is a serious concern as life history data are crucial to determining the amount of fishing pressure shark populations can sustain. A further complication is that it may often be very difficult to tell different species of sharks apart. For example, in 1986, the main species harvested in the Northern Shark Fishery was found to comprise two similar but distinct species, the spot-tail shark (*Carcharhinus sorrah*) and the Australian blacktip shark (*C. tilstoni*).[23,54] These two species were previously thought to be the same species.

Currently, the only information available about the status of sharks and rays in the Reef is based on data collected by the following programs:

- The Northern Pelagic Fish Stock Research Program
- Independent research projects
- Commercial fisheries logbooks

Data from the Northern Pelagic Fish Stock Research Program (1980 – 1987)

The Northern Pelagic Fish Stock Research Program (NPSFRP) collected data from sharks taken by Taiwanese and Australian gill net fishermen and research vessels between 1980 and 1987.[48,52] The region studied extended from Port Hedland in Western Australia, through the Gulf of Carpentaria to Cape York and southwards along the inshore regions of Queensland's east coast to Cairns. The program collected biological information on a variety of sharks found in northern Australia, including 27 species also found in the Reef. The study documented the species composition, size and sex ratios of the northern Australian shark

catch, shark weight to length relationships, diet, and reproductive characteristics.[26,28,51-54] The program also provided information on the population dynamics of certain species. For example, tagging and genetic studies were undertaken for the two main species taken by gill net fishermen (the Australian black tip shark and spot-tail shark) to determine their movement patterns, distribution, stock structure and population dynamics.[13,23,50,53] While this study generated important information about sharks and rays in northern Australia, it is unknown how closely the findings can be applied to shark populations in the Reef.

Data from independent research

Independent studies on sharks in the Reef are limited to research on individual species at specific locations,[18,42,44] and from specimens caught in the Queensland Shark Control Program.[41] More recently, independent research at James Cook University has been undertaken on the biology, abundance and status of the grey reef shark (*Carcharhinus amblyrhynchos*) and whitetip reef shark (*Triaenodon obesus*). Preliminary data from this work suggests that Reef populations of grey reef sharks and whitetip reef sharks are declining (Robbins, W., pers. comm., Feb 2005). Movement and habitat use studies are also being conducted for some species. Satellite tag tracking data have shown that tiger sharks migrate for significant distances, with tiger sharks (*Galeocerdo cuvier*) tagged off Raine Island in the northern Reef swimming as far as the Gulf or Carpentaria (Fitzpatrick, R., pers. comm. Feb 2005). While independent research has provided important information for some species, there is little information about the population status, distribution and life history traits for most of the sharks of the Reef.

Data from commercial fisheries logbooks

Since 1988, Queensland's commercial fishermen have been recording the *harvest*[*] of sharks and fishing effort in standardised Commercial Fisheries Information System (CFISH) logbooks. However, the information recorded in CFISH logbooks is limited. Furthermore, the logbook data have not yet been validated[†], and it is unknown how well logbook data represent actual harvest and effort levels.

Some fisheries in the Great Barrier Reef take species such as the grey reef shark (above). Unfortunately the information recorded in commercial fisheries logbooks cannot be used to identify species level catch rates, or trends in shark populations.

Limitations of logbook effort data

Information about *fishing effort*[§] is important for calculating *Catch Per Unit Effort*[#] statistics. These statistics are often used as an indicator of population condition (see *Limitations of catch per unit effort trends*). However, the information about fishing effort in the Reef recorded in commercial fisheries logbooks is limited. In Queensland waters there is no specific "shark fishing licence", instead, fishermen participating in net and/or line fisheries are permitted to take sharks as part of their catch (see *Pressure*). As such, it is difficult to define what a shark fisher is and subsequently, difficult to calculate how much targeted fishing effort is directed at sharks.[36] Currently, targeted shark fishing is recorded in CFISH logbooks as a fishing day where the majority of the catch is shark. This may not accurately portray targeted shark fishing effort as it is unclear whether the sharks caught were targeted or taken as *bycatch*[‖] while fishing for other species.

Limitations of logbook catch data

Currently, the take of sharks is only recorded as the weight of fillets, trunks or fins. No information is recorded about the number of sharks of different species taken, their sex or their size.[37,38] As the sharks are not identified to species, logbooks do not provide any information on whether the catch is comprised of large numbers of a few species, or more similar numbers of sharks taken from a wide range of species. This means that the pressure on any particular species is unknown. Identifying the species composition of the catch is vital in determining the sustainability of the fishery, as faster growing and early maturing sharks such as the sharpnose shark (*Rhizoprionodon taylori*) are better able to sustain limited levels of commercial fishing than slower growing species.[45] Another limitation of the logbook data is that the bycatch of sharks is poorly recorded. Therefore, the total catch of sharks (which includes both sharks that are retained, and sharks taken as bycatch) is unclear (see *Pressure: incidental catch and shark finning*).

Limitations of Catch Per Unit Effort trends

Fisheries managers often use Catch Per Unit Effort[#] (CPUE) data as an indicator of population condition. Unfortunately, the limitations of shark catch and effort data in CFISH logbooks mean that CPUE trends cannot be generated for individual shark species or populations. While logbook data have been used to show that the overall CPUE for sharks is increasing (see *Pressure – Fig 1*), this does not provide any information about the condition of specific species or populations. Programs have been implemented to improve the recording of the commercial shark catch and to validate logbook data (see *Response*).

The limitations of logbook data were made apparent in 1997 during the stock assessment workshop for the Northern Shark Fishery (which includes part of the northern Reef). The workshop noted that the CPUE data recorded in the fishery's commercial logbooks were unlikely to provide trends that were proportional to changes in actual stock size, and there was little prospect that the data would prove to be more useful in the future.[48]

Condition: Sharks of conservation concern

Several sharks found in the Reef are recognised as being of particular *conservation concern*. Some of these sharks are protected under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999) and state legislation (see *Response*). Many species are also listed under the World Conservation Union (IUCN) Red List as shown in Table 1.

Table 1, EPBC and IUCN conservation status listings for some sharks found within the Reef (compiled from Pogonowski *et al*, 2002; Cavanagh *et al*, 2003)

CR – Critically endangered	EN – Endangered	VU – Vulnerable
NT – Near Threatened	LC – Least concern	DD – data deficient
* specific listing for Australia	** specific listing for QLD and/or NSW	

More information about these categories and how species are assessed can be found at the IUCN Red List website.

Common and Taxonomic Name	EBPC listing 2002	IUCN listing 2003
Bizant River shark *Glyphis* sp. A	**CR**	**CR***
Grey nurse shark *Carcharias taurus*	**CR**	**VU*/CR****
Dwarf sawfish *Pristis clavata*	-	**EN***
Green sawfish *Pristis zijsron*	-	**EN**
Freshwater sawfish *Pristis microdon*	**VU**	**EN**
Narrow sawfish *Anoxypristis cuspidata*	-	**EN**
Whale shark *Rhincodon typus*	**VU**	**VU**
Great white shark *Carcharodon carcharias*	**VU**	**VU**
Colclough's shark *Heteroscyllium colcloughi*	-	**VU**
Estuary stingray *Dasyatis fluviorum*	-	**VU***
Porcupine ray *Urogymnus asperrimus*	-	**VU**
Gulper shark *Centrophorus granulosus*	-	**VU**
Blacktip reef shark *Carcharhinus melanopterus*	-	**NT**
Dusky shark *Carcharhinus obscurus*	-	**NT**
Sandbar shark *Carcharhinus plumbeus*	-	**NT**
Crocodile shark *Pseudocarcharias kamoharai*	-	**NT**
Shortfin mako *Isurus oxyrinchus*	-	**NT**
Blacktip topeshark *Hypogaleus hyugaensis*	-	**NT**
Grey reef shark *Carcharhinus amblyrhynchos*	-	**NT**
Spinner shark *Carcharhinus brevipinna*	-	**NT**
Bull shark *Carcharhinus leucas*	-	**NT**
Tiger shark *Galeocerdo cuvier*	-	**NT**
Blue shark *Prionace glauca*	-	**NT**
Whitetip reef shark *Triaenodon obesus*	-	**NT**
Scalloped hammerhead *Sphyrna lewini*	-	**NT, LC***
Great hammerhead *Sphyrna mokarran*	-	**DD, LC***
Bluespot ribbontail ray *Taeniura lymma*	-	**NT**
Spotted eagle ray *Aetobatus narinari*	-	**DD**
Manta ray *Manta birostris*	-	**DD**
Banded wobbegong *Orectolobus ornatus*	-	**NT**
Common blacktip shark *Carcharhinus limbatus*	-	**NT**

Sharks of particular conservation concern in the Reef include the great white shark, grey nurse shark, whale shark, Bizant River shark and several species of sawfish.

- The great white shark (*Carcharodon carcharias*) is rarely seen in the Reef and is known mainly from records maintained by the Queensland Shark Control Program. This species is highly migratory and tagged individuals have been shown to travel distances up to 3,000km (CSIRO, August 2004) The great white shark is thought to be naturally scarce and has a very low reproductive output. The number of great white sharks caught in shark control gear and by game fishermen has declined since the 1950s, but there are no detailed population estimates available.[9,33]

- Grey nurse sharks (*Carcharias taurus*) are sighted more frequently in the coastal waters of southern Queensland and New South Wales, but there are confirmed records of their occurrence in the Reef. These records include sharks that were tagged in southeast Queensland, demonstrating that these sharks may travel significant distances along the east coast. The east coast grey nurse shark population is listed as critically endangered, with an estimated 500 individuals remaining.[9,33] The main pressures on grey nurse sharks appear to be fishing activities and shark control programs.

The grey nurse shark is a transient visitor to the Great Barrier Reef. These sharks are critically endangered, and surveys suggest that only 500 individuals remain on the Australian east coast.

- Whale sharks (*Rhincodon typus*) are occasionally sighted in the Far Northern regions of the Reef. Whale sharks are highly migratory and are believed to range widely throughout the Indo-Pacific region. As such, pressures throughout the extent of their range affect their condition. The main threat to whale shark populations in the Indo-Pacific region appears to be commercial fishing. There are indications that the global whale shark population has declined.[33]
- The Bizant River shark (*Glyphis species A*) is one of possibly five *Glyphis* species, and there is very little information available about these species. Although *Glyphyis* sp. A has only been recorded in the upper freshwater and brackish regions of the Bizant River near Princess Charlotte Bay, this species may also occur in estuarine habitats within the Great Barrier Reef Marine Park (Last, P., pers. comm., October 2004; Pillans, R., pers. comm., October 2004). Although it is not targeted by fishermen, its extreme rarity, low reproductive rate and limited distribution make the Bizant River shark exceptionally vulnerable to habitat loss and localised fishing pressure.[9,33] There are concerns that the Bizant River Shark may have disappeared from the Bizant River and further research on the status and distribution of this species is required.[21]
- At least four species of sawfish have been recorded in the Reef region and all are generally considered as vulnerable species. The freshwater sawfish (*Pristis microdon*) is already listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act), and the other sawfish species have been recommended for listing.[33] Worldwide, sawfish populations have sharply declined. Sawfish reproduce slowly and their large toothed saws are easily entangled in nets. In northern Australia there is evidence that populations of the dwarf sawfish (*P. clavata*), green sawfish (*P. zijsron*), freshwater sawfish (*P. microdon*) and narrow sawfish (*Anoxypristis cuspidata*) have been significantly reduced due to fishing pressure. Sawfish were once a major component of the bycatch in net fisheries but are now infrequently encountered.[33] Additionally, sawfish fins are considered to be amongst the most valuable shark fins by Asian markets. Around the world, this has motivated some fishermen to retain and fin any sawfish taken as bycatch.[37] While there are numerous records of the dwarf sawfish and green sawfish from the Reef, there are relatively few records of the

Sawfish are easily entangled in nets. Bycatch in trawl and gill nets is a major cause of sawfish declines around the world.

freshwater sawfish and narrow sawfish. The freshwater sawfish *P. microdon* has been recorded from river systems adjacent to the Reef, but anecdotal reports suggest that this species is also found in estuarine and marine habitats of the Great Barrier Reef Marine Park (Squire, L., pers comm., June 2004; Simpfendorfer, C., pers comm., July 2004). There are also records of the narrow sawfish (*A. cuspidata*) occurring in the Great Barrier Reef Marine Park from independent research and the Queensland Shark Control Program[33] (Simpfendorfer, C., pers comm., July 2004).

Condition summary

Overall, the condition of sharks in the Reef is unknown. While new research programs have been initiated since 2000 (see *Response*), there is a significant lack of knowledge about the population status, distribution, life history traits and ecological characteristics for most species of shark and ray found on the Reef.

The biological susceptibility of sharks to over fishing, evidence for increasing fishing pressure and lack of information have given rise to increasing concern about the sharks and rays of the Reef.

Australia's freshwater sharks:

At least seven species of shark and ray are thought to live exclusively in freshwater habitats throughout Australia. A further 90 Australian shark and ray species are known to venture into estuarine and freshwater habitats from time to time.[21] There are very few records of freshwater sharks and little is known about their biology or distribution. The only records of the Bizant River shark (*Glyphis Species A.*) were taken from specimens captured over 15 years ago. The reason for this lack of records remains a mystery.[21]

Around the world, freshwater sharks and rays are amongst the most threatened of all shark and rays species due to their restricted distribution and proximity to humans. The degradation of freshwater habitats caused by dams and water impoundments, diversion of river water for irrigation, pollution, land clearing and siltation place considerable pressure on these sharks. Fishing in inshore habitats and rivers also poses a significant threat given the restricted distribution and slow reproductive rates of these species.[11,21] It is possible that the Bizant River shark has already become locally extinct, however more research into the status of this species is required.[21] Some freshwater sharks are now listed as protected species, and research is being conducted to find out more about their distribution and habitat use.[32]

Freshwater sharks, such as the freshwater sawfish (above), are considered especially vulnerable to human impacts.

Pressure

The sharks of the Reef are affected by a variety of pressures. Although fishing activities place the most direct pressure on sharks, factors such as habitat degradation and tourism may apply indirect pressure on shark populations. The individual pressures discussed in the following section may occur simultaneously, resulting in multiple pressures on the sharks and rays of the Reef.

Pressure: Commercial fishing

Global trends in shark fisheries

Sharks have historically been harvested for meat, fins, cartilage and shark liver oil. Since the mid 1950s, sharks have come under increasing pressure from commercial fishing. Data from the United Nations Food and Agricultural Organisation show a steady increase in reported global shark landings from approximately 271,813 tonnes in 1950 to 824,772 tonnes in 2001 (Sant, G, *pers comm*. Nov 2003). However, there is concern that the actual shark catch may be twice that recorded in fisheries logbooks due to under-reporting of both catch and bycatch.[5]

Much of this increased fishing pressure has been driven by increased demand for alternative sources of fish protein as traditional fisheries have declined, and rising demand for shark liver oil and cartilage.[58] Since the 1980s, economic success throughout Asia has made luxury items such as shark fin soup more affordable. As a result, the global demand for shark fins has dramatically increased. [37,58] Given their conservative life history traits, sharks are unable to

sustain the levels of fishing that most teleost fishes can maintain. There are many examples of collapsed shark fisheries around the world, including shark fisheries subjected to monitoring and management efforts. Well known examples of 'boom and bust' shark fisheries include the Californian soup-fin shark fishery, the porbeagle shark fishery in Norway, the school shark fishery off southern Australia, the spiny dogfish fishery in the Northern Atlantic and the common skate fishery in Western Europe.[5,6,8,58] While Australia lands only a small fraction of the global shark harvest,[5,58] sharks comprise 4.9% of Australia's total capture fishery production, the fourth highest such statistic in the world.[40]

Commercial shark fisheries in the Great Barrier Reef

In the Reef, sharks are taken as both target species and as bycatch in various fisheries. However, there is no designated shark fishery in the Reef and sharks are taken by fishermen participating in net and line fisheries along the Queensland east coast. Consequently, there are no fisheries management plans in place that consider the vulnerable nature of sharks to fishing pressures (see *Response: Management of the Great Barrier Reef net fishery*).

In the Reef, over 90 % of the reported commercial shark harvest is taken by some 200 vessels participating in the coastal and offshore gillnet fishery.[38,40] The gill net fishery is also known as the N1 and N2 gillnet fisheries, and catches and harvests shark along with mackerel, barramundi, threadfin salmon and other finfish. The remaining 10% of the reported shark harvest is taken by the reef line and trawl fisheries. The reef line fishery retains mainly silky sharks, blacktip reef sharks and whitetip reef sharks for their fins,[37] while the trawl fishery has previously reported landings of between 10 and 30 tonnes of shark per year.[38,60] However, sharks are no longer retained by the trawl fishery, and the practice of removing shark fins and discarding the carcass at sea is now prohibited in Queensland waters (see *Response: bycatch and shark finning*). For more information on these fisheries, see *Management status – fisheries* and *Environmental status – fishes* *[Note-currently being updated]*.

In recent years, the proportion of the total shark harvest taken from the Reef has risen from approximately 60% of the total Queensland east coast harvest in 1993, to 84% of the harvest in 2003.[34] The total Gross Value of Production derived from sharks taken from the Reef has risen from A$2.1 million in 1988, to A$7.7 million in 2003.[34]

Species composition of the Great Barrier Reef shark harvest

There are no long-term data on the numbers of individual shark species taken by commercial fishermen in the Reef. Additionally, many sharks are difficult to identify and the taxonomy for some species has not been adequately studied. Since 2001, steps have been taken to improve the recording of shark catch (see *Response*) and preliminary data from projects undertaken by the Fisheries Research and Development Corporation (FRDC) and CRC Reef Research Centre (CRC Reef) are now available. Observers on board commercial fishing vessels have now collected data on the species composition of the catch for four fishing trips. These data suggest that while the catch composition of shark species varies between areas and fishing depths, the catch appears to be dominated by the Australian blacktip shark (*Carcharhinus tilstoni*) (32% of shark catch) and the scalloped hammerhead shark (*Sphyrna lewini*) (18% of shark catch).[38] Other sharks taken include the spot tail shark (*C. sorrah*) (7.7% of shark catch), the white-cheek shark (*C. dussumieri*) (7.5% of shark catch), milk shark (*C.Rhizoprionodon acutus*) (6.8% of shark catch) and the grey reef shark (*C. amblyrhynchos*) (6.6% of shark catch).[38] A further 14 species taken in lower numbers.

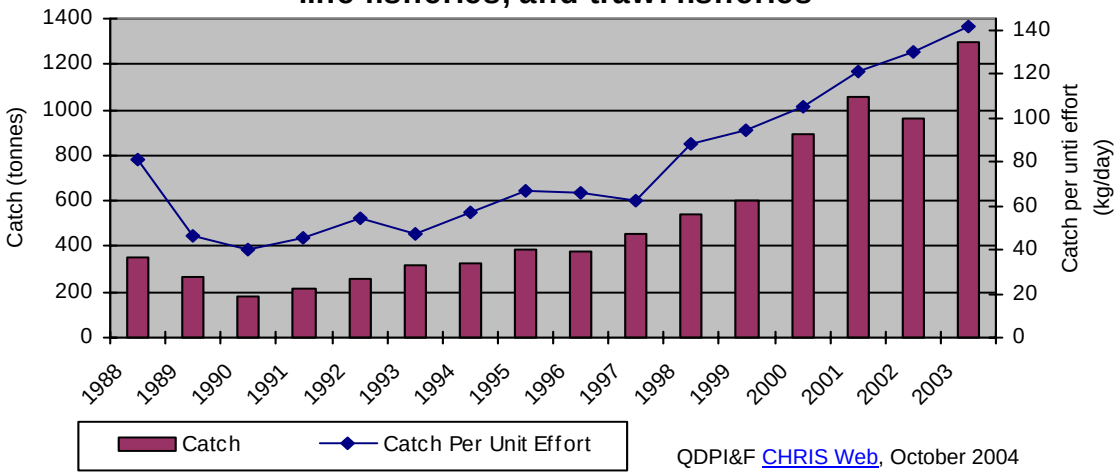
Nevertheless, more data over longer periods are required to gain an adequate understanding of the species composition of the catch. Until there is better information about the catch composition and the resilience of these species to fishing pressure, the sustainability of current fishing levels cannot be determined.

Trends in shark catch and fishing effort on the Great Barrier Reef

Pressure on sharks is increasing in the Great Barrier Reef, with annual shark harvests tripling in recent years and increased fishing effort targeting sharks.

The pressure on sharks in the Reef has been steadily increasing since 1990, with more specialist shark fishermen entering the gillnet fishery and more effort being directed to target sharks.[38] CFISH logbooks record a four-fold increase in the reported shark harvest from about 326 tonnes in 1994 to 1294 tonnes in 2003 (Fig. 1). The rise in CPUE is most probably explained by changes in fishing activity. Estimates of targeted shark fishing effort (as the percentage of fishing days targeting shark) have risen by 28% over the same period (Table 2). In 2001, the Townsville region was the most productive shark fishery along the east coast, with an estimated 30% of the total catch and 21% of the effort.[38] For more information about gillnet and reef line fisheries and their management, see *Environmental status – Fishes* and *Management status – fisheries*.

Fig. 1 **Annual shark harvest and Catch Per Unit Effort for the Great Barrier Reef World Heritage Area from net and line fisheries, and trawl fisheries***



* it is now prohibited to retain sharks taken as bycatch in trawl nets. As such, catch figures for 2003 are for net and line fisheries only

While fisheries logbooks indicate that fishing pressure on sharks is increasing, at this time they cannot provide more detailed information on fishing effort and population condition due to the data's limitations (see *condition – data on stock condition from fisheries logbooks*). Furthermore, until logbook data are validated, the reported figures for shark harvests can only be considered as indicative.

Table 2. Changes in gill net fishery catch and effort, and an estimate of the targeting of shark by gill net fishermen in the Great Barrier Reef. Data from Rose *et al*, 2003b.

	1994	1995	1996	1997	1998	1999	2000	2001
Total days	3565	3664	3524	4765	3826	3959	4706	5112
% of fishing days 'targeting' shark	32	34	32	31	28	29	39	41
Total shark harvest (tonnes)	209	218	222	306	353	413	637	628
% of the total shark harvest resulting from targeted effort	56	58	58	63	72	72	80	76

Pressure from fisheries in adjacent regions

Many species of shark that occur in of the Reef are highly migratory. For example, tagging and genetic studies have shown that Australian blacktip shark and spot tail shark populations should be considered as a single population across northern Australia.[53] Another study using satellite tracking has shown that tiger sharks travel large distances throughout northern Australia (Fitzpatrick, R, *pers comm.* 2003). Consequently, Reef shark populations may experience fishing pressure from fisheries in adjacent regions such as the Northern Shark Fishery, the Coral Sea fishery, the Eastern Tuna and Billfish Fishery, as well as fisheries in Indonesia. It is clear that the main pressure on sharks of particular conservation concern, such as the whale shark, great white shark and grey nurse shark, is the catch and bycatch of these species by fisheries throughout the rest of Australia and the wider Indo-Pacific region. However, identifying the specific impacts of these fisheries is very difficult, and the pressure these fisheries place on sharks in the Reef is not known. Further, it is unclear how many sharks are taken as targeted catch or bycatch in these fisheries (see below).

Pressure: Incidental catch and shark finning

Bycatch

Around the world, bycatch is often poorly reported and as a result, the total catch and impact of fisheries on shark stocks is often underestimated. Bonfil (1994) suggests that the actual global catch of sharks is double the reported catch due to the poor reporting. The 2001 Australian Government *Shark Assessment Report* suggests that across Australia, unrecorded bycatch levels may be up to 50% of the recorded catch,[37] and that much of this bycatch was finned (see *Pressure: shark finning*).

In Australian waters, sharks are also caught as bycatch in trawl fisheries, and in open ocean (pelagic) fisheries such as the Eastern Tuna and Billfish Fishery and Coral Sea fishery. A study of the Northern Prawn Fishery in the Gulf of Carpentaria found that 56 of the 70 shark species known to inhabit the area were taken as bycatch by prawn trawlers. This research also showed that over half these sharks died during capture.[40,55] In 1998 and 1999, the Eastern Tuna and Billfish Fishery captured between 10,000 and 14,000 sharks, most of which are thought to be bycatch. Blue

Many sharks such as the leopard shark (above) are taken as bycatch in various fisheries. Bycatch is a major issue in the management and conservation of sharks as it is generally poorly recorded, and may have significant impacts on shark populations.

sharks and porbeagle sharks are the main species caught by the fishery. Both species are sharks of concern and are listed on the IUCN Red List.[40]

Bycatch may also result in the take of vulnerable shark species. Research conducted on the Northern Prawn Fishery suggests that the sharks most at risk from trawl bycatch are those that are already scarce, are easily captured by trawl nets, and/or have low reproductive capacities. These species include sawfishes and some rays.[55] Sawfishes are particularly vulnerable to netting and trawling as their large toothed rostra are easily entangled. Bycatch in fishing nets is thought to be the major factor in the decline of these sharks.[33]

There is little information about the levels of bycatch on sharks in the Reef. The East Coast Trawl Fishery is thought to have taken a significant amount of shark bycatch, however the introduction of Bycatch Reduction Devices in 2000 may be reducing bycatch levels.[20] The effectiveness of Bycatch Reduction Devices in reducing the bycatch of sharks is currently being investigated (see *Response*). Sharks are also taken as bycatch in the gillnet and reef line fisheries, but little is known about bycatch levels, the species caught or the number of sharks that fishermen discard or release alive. The survival rate of those sharks released alive is also unknown, as is the catch of vulnerable shark species in these fisheries. Consequently, the total catch and impact of commercial fisheries on shark populations in the Reef is hard to determine.

Shark finning

In recent years there has been increasing attention drawn to the practice of cutting the fins off sharks and discarding the shark, sometimes still alive, back into the sea. Shark fins are prized by Asian markets for shark fin soup, a delicacy that has become more affordable with the increasing affluence of Asian countries.[37] According to some Australian shark fin traders, the fins of tiger sharks and guitarfish have the highest value, followed by the fins of hammerhead, blacktip and whitetip reef sharks and sawfish. Demand has raised fin prices and dealers may pay fishermen up to A$275 per kilogram of dried shark fin.[37]

Finning may result in additional pressure on shark populations. Since shark fins fetch high prices, some fishermen may choose to fin any sharks taken as bycatch instead of returning them to the water. For example, in Hawaii the numbers of sharks retained by fishermen rose from 2,200 sharks in 1991 to 60,000 sharks in 1998 of which approximately 99% were finned.[37] Alternatively, high prices may prompt some fishermen to begin targeting sharks specifically for their fins. By retaining only the fins, fishermen can maximise profits per trip as hold space is retained for only the most valuable products. Furthermore, shark finning is often not reported in logbooks, leading to the actual pressure on shark stocks being underestimated.

Shark finning in the Great Barrier Reef and Coral Sea

In Queensland, the practice of shark finning has been restricted since 2002 (see *Response*), meaning that fishermen in Queensland are no longer allowed to remove fins from sharks and discard the carcass. A national review of shark finning released in 2001 suggests that prior to the 2002 restriction of shark finning, significant numbers of sharks taken as bycatch in Queensland waters were finned.[37] Additionally, much of the shark taken by coral trout and crayfish vessels on the Reef were caught specifically for their fins.[37]

Nevertheless, relatively little is known about the trade of shark fins in the Reef. Data from the Queensland Department of Primary Industries and Fisheries (QDPI&F) suggest that between

108kg and 280kg of shark fin were produced between 1995 and 1997, however the actual level of shark fin derived from Queensland waters is unknown.[37] Differences between the various fisheries and the attitudes of fishermen to finning have hindered efforts to derive reliable estimates of the quantities of shark fin that have been generated by shark finning in Queensland.[37]

Outside the Reef, a large number of sharks were finned by the Eastern Tuna and Billfish Fishery operating in the Coral Sea, and by foreign longline vessels permitted to operate in Australian waters.[37]

Finned grey reef sharks. The high prices paid for shark fins have prompted fishermen around the world to fin sharks taken as bycatch. It is no longer permitted to fin sharks and discard the carcasses at sea in Queensland waters and the Great Barrier Reef. Photo courtesy of R and V Taylor.

Shark finning may also generate conflict with other users of the Reef. Recreational divers and tourism operators have reported finding finned shark carcasses at key dives sites in the Reef and Coral Sea. In some cases, the sites are renowned for the large numbers of sharks present and tourists chose to dive these sites specifically to see sharks. Encountering finned carcasses at such sites has a negative impact on the tourism industry given the economic value of sharks to the Reef tourism industry as dive attractions (see *Pressure: tourism*). Shark finning has been recognised as a wasteful and unsustainable practice and shark finning is now banned or restricted in fisheries operating in Queensland and the Coral Sea (see *Response: bycatch and shark finning*).

Pressure: Recreational fishing

A review of the recreational catch of sharks was undertaken as part of Australia's *Shark Assessment Report* released in December 2001. Recreational fishing is a major leisure activity with an estimated 800,000 Queensland residents participating in the fishery.[60] There are no recreational size or catch limits currently in place for sharks in Queensland, however recreational fishermen may not retain protected shark species and must abide by zoning provisions when fishing in the Great Barrier Reef Marine Park (see *Response*).

Recreational catch of sharks and rays

In 1997 and 1999, the QDPI&F conducted telephone interviews and surveys of recreational fishing diaries. These surveys suggest that sharks are a minor component of the catch kept by recreational fishermen, comprising 0.3% of the total number of fish retained by recreational fishermen in 1997, and 0.2% of the retained catch harvest in 1999. However, given the number of recreational fishermen in Queensland, these harvest rates equate to approximately 71,000 and 43,000 sharks retained by recreational fishermen in 1997 and 1999 respectively. A national survey of recreational fishermen conducted in 2000 and 2001 estimated that 35,899 sharks are retained by Queensland anglers every year.[27]

Using an estimated average weight of 15kg per shark retained (based on the Australian *Shark Assessment Report*),[40] the recreational shark harvest can be estimated as between 538 and 1097 tonnes per year. These levels are significant when compared to the commercial shark harvest fisheries across Queensland.

Recreational bycatch

The national survey of recreational fishermen suggests that across Australia, up to 81% of sharks caught by recreational fishermen are released.[27] Unfortunately, there is little information on the recreational bycatch and release rates of sharks in Queensland. It is also not known how many sharks survive after being released. An additional concern is that some recreational fishermen may not recognise the ecological value of sharks and instead, view them as "pests". This may motivate some recreational fishermen to destroy any sharks caught or use them for bait instead of releasing them. The lack of public understanding about the ecological values of sharks and their vulnerability have been recognised as a significant issue that is currently being addressed at a national level (see *Response: international and national management initiatives*).

Given the vulnerability of sharks to over fishing, the lack of data and difficulties in managing and monitoring recreational fishing, the harvest of sharks by the recreational sector is a growing concern. For more information about recreational fishing in the Reef, see *Environmental status – fishes.*

Pressure: shark control programs

Shark control or bather protection programs have operated in Queensland since 1962, and since 1937 in New South Wales. Currently, the Queensland Shark Control Program (QSCP) deploys six nets and 127 drum lines within the Great Barrier Reef Marine Park. The program operates on the principle that reducing the local population of potentially dangerous sharks reduces the risk to swimmers.[14,16] QSCP data show that between 1990 and 2000, an average of 916 sharks were caught per year. Approximately 33% of the sharks caught during this period are considered as dangerous to humans (23% of the catch being tiger sharks, 9% bull sharks, <1% great white sharks).[14]

While the Queensland Shark Control Program aims to reduce local populations of potentially dangerous sharks such as the tiger shark (above), it also takes many non-threatening sharks and rays.

Overall, the QSCP captures some 75 species of sharks and rays, many of which are relatively benign to humans.[14] The QSCP also captures sharks of conservation concern such as sawfish, grey nurse and great white sharks, as well as other threatened species such as dugongs and marine turtles (see *Environmental status – marine mammals* and *Environmental status – marine reptiles*). The QSCP annual catch of sharks is very low compared to the commercial and recreational catch, however the program appears to have contributed to localised depletions of some sharks, including relatively benign species.[30,43] QSCP contractors are urged to release benign species, but all 'large' sharks, including protected species such as the great white shark, are still retained. The program has been reviewed due to concerns about the cost and effectiveness of the program, and the take of bycatch species including threatened species such as the grey nurse and great white shark. These reviews have led to the replacement of nets with drumlines in some areas.[43] Research has demonstrated that drumlines can be as effective as nets in catching target shark species whilst reducing impacts on threatened species, nevertheless, research is currently being conducted to identify mechanisms to further reduce the QSCP's impact on bycatch species (see *Response*).

Pressure: habitat loss and ecosystem degradation

Many fishes, including sharks and rays, rely on inshore habitats for food, shelter or as nurseries for juveniles and pups. One study in northeast Australia suggests that a third of the fish species present were dependent on estuaries in some form.[4] Research on nearshore areas off Townsville revealed that at least eight species of sharks utilise inshore habitats, such as seagrass beds, as nursery areas for their pups.[46] Furthermore, such habitats are important foraging grounds for species such as tiger sharks.[17]

While the extent of habitat destruction evident in some areas of the world has not occurred in the Reef, habitats such as seagrass meadows and inshore coral reefs are under increasing pressure. Nearshore habitats may be affected by coastal development and the increasing run-off of sediments, pesticides and nutrients from the land. This increased run-off is a result of development, particularly agriculture, in catchments adjacent to the Reef. The impacts of run-off are being exacerbated by the loss of coastal habitats such as rainforests and wetlands that would otherwise 'filter' run-off. The run off of land based pollutants may result in excessive levels of nutrients that lead to more frequent algal blooms and ecosystem imbalances, smothering of inshore habitats by increasingly fine sediments, and the disruption of biological processes by increased levels of toxic pollutants. For more information on the status and pressures on important shark habitats, see *Environmental status - seagrasses*, *Environmental status - inter-reefal and lagoonal benthos*, and *Environmental status - water quality*.

Other factors may also exert pressure on the habitats that sustain the sharks and rays of the Reef. Climate change is predicted to cause changes in temperature regimes, sea level and weather patterns, which will subsequently have significant effects on habitats such as seagrass beds and coral reefs. Furthermore, these changes may also alter ocean circulation patterns and food web dynamics. While climate change is unlikely to directly affect shark populations, it may exert a significant, albeit indirect pressure on shark populations if critical habitats and food webs are degraded. More information on the habitats utilised by sharks can be found in the following chapters: *Environmental Status - water quality*; *Environmental status - seagrasses*; *Environmental status – inter-reefal and lagoonal benthos* and *Environmental status – corals*.

Habitats such as seagrass meadows are important nursery and foraging grounds for sharks.

Direct pressures from pollution

As apex predators, large sharks may accumulate high levels of toxic pollutants in their bodies over time. An analysis of sharks taken in the Northern Shark Fishery revealed that the flesh of large sharks had levels of mercury that exceeded limits recommended by the National Health and Medical Research Council.[24,25] In March 2004, Food Standards Australia New Zealand advised that pregnant and breastfeeding women should consume less that 150grams of shark or flake per fortnight.[15] Similar advisories have been released in the United States and United Kingdom.[56,57] In the Reef, fishermen avoid large sharks due to these concerns. In Southeast Asia, education campaigns by conservation groups have highlighted the risk of mercury contamination in shark fins used to make shark fin soup.[3] Apart from the risks to consumers

of shark products, there is concern over the potential effects of these pollutants on the health and reproduction of these sharks. However, these effects have yet to be investigated.

Pressure: Traditional use and cultural connections

Sharks and rays are an important food source for Aboriginal and Torres Strait Islander Communities. Many Indigenous communities have a wealth of traditional knowledge about the habits and behaviour, hunting and use of these animals. Fishing is a significant part of both the culture and day to day lives of Indigenous Australians in northern Australia, with over 90% of the community taking part in fishing activities.[10]

In parts of northern Australia, sharks and rays are seasonal foods that are usually caught between October and April. Some Aboriginal communities on the Cape York Peninsula consider certain species of stingray to be in season after the first thunderstorms of the wet season, or after the arrival of the Torres Strait Pigeon (*Ducula spilorrhoa*).[47] To some Aboriginal groups in the Kalumburu region of north-western Australia, the flowering of the Bush Almond is a sign to start fishing for stingrays.[12]

Sharks and rays are important to Indigenous Australians as a source of food, but many tribes have strong cultural connections with sharks and rays through totems and stories.

Traditional fishermen catch rays using spears thrown from the bow of a boat, or when wading. Stingray spines may be used as spear tips, and their livers are considered a delicacy by many traditional communities.[29] After capture, the livers are checked and a large white/pinkish liver indicates that the animal is suitable to eat.[47] In the Hope Vale and Lockhart River Communities on the Cape York Peninsula, small sharks such as the blacktip reef shark (*Carcharhinus melanopterus*) are eaten as well as rays, although they are not preferred. In these communities, sharks and rays are usually prepared as *buunhdhaarr*: the liver and flesh are separately washed, boiled, minced and then re-mixed together. *Buunhdhaarr* may be eaten straight or combined with onion and fried as meat patties.[47] In these communities the cowtail ray (*Pastinachus sephen*), thorny ray (*Urogymnus asperrimus*) and mangrove ray (*Himantura granulata*) are amongst the preferred species of ray, while rays with two caudal spines, such as the blue-spotted stingray (*Dasyatis kuhlii*) and blue-spotted fantail ray (*Taeniura lymna*) are considered inedible. Manta rays are also considered inedible.[47]

Little is known about the numbers of sharks and rays harvested by Indigenous communities in the Reef. In 2000 and 2001, a national survey of recreational and Indigenous fishermen was undertaken. The survey results suggest that Indigenous fishermen in Queensland catch an estimated 3,800 sharks and rays per year, most of which are taken from inshore waters.[10]

The Bandjin people tell the story of a giant shovelnose ray carrying two warriors into the sky, forming the constellation more widely known as the Southern Cross.

Many Indigenous communities have strong cultural connections with sharks and rays that are expressed through art, Dreamtime stories and totems. Rays are depicted in ancient rock art paintings as well as modern

artworks, and are totems for individuals and tribes. For example, the diamond stingray or *Yawa* is the totem for the Wuthathi people of Shelbourne Bay in north Queensland, and the shark is the totem of the Miriam Islanders of the Murray Islands in the eastern Torres Strait. A Dreamtime story told by the Bandjin people from the Hinchinbrook region tells the tale of two warriors who were carried into the sky by a shovelnose ray. The ray forms the constellation more commonly known as the Southern Cross, with the two warriors (the two pointer starts Alpha and Beta Centauri) being dragged along behind it (Butler, R., *pers comm.*, Feb 2005). There are many more Dreamtime stories that tell of sharks and rays carving out rivers and landscapes, and their close relationship with ancestors and traditional customs. More information about the cultural significance of sharks and rays to Aboriginal and Torres Strait Islander people may be found at the Great Barrier Reef Traditional Owners website.

Pressure: tourism

Tourism is a major commercial activity undertaken in the Reef, generating over A$5 billion per annum.[2] While thousands of tourists visit the region every day, most interactions between sharks and tourists in the Reef are passive with tourists encountering sharks by chance while snorkelling, diving or reef walking. Shark feeding is not permitted in the Reef, but several tourism companies operate long distance live-aboard dive vessels and conduct shark feeds on reefs in the Coral Sea.

It has been suggested that the intensive use of dive sites and harassment of sharks and rays by divers, may displace these animals from frequently visited sites.[1] In some areas of the Florida Keys, diving and boating activities have been identified as a disturbance to nurse sharks mating in shallow waters.[7] Nevertheless, tourism activities on the Reef are closely managed (see *Response*) and there is little information to suggest that tourism places significant pressure on sharks in the Reef. In contrast, tourism activities can promote the conservation and sustainable use of sharks as living resources. Sharks have an iconic status in the marine tourism industry in many areas including the Reef,[1] and shark ecotourism has been used in many areas to promote shark conservation efforts. Furthermore, the economic value of shark tourism is significant. A study in the Maldives during 1993 found that a single grey reef shark generated approximately US $33,500 per year at the most popular shark watching dive site, and was worth on average US $3,300 per year across all shark watching dive sites. In contrast, a dead grey reef shark was calculated to have a one-time value of US $32. In the Caribbean, the value of a single live Caribbean Reef Shark has been estimated at between US $13,300 and US $40,000 per year.[1] The income generated by shark ecotourism has prompted increased awareness and community education of shark conservation, as well as providing economic benefits for local communities.[1] For more information on tourism in the Reef, see *Management status – tourism and recreation*.

Scuba divers commonly encounter white tip reef sharks (above) on the Great Barrier Reef. Sharks are an important natural attraction to the Great Barrier Reef dive industry, and shark watching may generate significant economic benefits.

Response

Response: commercial and recreational fisheries

Jurisdictional arrangements

Fishing is the main pressure on sharks in the Great Barrier Reef Marine Park (the Marine Park). Within the Marine Park, both commercial and recreational fisheries are managed by the QDPI&F in accordance with the *Offshore Constitutional Settlement 1995*, while the Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for the conservation and wise use of the natural resources (including the fisheries resources) of the Marine Park. The QDPI&F's main management tools are fisheries management plans and regulations, and Fish Habitat Areas that restrict habitat disturbance in important fish habitats. As a multiple use marine park, the Zoning Plan implemented by the GBRMPA allows for extractive uses such as fishing in over 65% of the Marine Park. However, the type of fishing activities permitted are regulated through the Zoning Plan, and up to 33% of the Marine Park is set aside as no-take marine reserves that are closed to extractive activities such as fishing. The GBRMPA also participates in the QDPI&F's management planning process via membership on its fisheries Management Advisory Committees. For more information, see *Environmental status – Fishes* and *Management status – Fisheries*.

Management of the Great Barrier Reef net fishery

As 90% of the reported Reef shark catch is taken by the gillnet fishery, the management arrangements for this fishery are particularly important to consider. Current management arrangements for this fishery include the following:

- **Entry restrictions**: entry to the fishery is limited to licensed fishermen. In early 1998, a licence buy-back operation resulted in a reduction in the number of east coast commercial net endorsements from 1029 to 814.
- **Gear restrictions**: the length, drop, mesh size and line strength of commercial nets are regulated.
- **Vessel restrictions**: there are limitations to vessel size, upgrade and replacement.
- **Closures:** spatial and temporal closures have been introduced to protect juvenile and breeding stocks of target species (other than shark), and to reduce conflict among fishing sectors.

Nevertheless, there is no designated shark fishery on the Queensland east coast. Consequently, there are no fishery management plans, regulations or limits designed specifically for sharks and which consider the susceptibility of sharks to fishing pressure.[40] Fishermen generally avoid large sharks due to their mercury content but this is not mandatory. The lack of specifically designed management arrangements for sharks is of concern as sharks require a more conservative management approach if they are to be harvested sustainably.[59]

The QDPI&F has indicated that with the implementation of the *Coral Reef Finfish Management Plan*, resources are being made available to develop an East Coast Inshore Finfish Fishery Management Plan that includes sharks. In September 2004, the QDPI&F released a *Strategic Directions Document* to clarify the process and principles for developing a management plan for the fishery. The fishery will also be assessed under the

New research is underway to identify the species composition of the commercial shark catch, and to collect information on the biology and reproduction of these animals.

Environmental Protection and Biodiversity Conservation Act (1999) against the Australian Government's *Guidelines for the Ecologically Sustainable Management of Fisheries*. For more information on the management of the net fishery see *Environmental status – fishes* and *Management status - Fisheries*.

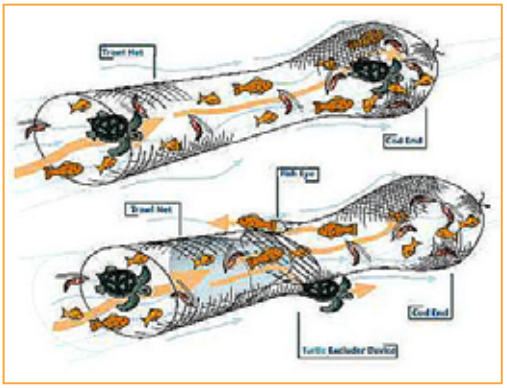
Fisheries research and monitoring

National initiatives such as the National Plan of Action (see *Response: international and national management initiatives*), and growing recognition of the need to conserve sharks, have prompted renewed efforts to monitor and assess Australian shark populations. Since 2000, the FRDC Sustainability of Northern Sharks and Rays Phase I and II projects, and the CRC Reef Research Centre Coastal Fisheries Resources Monitoring program, have provided new information on commercial shark fisheries in the Reef. These programs involve placing independent observers on fishing vessels to collect independent information on the commercial shark catch, and to collect biological and life history data on the species taken. The FRDC project also involved workshops and the publication of a new shark identification guide to assist fishermen in identifying and recording the species of shark taken as catch and bycatch. Preliminary information from these two projects has already provided new information on the shark catch along the Queensland east coast (see *Pressure: species composition of the Great Barrier Reef shark harvest*). There has also been new independent research on species such as whitetip reef sharks, grey reef sharks and tiger sharks commenced in recent years.

Collectively, these studies are providing critical information about the life history, movements and distribution of these species. These programs will help to provide managers with a better understanding of the shark fishery and provide much needed biological information on sharks. This type of information will be invaluable for developing stock and risk assessments for the sharks of the Reef. A preliminary risk assessment is being prepared as part of the FRDC Phase II project.

Bycatch and shark finning

A number of recent initiatives have been introduced to reduce the levels of bycatch taken in various fisheries. In 2000, the *Queensland East Coast Trawl Fishery Management Plan* (Trawl Plan) was introduced. The Trawl Plan included provisions for improved recording of bycatch and made the use of Bycatch Reduction Devices mandatory. Studies conducted in the Northern Prawn Fishery show that these devices reduce the catch of large sharks. However the effectiveness of Bycatch Reduction Devices will ultimately depend on the design of the device, and the size and shapes of the bycatch species.[55] Research is currently underway in the East Coast Trawl Fishery to determine the effectiveness of bycatch reduction devices in reducing the catch of bycatch species such as sharks and rays. In 2001, arrangements were introduced under the Trawl Plan that prohibited the retention of sharks taken in trawl nets in the East Coast Trawl Fishery. [20]



The introduction of bycatch reduction devices is an important step towards reducing the bycatch of sharks taken by trawlers.

The Australian Fisheries Management Authority has introduced a *Bycatch Action Plan* for the Eastern Tuna and Billfish Fishery. The plan includes measures such as reducing the use of wire traces on longlines, making it easier for sharks to free themselves after being hooked. In June 2005 the Australian Fisheries Management Authority announced that the use of wire

traces will be banned across the whole fishery with the ban coming into effect on 1 July 2005.The Australian Fisheries Management Authority has also enforced of a limit of 20 sharks and their fins per vessel per trip, and has banned the practice of removing shark fins and discarding the carcass at sea. Shark finning is also banned in the Coral Sea Fishery and fishermen must retain the shark carcass with the fins. A management plan for the fishery is nearing completion.

In 2002, the practice of removing shark fins and discarding the carcass at sea was banned in Queensland. The intent of this initiative is to reduce the capacity of fishermen to target sharks solely for their fins as the carcasses must be retained with the fins. Under the Australian *National Plan of Action for the Conservation and Management of Sharks* (see below), both State and Commonwealth fisheries have an obligation to optimise the use of landed sharks for more than just fins.

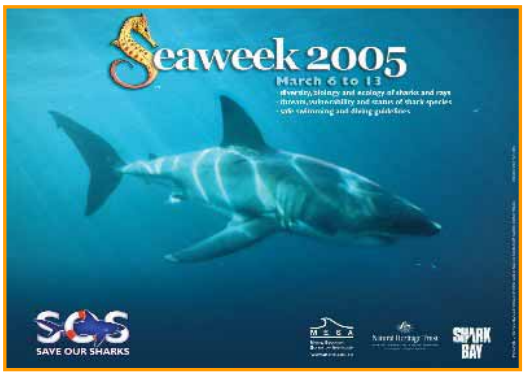
Response: international and national management initiatives

Growing concern over the state of shark populations has prompted initiatives to address the management of shark fisheries around the world. In 1999, the United Nations Food and Agricultural Organisation (FAO) released the *International Plan of Action for the Conservation and Management of Sharks*. The plan urges member countries of the FAO to implement National Plans of Action (NPOAs) for their shark fisheries. The NPOAs will form a framework for fisheries managers to assess shark fisheries and develop effective management plans. In 2000, the FAO released *Technical Guidelines for Responsible Fisheries* relating to the conservation and management of sharks. The Guidelines encompass issues such as shark finning, research and data collection, management principles and legal frameworks for managing shark fisheries, and will help member nations in developing NPOAs and fisheries management plans.

The NPOA framework also recommends the completion of an assessment of shark resources and fisheries. In December 2001, the Department of Agriculture, Fisheries and Forestry, Australia released the *Australian Shark Assessment Report* providing a comprehensive overview of Australian shark fisheries and management. This assessment was used to develop the Australian NPOA that was released in May 2004. The Australian NPOA is based around six key themes:

- Reviewing existing conservation and management measures;
- Improving management and conservation measures;
- Improving data collection and handling;
- Undertaking targeted research and development;
- Undertaking education and awareness raising; and
- Improving coordination and consultation.

These six themes incorporate 43 actions to be implemented by various environmental and fisheries agencies. The Shark Plan Implementation and Review Committee was established in July 2002 to monitor the progress and implementation of the Plan.



Community education is an important step towards the conservation and management of sharks. The need for greater public awareness is highlighted in national and international plans. *Click to download the poster.*

Education and awareness raising

The need for increased community understanding about the conservation of sharks is gaining recognition, and public education and awareness raising is one of the six

themes of the Australian National Plan of Action. In 2004 the Australian Government launched the Shark Education and Awareness Raising Program to coordinate and promote shark education and public awareness programs across Australia. The Marine Education Society of Australasia (MESA) highlighted shark conservation as the theme for Seaweek in March 2005. In conjunction with MESA, the national Program developed shark information sheets, hosted public events and helped MESA coordinate Seaweek shark education activities across Australia. In concert with Seaweek and MESA, the GBRMP launched a new web based shark education program for school students, and held special shark education sessions at the Reef HQ Aquarium.

Response: bycatch in the Queensland Shark Control Programs

Concerns have been raised over the impact of the Queensland Shark Control Program (QSCP) on bycatch species. In recent years, changes to the program have reduced the bycatch of dugongs and green turtles in the QSCP (see *Environmental status – marine mammals* and *Environmental status- marine reptiles*). The QSCP is investigating the effectiveness of sonic 'pingers' to reduce bycatch of cetaceans, and the use of electromagnetic shark deterrent devices which could replace nets and drumlines. The QSCP also records all catch and bycatch species and contractors are trained to release bycatch species alive, including non-threatening shark species.[14]

Response: conservation of threatened shark species

The Australian Government and various State Governments have introduced a number of conservation measures for threatened shark species. These include protected species listings in Commonwealth and State legislation, and the development of conservation plans to reduce human pressures on these species and promote the recovery of their populations.

Great white shark

The great white shark is listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act (1999)*, and is protected in every Australian state where it occurs. A national recovery plan for the great white shark has also been developed that includes measures to reduce the impacts of commercial and recreational fishing, shark control programs and the trade of white shark products on the species. In October 2004, the great white shark was listed in Appendix II of the Convention on International Trade of Endangered Species (CITES). This listing means that any of the 166 member countries of CITES exporting great white sharks or its products, must regulate the trade through export permits or certificates, certify that the specimen was legally obtained, and demonstrate that the trade will not be detrimental to the species' survival. In the Reef, the great white shark is listed as a protected species under *Regulation 29* of the *Great Barrier Reef Marine Park Act 1975*, and is protected in Queensland waters under the *Queensland Fisheries Act 1994*.

Grey nurse shark

The east coast population of grey nurse shark is listed as critically endangered under the *Environmental Protection and Biodiversity Conservation Act (1999)* and is protected in Australian waters. The grey nurse shark is listed under the *Queensland Fisheries Act 1994* as a protected species in Queensland, but is also protected in New South Wales, Victoria, Tasmania and Western Australia by various wildlife conservation and fisheries acts.[33] In the Reef, the grey nurse shark is listed as a protected species under *Regulation 29* of the *Great Barrier Reef Marine Park Act 1975*. A grey nurse shark recovery plan has also been developed that includes measures to reduce the impact of fishing and shark control programs, improve the recording of incidental catch, and to establish monitoring programs. In December

2002 and 2003, protected areas were established at key grey nurse aggregation sites in Queensland and New South Wales. These sites exclude the types of fishing that pose the greatest threats to grey nurse sharks.

Whale shark

In 2002,the whale shark and basking shark became the first sharks to be listed under Appendix II of CITES, meaning that trade of whale shark products must be controlled through export permits or certificates. The whale shark is also protected in Western Australia and Tasmania, and listed as a 'matter of national environmental significance under the *Environment Protection and Biodiversity Conservation Act (1999)*. The whale shark is also listed as a protected species under *Regulation 29* of the *Great Barrier Reef Marine Park Act 1975*. A recovery plan for the whale shark has been prepared by the Australian Government Department of the Environment and Heritage.

Bizant River shark

The Bizant River shark is listed as critically endangered under the *Environment Protection and Biodiversity Conservation Act (1999)* due to its extreme rarity, localised distribution and low reproductive rates. Given the lack of information about this species, Pogonowski (2002) recommended the formation of a national recovery team and further research to establish the population status and distribution of this shark. The Department of the Environment and Heritage has prepared a recovery plan for the Bizant River shark that is currently under review.

Sawfishes

Currently, only the freshwater sawfish (*Pristis microdon*) is listed under the *Environment Protection and Biodiversity Conservation Act (1999)*, and the green sawfish is the only sawfish protected under state legislation (in New South Wales). However, many sawfish are listed as vulnerable or endangered under the World Conservation Union (IUCN) Red List, and an assessment of the conservation status of Australian marine and estuarine fishes recommends listing of many sawfish species, including those found within the Reef, as threatened species under the *Environment Protection and Biodiversity Conservation Act (1999)*.[33] A recovery plan for sawfish is currently being developed by the Department of the Environment and Heritage, and research is currently being undertaken on the biology, life history and habitat use of sawfish in Northern Australia.[31,32]

Response: habitat loss and degradation

Addressing water quality and coastal development

The GBRMPA works together with local governments, stakeholders and state government agencies to address water quality and coastal development issues that affect the Reef. The GBRMPA participates in State and local government impact assessment and regional planning processes to promote land use practices and management that are complementary with the protection of the Reef. The management of these issues is described in more detail in *Environmental status – water quality.*

In September 2001, the GBRMPA released the *Great Barrier Reef Catchment Water Quality Action Plan* that included recommendations for water quality targets. This lead to the development of Memorandum of Understanding by the Queensland Government and Australian Government in 2002 to develop a joint plan to address declining water quality in the Reef. This process also included a review of water quality issues by an independent scientific panel that concluded that there has been a significant increase in nutrient run-off

into the Reef, and that some inshore coral reefs have been affected. A Productivity Commission report into Reef catchments was released in February 2003 that identified declines in water quality, and recommended that programs for improving water quality should be implemented at a sub-catchment level.

In 2003, the *Reef Water Quality Protection Plan* was launched with the goal of halting and reversing the decline of water quality in the Reef within 10 years. The *Reef Water Quality Protection Plan* will be implemented in partnership with regional Natural Resource Management bodies and other stakeholders to ensure that water quality programs and targets are appropriate for each region. For more information on the *Reef Water Quality Protection Plan*, see *Environmental status – water quality*.

Protecting biodiversity and preserving ecosystem function

In 2001, the GBRMPA launched the Representative Areas Program to better protect the biodiversity and ecological functions that support the Reef ecosystem. The Representative Areas Program used the best available scientific information to identify separate regions of biodiversity (called bioregions) in the Reef and compared them with existing zoning plans. The process highlighted that under the existing zoning system, less than 5% of the Marine Park was highly protected, and that these protected areas were focused on coral reef habitats. This left some habitat types without any protective zoning, potentially exposing them and the organisms living within them to extractive activities throughout their entire geographic range. This also meant that in some regions, there was inadequate protection of the ecological resources that would be required to help nearby habitats recover should they be subjected to some type of disturbance.

The rezoning of the Marine Park will help protect the Reef's biodiversity, and maintain the habitats and ecological functions that support species such as the tawny nurse shark (above).

To redress this imbalance, the entire Great Barrier Reef Marine Park was rezoned and the new Great Barrier Reef Marine Park Zoning Plan 2003 came into effect on 1 July 2004. The new Zoning Plan has increased the area of 'no-take' zones to approximately 33% of the Marine Park, and ensures that a minimum of 20% of each bioregion is afforded adequate protection. While these measures will reduce the direct pressure on some shark species, the intent of the new zoning is to maintain the ecological health of the entire Reef ecosystem. By setting aside an adequate network of 'no-take' reserves, the new Zoning Plan will better protect the Reef's biodiversity, and maintain the ecological functions and biological connections that sustain the Reef. In doing so, the new Zoning Plan will also increase the Reef's capacity to cope with increasing pressures, and recover from impacts. Overall, the new Zoning Plan will better protect the habitats and biological systems that sustain the sharks and rays of the Reef.

Response: Traditional use and cultural connections

The GBRMPA undertakes a number of activities to manage the traditional use of marine resources. In July 2004, a new system for managing the traditional use of marine resources in the Great Barrier Reef Marine Park came into effect as part of the new zoning provisions for the Marine Park. Under the new system, some traditional use of marine resources will continue to be 'as of right'. Other traditional use of marine resources may be conducted in

accordance with a Traditional Owner-developed and GBRMPA-accredited '*Traditional Use of Marine Resources Agreement*' (TUMRA). For more information about these Agreements, see *Management status – Indigenous connections with the Great Barrier Reef*.

Response: tourism

The GBRMPA manages tourism through the Marine Park Zoning Plan and permits. These management tools specify where commercial tourism activities may occur and how these activities must be conducted. Permit conditions may include restrictions on the number of visitors permitted at a site per day, restrict access to sensitive areas and apply specific conditions for each activity undertaken at the site. Shark feeding is prohibited in the Marine Park and the GBRMPA has developed guidelines and *Best Environmental Practices* for divers and snorkellers to minimise their impacts on the flora and fauna of the Reef.

Further reading

About sharks

- General information about sharks from Reef ED website
- General information about sharks from the CRC Reef Research Centre website
- General information about sharks from the Mote Marine Laboratory website
- Sharks in Australian waters (Australian Department of the Environment and Heritage)
- About the grey nurse shark (Australian Museum)
- Biological profiles of shark species (Florida Museum of Natural History)
- About the whale shark (Florida Museum of Natural History)
- About the great white shark (Florida Museum of Natural History)
- National Oceanic and Atmospheric Administration Fisheries shark website
- Shark information sheets developed by the Marine Education Society of Australia.
- Aboriginal and Torres Strait Islander Connections with Sharks and Rays (ReefED)
- FISHBASE, a Global Information System on fish biology, includes data on specific shark species.

Shark conservation and management

- United Nations Food and Agricultural Organisation *International Plan of Action for the Conservation and Management of Sharks*
- The Australian *National Plan of Action for the Conservation and Management of Sharks*
- The International Union for the Conservation of Nature Shark Specialist Group (includes reports and IUCN Red List conservation listings for Australian sharks and rays)
- Australian shark conservation (including species profiles and recovery plans) (Australian Department of the Environment and Heritage)
- Information about Queensland's East Coast Fisheries (CRC Reef Research Centre)
- Grey nurse sharks in New South Wales (New South Wales Fisheries)
- Grey nurse sharks in Queensland (Environmental Protection Agency)
- Grey nurse shark protection areas in Queensland (Queensland Department of Primary Industries and Fisheries)
- DRAFT whale shark recovery plan (Australian Department of the Environment and Heritage)
- Conservation overview and action plan for Australian threatened and potentially threatened marine and estuarine species (Australian Department of the Environment and Heritage)
- About Australian sawfish (Australian Department of the Environment and Heritage)
- Sawfish Conservation (Mote Marine Laboratory, Florida)
- The sawfish recovery team (Florida Museum of Natural History)
- About the small tooth sawfish (National Oceanic and Atmospheric Administration Fisheries, USA)

About shark attack and shark myths

- The Australian Shark Attack File at the Taronga Zoo
- The International Shark Attack File at the Florida Museum of Natural History (includes statistics about shark attacks and the relative risks of shark attack)
- About shark cartilage and cancer

Shark research

- CSIRO shark tagging research on great white, grey nurse and whale sharks

- Fisheries Research and Development Corporation, Sustainability of Northern Sharks and Rays Phases I and II programs
- Tracking the green sawfish in the Gulf of Carpentaria, media release and report (in PDF format)
- The National Shark Research Consortium: comprising the Mote Marine Laboratory, Florida Program for Shark Research, Virginia Institute of Marine Science and Pacific Shark Research Centre (United States)
- The Natal Sharks Board (South Africa)
- Hawaii Institute of Marine Biology Shark Research Group

End Notes

[*] *harvest* - It is important to distinguish between *catch* and *harvest*. The *catch* is the total number of sharks caught by fishermen, and includes sharks that are kept as well as those that are later discarded or released. *Harvest* means only the sharks that are kept or retained by the fishermen.

[†] *validated* - Checked against information collected by independent observers. This can be used to determine how well logbooks represent the actual catch and effort of the fishery.

[§] *fishing effort* - Fishing effort is a measure of fishing activity, for example, the number of days fished, or the length of net or number of hooks and lines deployed per day.

[‖] *bycatch* - The incidental or accidental capture of a species by fishermen targeting other species. Bycatch is usually discarded, however animals taken as bycatch may be dead or seriously injured by the time they can be released.

[#] *Catch per unit effort* - is a measure of how much fish is caught per unit of fishing effort (eg: per net shot or day of fishing). CPUE can be used as an indicator of stock condition. For example; if fish stocks are declining, fishermen may catch les fish per day of fishing. However there are limitations to the use of CPUE data, for more information on CPUE see *Pressure* and *Environmental status - fishes*

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