

A Vulnerability Assessment for the Great Barrier Reef



Sharks and rays

Information valid as of Feb 2012

Summary

Diversity

Currently 134 known species of sharks and rays divided into six functional groups.

Susceptibility

Using ecological risk assessment processes,^{1,2} at least 30 species of shark and ray in the World Heritage Area are known to be at risk to climate change and 11 species are assessed as being at high risk to the Queensland East Coast Otter Trawl Fishery. These species are particularly vulnerable as they tend to exhibit the life-history traits of slow growth rate, low reproduction rate, late maturing, are found in low abundance and are relatively long-lived (population not adapted to early mortalities). They can also display high habitat specificity and have a highly selective diet exposing them to certain impacts. Further ecological risk assessment processes are likely to reveal other species vulnerable to particular impacts due to them exhibiting similar traits.

Major pressures

Commercial fishing, recreational fishing, climate change, coastal development, declining water quality due to catchment run-off and the combined effect of these.

Cumulative pressures

Cumulative impacts are of great concern as they act over space and time to apply a combined effect that is often difficult to quantify. Sharks and rays associated with inshore habitats are exposed to cumulative pressures resulting from climate change, coastal development, declining water quality and commercial and recreational fishing. These pressures are likely to impact on the species directly, on their habitats and available prey species.



A group of whiprays (*Himantura* sp) settling in the shallows at Heron Island.

Management in the Great Barrier Reef and adjacent areas in Queensland

Legislated management tools for the conservation of sharks and rays that occur in the World Heritage Area include the *Fisheries Act 1994* (Qld); *Great Barrier Reef Marine Park Act 1975*; *Environment Protection and Biodiversity Conservation Act 1999*; *Great Barrier Reef Protection Amendment Act 2009* (Qld); Fisheries Queensland management arrangements under the East Coast Inshore Fin Fish Fishery (ECIFFF), East Coast Otter Trawl Fishery (ECOTF) and the Coral Reef Fin Fish Fishery (CRFFF); *Nature Conservation Act 1992* (Qld); and others (refer Management table, p. 10).

Existing management actions

A range of management actions are in place in the World Heritage Area that 'operationalise' legislative management tools and provide additional guidance and/or strategic direction to Marine Park management operations. These include:

- The joint Great Barrier Reef Marine Park Authority (GBRMPA) – Queensland Government Field Management Program that enforces spatial protection provided by the *Great Barrier Reef Marine Park Zoning Plan 2003* and *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004* (Qld)
- Spatial protection via inshore habitat conservation areas such as Dugong Protection Areas and Fish Habitat Areas under Queensland fisheries regulations
- *Reef Water Quality Protection Plan 2009* that works with landholders to halt and reverse the decline of water quality entering the Marine Park
- *Reef Rescue Land and Sea Country Indigenous Partnerships Program* that enables collaborative management arrangements with Traditional Owners in the Marine Park.
- Suggested points of action for the conservation of sharks and rays under the *Great Barrier Reef Biodiversity Conservation Strategy 2012* as identified



Cowtail ray (*Pastinachus atrus*) skimming a blotched fantail ray (*Taeniuroys meyeri*).

through the vulnerability assessment process.

- Education and stewardship programs (*Reef Guardian Program*, high standard tourism operators certification) aimed at developing industry and community involvement in management of the Great Barrier Reef through land and sea-based actions to reduce pollution and improve the water quality of the World Heritage Area.
- Queensland Government management arrangements for fisheries with a shark component (either as catch or by-catch):
- maximum size limit of 1.5 m for fishers that do not hold a shark (S) fishery symbol and accompanying net fishery symbol
- a Total Allowable Commercial Catch (TACC) for the commercial take of shark and rays set at 600t and no discard of 'finned' bodies at sea
- bag limit of 10 shark or ray for net and four for line for commercial fishers in the ECIFFF without an 'S' symbol
- recreational bag limit of one shark or ray in possession
- mandatory use of turtle excluder and by-catch reduction devices in otter trawl apparatus to reduce landings of sharks and rays
- replacement of the majority of nets set for bather safety in the Great Barrier Reef Marine Park (the Marine Park) under the Queensland Shark Control Program with drumlines (10 nets remaining in the Marine Park).

Great Barrier Reef Outlook Report 2009 assessment

Poor, with little information available on which to base the grade.

Vulnerability assessment: High, particularly in inshore and estuarine habitats

- Many chondrichthyan fishes have life-history traits that make them particularly vulnerable to adult mortality from human-related sources, as the number of young produced is closely linked to the number of breeding adults. Other species have life-history traits that enable greater abundance or are more adaptable to their environment and are thus more resilient. For those less resilient species, once populations are depleted, recovery could take several decades even if effective



Lemon sharks (*Negaprion acutidens*) feeding inshore.

conservation measures are introduced.³

- Thirty species of shark and ray from the Great Barrier Reef have been assessed as having a 'high' or 'moderate' vulnerability to climate change.¹ Eleven species of shark and ray have been assessed as having a high risk to otter trawl operations.²
- Habitat loss and degradation from human-related activities in inshore areas are likely to be impacting on the distribution and abundance of those species associated with those habitats. Pressure is being exerted by coastal development and population growth, including new and expanding port facilities, (includes impacts from land reclamation and remodelling, dredging, increased vessel activity, pollution and underwater noise); reduced water quality due to increased catchment run-off; and climate change related impacts.
- Coastal/inshore and freshwater/estuarine sharks and rays have been identified as amongst the most vulnerable groups of sharks and rays within the World Heritage Area and adjacent waters due to the elevated and cumulative pressures they experience across those habitats. A number of sharks have been identified as being most at risk through ecological risk assessment processes and other research.^{1,4,5,6}
- The spartooth shark (or Bizant River shark, *Glyphis glyphis*) has its last known occurrence in east coast Queensland in waters adjacent to and within the World Heritage Area. This species of estuarine shark is 'critically endangered' under Commonwealth legislation and is listed as a high priority under Queensland's Back on Track species prioritisation framework and requires a particular management focus.
- There are particular concerns for sawfish species that occur in the World Heritage Area and this group is addressed in their own vulnerability assessment for the *Great Barrier Reef Biodiversity Conservation Strategy 2012*.
- A number of pressures are exerted upon sharks and rays in the World Heritage Area from fishing activities that are likely to be causing population declines. These pressures include the possible overharvest of little-known target and non-target species, post-release mortality of shark by-catch (captured incidentally while fishing for other target species), and habitat degradation due to otter trawling. The extent and total impact of these pressures is not completely clear and more



Critically endangered grey nurse shark, (*Carcharias taurus*).

species-specific information is required to confidently establish ecologically sustainable harvest levels and other management arrangements for sharks and rays and their habitats in the World Heritage Area.

- Abundance estimates of reef-associated sharks indicate that they may be under particular pressure from fishing-related pressures, as outlined in the previous point.
- Sharks and rays are captured in a number of different fisheries that operate within the World Heritage Area (commercial and recreational) but accurate identification of species taken may still be lacking along with broad confidence in the validity of catch and release data in both commercial and recreational fisheries. Knowledge of this may be hampered by what appears to be inadequate observer program coverage to validate commercial fishing logbooks.
- There are emerging concerns for the impacts that fishing can have on deepwater chondrichthyans.
- Currently, species-specific research and fishery-independent and fishery-dependent data gathering is being improved in Queensland's fisheries that have a shark component either as catch or by-catch. However, current species-specific knowledge of sharks and rays in the World Heritage Area is not sufficient to provide confidence in the non-specific management arrangements being relied upon to manage their harvest (for example, Total Allowable Commercial Catch quotas).

Suggested actions to address vulnerabilities

- Focus management on pressures that can be addressed such as habitat protection, reducing remaining pressures from fishing, and implementing conservation actions for those species already at risk from other cumulative factors.
- Develop programs to better understand the effects of climate change experienced by those sharks and rays assessed as having a 'high' or 'moderate' vulnerability to climate change as per Chin and colleagues.¹ Programs should be guided by the outcomes of a resilience analysis for these species.
- Undertake a coordinated program to address pressures on inshore species of sharks and rays. This should comprise:
 - A risk assessment for inshore biodiversity to inform priority management actions aimed at reducing the pressures experienced by sharks and rays in these habitats.
 - This needs to inform programs developed to better understand the cumulative impacts affecting sharks and rays in inshore habitats, including an assessment of the remaining impacts of fishing and impacts of habitat loss and degradation caused by coastal development and declining water quality due to catchment run-off.
 - At the Reef-wide scale, this should integrate efforts being undertaken with land users (mining, agriculture, waterways managers) to halt and reverse the decline of water quality entering the Marine Park through the *Reef Water Quality Protection Plan 2009*; the implementation of the *Reef Rescue Land and Sea Country Indigenous Partnerships Program* that enables collaborative management arrangements with Traditional Owners in the Marine Park; and by taking a strategic approach, in collaboration with state agencies and wider stakeholders, to managing impacts from coastal development.
- At the local scale, regional management of fisheries should be pursued and local stewardship of fisheries should be expanded through the *Reef Guardians Stewardship Program*.
- GBRMPA support and collaborate with the independent Shark Panel established by the then Fisheries Queensland to guide the assessment of Queensland east coast shark resources. Knowledge gained must inform specific management arrangements that ensure the ecological sustainability of all species of sharks and rays in those Queensland fisheries with a shark component, either as catch or incidental capture and discard.
- Continue to improve accuracy in the gathering, reporting, and transparency of information collected within state fisheries that target and incidentally capture sharks and rays in the World Heritage Area. This information is vital in helping managers understand the stock structure of fisheries and allows for informed decisions on how to reduce cumulative pressures that are managed across governance jurisdictions.
- Support the Queensland Government to further improve their fisheries-independent observer program to a point where it can broadly be considered sufficiently robust to validate commercial logbook data for catches of shark and rays, providing statistically representative coverage of vessel effort from the ECIFFF, East Coast Trawl Fishery and east coast line fisheries (coral reef and Spanish mackerel) (including those vessels operating in remote/less-accessible regions north of Cooktown). This fisheries-independent data is vital for stock assessment and ecological risk assessment work.
- Support efforts to increase the capacity of commercial operators to identify sharks and rays to species level.
- Additional research on the biology, behaviour and habitat requirements of sharks and rays is required to continually refine management strategies that enable ecosystem-based management objectives to be achieved and provide confidence in the sustainable management of fisheries and the Great Barrier Reef Marine Park.
- GBRMPA advocate for a precautionary approach when considering the consequences of deep-sea fisheries. Management arrangements should be developed in view of the lack of knowledge of the species composition and basic biology of sharks and rays of these habitats and the potential ecological risks of overfishing as a result of high mortality through by-catch.

Background

Brief description of sharks and rays

Sharks, rays, skates and chimeras are referred to as chondrichthyan fishes which have skeletons made of light and flexible cartilage instead of bone. This separates them from bony fish (teleosts) such as mackerel and coral trout. The sharks and rays of the Great Barrier Reef are 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).

Sharks and rays generally have very different life-history traits to bony fishes (teleosts). Where teleosts do not bear live young and are not particularly long lived, sharks generally adopt a strategy whereby they mature late, produce a small number of live young that have high survival rates and succeed by being long-lived. In this way, many shark populations have characteristics comparable to marine mammals such as dolphins, species which are vulnerable to human impacts.⁷

For many shark species, this suite of life-history characteristics results in low reproductive potential and low capacity for population increase as the number of young produced is closely linked to the number of breeding adults.⁸ This is because sharks, generally considered as top predators with few natural enemies, traditionally need to produce very few young capable of reaching maturity in order to maintain population levels at the carrying capacity of the ecosystem. Species with life-histories such as these have often been called 'K-selected'. These life-history characteristics have serious implications for chondrichthyan populations, as they limit the capacity of populations to recover from over-fishing or other negative impacts.^{3,8} These traits are especially true for medium to large species of sharks and rays⁹ which intrinsically tend to be those with high value to commercial markets or susceptible to target or incidental capture in net fisheries. However, there are also species of shark and ray which have a high potential to rebound from exploitation in that they mature earlier, are more highly productive and with shorter life spans.⁹

All sharks and rays are predatory and feed on a wide variety of prey. Small, bottom dwelling sharks and rays may feed on crustaceans and molluscs while reef and pelagic sharks prey primarily on fishes. Some species, such as whale sharks and manta rays, are specialist feeders that live on plankton.¹⁰ Sharks and rays live in a variety of habitats, ranging from coral reefs to open water pelagic environments and benthic habitats of the inter-reefal and lagoonal regions of the continental shelf, slope and beyond.^{4,11,12} Many species found in the Great Barrier Reef move between these different habitats at various stages of their life cycle, using habitats such as estuaries and seagrass meadows as nurseries or foraging ground.^{4,11}

As established by Chin and Kyne,⁴ the sharks and rays of the Great Barrier Reef can be divided into six functional groups primarily defined by the habitat they use. Membership of each functional group is defined on the basis of the species' prevalence in different habitat zones found between the coast and the deep waters of the continental slope within the Marine Park. Each habitat zone consists of a number of specific habitats (e.g. mangroves and salt marsh). A species is included in a functional group if it occurs *primarily* in the habitats found within that zone. As a generalisation, habitats which sharks and rays populate determine the food individual species prey on and correlate closely to their distribution and abundance, all of which are determined by the physical, chemical and ecological processes occurring in those habitats. As a corollary to this, highly mobile and 'flexible' species such as the bull shark (*Carcharhinus leucas*) commonly occur in more than one habitat type and thus appear in more than one functional group. In contrast, more sedentary and less 'flexible' species such as the freshwater sawfish (*Pristis microdon*) are restricted to particular habitats and are only listed in one functional group.

The habitats that define each functional group are described below (from Chin and Kyne⁴):

- Freshwater and estuarine (four species) – Habitats include rivers and streams, inter-tidal zones of estuaries and bays, mangroves and salt marshes, intertidal seagrass beds, foreshores and mudflats.
- Coastal and inshore (47 species) – Habitats extending from coastal sub-tidal habitats to the mid-shelf platform reefs. They include estuaries and bays, sub-tidal seagrass beds, inshore fringing reefs, shallow coastal waters, rocky shoals, sponge gardens and other benthic habitats of the Great Barrier Reef lagoon to 30 metres depth.
- Reef (19 species) – Habitats on and immediately adjacent to mid-shelf and outer-shelf coral reefs, down to a maximum depth of 40 metres in the Great Barrier Reef lagoon and to 60 metres on outer shelf reefs. They include outer ribbon reefs.
- Shelf (26 species) – Deeper water and seabed habitats between the mid-shelf and outer reefs, extending to the continental slope edge. Includes waters from the surface to 200 metres (approximately the shelf edge) and benthic habitats such as deepwater seagrass beds and Halimeda mounds, rocky shoals and sponge gardens (40 to 60 metres depth).
- Bathyal (54 species) – Benthic habitats of the continental slope and beyond, extending down to 2000 metres depth.
- Pelagic (10 species) – Open ocean waters extending from the edge of the outer reefs and beyond into the Coral Sea.

While 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 and rays within the Great Barrier Reef and adjacent waters.¹³

Geographical distribution

There are 182 shark species, 125 ray species and 15 chimaerid species in Australian waters, the highest diversity of chondrichthyans of any continental area.¹¹ The sharks and rays of the tropical waters of northern Australia have one of the highest levels of diversity and endemism in the world; with half of the species present found nowhere else in the world.^{4,11} Many of the sharks that inhabit the waters of the World Heritage Area have broad distributions, with some species recorded moving in and out of the Marine Park.¹² Current information on the geographical distribution of shark and rays species that inhabit the World Heritage Area can be found in the Department of Primary Industries and Fisheries *Shark identification guide for Queensland fishers*¹⁴ and Last and Stevens.¹¹

Population status in the Great Barrier Reef Marine Park

There is limited information available about the status and trends of shark and ray populations in the Great Barrier Reef.¹⁵ The most extensive set of data are contained in catch records reported in commercial fisheries logbooks. However, until recently logbooks only recorded the combined catch of all shark and ray species and did not include any demographic (or life-history) information, and so could not be used to assess the status and trends of individual species. To improve the management of the shark fishery in Queensland, the *Independent Review of Proposed Management Arrangements for Queensland's East Coast Inshore Fin Fish Fishery* published in 2008, recommended, *inter alia*, improved and more species-specific data collection methods for shark.¹⁶ Since July 2009, a new logbook and fishery observer programs have increased the species and geographic resolution of the fishery-dependent data stream. Long-term fishery-independent surveys of shark populations on the Great Barrier Reef have not been conducted. Small-scale research surveys are ongoing, and although helpful, they are currently temporally and spatially limited.^{1,12,17,18,19,20}

In a Fisheries Research and Development Corporation study, Salini and colleagues²¹ studied the status of sawfish in the Gulf of Carpentaria and conducted a subsequent risk assessment, finding these species highly vulnerable to fisheries and coastal zone pressures.^a Additionally, recent research has revealed significant declines in populations of whitetip reef shark (*Triaenodon obesus*) and grey reef shark (*Carcharinus amblyrhynchos*) on the Great Barrier Reef.^{20,22} It should be noted that the study by Robbins and colleagues²² provides a snap-shot of trend data for those species of reef shark but cannot be used for other species. That requires further investigation and refinement in order to provide greater certainty in estimates of shark abundance.^{19,20}

There are conservation concerns for several species of sharks and rays in the Great Barrier Reef. Numerous species are listed as threatened (critically endangered, endangered or vulnerable) by the International Union for Conservation of Nature and Natural Resources in the 2010 *IUCN Red List of Threatened Species*.¹⁵ For example, the grey nurse shark (*Carcharias taurus*), spartooth shark (*Glyphis glyphis*) and all four species of sawfish occurring in the Great Barrier Reef Region are listed as critically endangered.

In Queensland the abundance and distribution of sawfish have been seriously depleted. In response all sawfish species are listed as no-take species under the *Fisheries Regulation 2008* and the three *Pristis* species (green, dwarf and freshwater sawfish) are listed as vulnerable marine species under the *Environment Protection and Biodiversity Conservation Act 1999*. Recovery Plans are currently being developed for these three species under this Act. Under this same Act the grey nurse shark, spartooth shark, white shark (*Carcharodon carcharias*) and whale shark (*Rhincodon typus*) are all listed species with Recovery Plans in place or under development (refer Management Table, p.10).

Ecosystem role/function

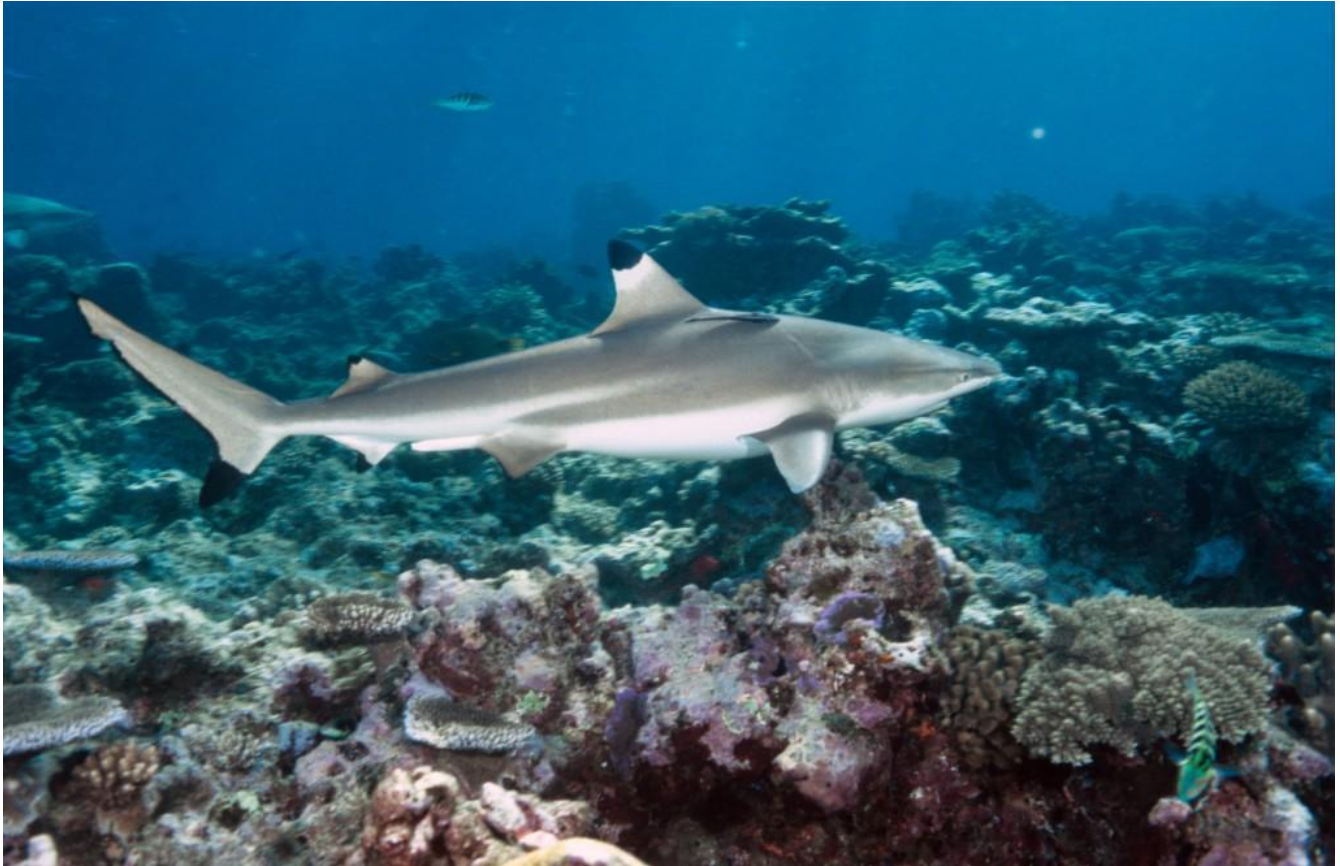
All sharks and rays are predators, with some considered apex predators (e.g. white shark, tiger shark) and occupy ecological niches at the top of the food chain.^{23,24} However, the majority of species would be considered mid to low-order predators. Some species are primarily planktivorous (whale shark). Consequently, many sharks and rays are naturally less common than prey species lower down in the food chain and are thought to have a significant effect on prey populations.^{21,25,26,27,28} Research has indicated that in this ecological role, many sharks and rays help to regulate the populations of prey species and in doing so maintain the balance of the ecosystem.^{24,29} Ecosystem models suggest that depleting 'k-selected' shark populations may have significant and unpredictable effects on marine food webs. In one situation, the overfishing of large sharks along the east coast of the United States led to an increase in other elasmobranchs, particularly cow-nosed rays, whose enhanced predation on bay scallops resulted in a dramatic decline in the scallops and closed a long-term commercial fishery.²⁴

^a Refer to the Vulnerability Assessment for the Great Barrier Reef - Sawfish

Ecosystem goods and services

Ecosystem goods and services category	Services provided by the species, taxa or habitat
<p>Provisioning services (e.g. food, fibre, genetic resources, bio-chemicals, fresh water)</p>	<p>Sharks and rays are taken both as target species in the Queensland East Coast Inshore Fin Fish Fishery and as retained by-catch in other fisheries.³⁰ The shark fishery supplies a variety of products including meat, fins, liver, skin, cartilage, jaws and teeth, which are sold both domestically and overseas.³⁰</p> <p>The pressure on sharks in the Great Barrier Reef increased between 1990 and 2003, with more specialist shark fishers entering the gillnet fishery and more effort being directed at targeting sharks.³¹ Commercial fishery logbooks have recorded a significant increase in reported shark catch and effort in the net fishery in the Great Barrier Reef, rising from 295 tonnes from 191 boats in 1994 and peaking at 1202 tonnes from 221 boats in 2003.³² Estimates of targeted shark fishing effort (as a percent of fishing days targeting shark) increased by 28 per cent over the same period, meaning that fishers have shifted effort to target shark.³¹</p> <p>The total Gross Value of Production (GVP) derived from sharks and rays taken from the Great Barrier Reef net fishery had risen accordingly, from A\$1.97 million in 1988, peaking at A\$7.21 million in 2003.³² Since 2003, both the number of boats and catch has declined in the World Heritage Area with 150 boats landing 634 tonnes in 2005 (worth \$3.8 million GVP)³² and 603 tonnes in 2006. This follows the buyout of 59 active net licenses under a structural adjustment package following rezoning of the Great Barrier Reef Marine Park.^{32,33} However, in 2006 there were still significant concerns regarding the fishery, including the long-term sustainability of the take of sharks and rays.^{34, b}</p> <p>In 2006, the harvest of sharks and rays in the whole of Queensland was 1005 tonnes and in 2009 fell to 509 tonnes to meet the newly implemented 600 tonne Total Allowable Commercial Catch set by Queensland Government.³⁵</p>
<p>Cultural services (e.g. spiritual values, knowledge system, education and inspiration, recreation and aesthetic values, sense of place)</p>	<p>The sharks and rays of the Great Barrier Reef have significant social, cultural and economic value. Sharks and rays are of great social and cultural importance to Indigenous communities of the Great Barrier Reef coast and Torres Strait and provide an important source of food for many communities. Several Indigenous groups consider sharks as cultural icons and totems, and sharks and rays are pivotal characters in many dreamtime stories.^{36,37,38}</p> <p>Sharks and rays are also valuable as dive attractions in the A\$6.1 billion Great Barrier Reef tourism industry. Surveys of SCUBA divers visiting the Great Barrier Reef found that sharks were rated as the top attraction that divers most wanted, and most expected, to see.⁴ The economic value of sharks as living attractions has been documented outside Australia.³⁹ The income generated by shark ecotourism has prompted increased awareness and community education about shark conservation, and provides economic benefits for both the tourism industry and local communities.³⁹ There is evidence from overseas locations that stingrays can be adversely affected by wildlife tourism,⁴⁰ so this activity, if permitted in the Marine Park, needs to be carefully managed.</p>
<p>Supporting services (e.g. primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling)</p>	<p>The supporting services of chondrichthyan fishes within marine ecosystems are largely unknown. With many species being apex predators, it is expected that they play a significant role in nutrient cycling within the ecosystems in which they occur.</p>
<p>Regulating services (e.g. invasion resistance, herbivory, pollination, seed dispersal, climate regulation, pest regulation, disease regulation, natural hazard protection, erosion regulation, water purification)</p>	<p>Many sharks are apex predators and may help to regulate populations of prey species and maintain ecosystem balance.⁴¹ The removal of top level predators can also have unexpected lower order effects on non-prey species, in what is generally referred to as 'trophic cascading'.^{24,30}</p>

^b This triggered a large-scale review of the fishery with broad ranging recommendations, such as the implementation of a robust observer program that provides sufficient coverage and thus confidence in the identification of species and species take, interaction and post-release information, both of shark and protected species, which is supplied through fishery logbooks.



Spot-tail shark, *Carcharhinus sorrah*, mainly inhabit reefs and deeper shelf waters

Pressures influencing sharks and rays in the Great Barrier Reef Marine Park

Pressures

Sharks and rays in the Great Barrier Reef are exposed to a range of pressures including fishing,^{2,16,18,42} coastal development and declining water quality¹⁷, and climate change.^{1,4} These pressures act on a range of different species and are likely to act cumulatively in some habitats, such as inshore waters.¹⁷ A more detailed description of the range of pressures that impact on sharks and rays in the Great Barrier Reef is provided in the vulnerability assessment matrix.

Vulnerability assessment matrix

The *Great Barrier Reef Outlook Report 2009*⁴³ identified a number of commercial and non-commercial uses of the Marine Park, along with habitat loss and degradation as a result of climate change, coastal development and declining water quality due to catchment run-off as the key pressures reducing the resilience of the ecosystem.

From the *Great Barrier Reef Outlook Report 2009*⁴³ it was considered that pressures such as climate change, coastal development, catchment run-off and direct use are the key factors that influence the current and projected environmental, economic and social values of the Great Barrier Reef. These pressures can impact directly and/or indirectly on habitats, species and groups of species to reduce their resilience. Using the vulnerability assessment framework adapted by Wachenfeld and colleagues,⁴⁴ this Vulnerability Assessment aims to provide an integrated assessment of social, ecological, economic and governance information. For each key pressure in the Marine Park, exposure and sensitivity is assessed in relation to each other to reach a level of potential impact. The potential impact is then reassessed having considered the level of natural adaptive capacity sharks and rays have to respond to the pressure and the adaptive capacity that management has, or can apply, to reduce the potential impact from the pressure.

This provides managers and stakeholders with an understanding of the key elements that each pressure can impose on these species to reach a final assessment of the overall residual vulnerability of sharks and rays to that particular pressure.^c This allows for the formulation of suggested actions to minimise the impact of the pressures which sharks and rays are most vulnerable to.

A summary of the assessment of impacts is tabled below, however, for the detailed assessment and explanatory notes refer to Appendix 1.

^c The GBRMPA recognises the inherent difficulties in undertaking such an assessment for such a large group of species within the Marine Park. The complexities of this process are best addressed in the vulnerability assessment matrix at Appendix 1.

Vulnerability assessment matrix summary for sharks and rays

		Exposed to source of pressure (yes/no)	Degree of exposure to source of pressure (low, medium, high, very high)	Sensitivity to source of pressure (low, medium, high, very high)	Adaptive capacity – natural (poor, moderate, good)	Adaptive capacity – management (poor, moderate, good)	Residual vulnerability (low, medium, high)	Level of confidence in supporting evidence (poor, moderate, good)
Pressures	Commercial marine tourism	Yes; locally	Low	Low	Good	Good	Low	Poor
	Defence activities	Yes; locally	Low	Low	Good	Good	Low	Poor
	Commercial fishing	Yes; state-wide	High; (at-risk species)	High	Poor	Moderate	High; (at-risk species)	Good
			Medium; (remaining species)				Moderate; (remaining species)	
	Recreational fishing	Yes; regionally	Medium	Medium	Poor	Moderate	Medium	Good
	Ports and shipping	Yes; locally	Medium	Medium	Poor	Moderate	Medium	Poor
	Recreation (not fishing)	Yes; regionally	Low	Low	Good	Good	Low	Poor
	Traditional use of marine resources	Yes; locally	Low	Medium	Good	Moderate	Low	Moderate
	Climate change	Yes	Very high	High	Poor	Poor	High	Moderate
	Coastal development	Yes; developing coast, nearshore	High; developing coast, nearshore	High; developing coast, nearshore	Poor; developing coast, nearshore	Moderate	High; developing coast, nearshore	Poor
Declining water quality due to catchment run-off	Yes; mostly developing coast, mostly nearshore	High; mostly developing coast, mostly nearshore	High; mostly developing coast, mostly nearshore	Poor; mostly developing coast, mostly nearshore	Moderate	High; mostly developing coast, mostly nearshore	Poor	

Key concerns

- Many sharks and rays are generally long-lived and have a slow growth rate, low reproduction rate, mature late and as predators, are less abundant than prey species. They also often display high levels of habitat and trophic specificity.^{1,4,5,6} ^d This combination of life-history traits predisposes sharks and rays to being susceptible to overfishing and slow to recover if overfished. Current species-specific knowledge of sharks and rays in the World Heritage Area may not be sufficient to inform the non-species-specific management arrangements being used, such as Total Allowable Commercial Catch quotas.^{6,16} More species-specific information is required on biological, ecological and population data and catch, release and survivorship data in order to confidently establish ecologically sustainable levels and methods of harvest of sharks and rays.
- It is recognised that there is a paucity of information on the biology and ecology of the majority of shark and ray fauna in the World Heritage Area and on what is required to maintain their habitats and populations. The *Great Barrier Reef Outlook Report 2009*⁴³ highlighted these concerns and the difficulties that this presents for informed management of sharks and rays in the Great Barrier Reef. Management arrangements should be developed with levels of precaution that reflect the paucity of information.
- Sharks and rays are captured in a number of different fisheries (commercial and recreational) that operate within the Great Barrier Reef World Heritage Area, but accurate identification of species taken may still be

^d Trophic specificity exists when an organism has highly selective diet or nutritional requirements.

lacking, along with broad confidence in the validity of catch, release and survivorship data in both commercial and recreational fisheries. Accurate species identification is vital for determining stock structure and population subdivision. This fisheries-independent data is vital for stock assessment and ecological risk assessment work and is required to continually refine management strategies.

- Although some excellent work has been undertaken hitherto,^{6,21,31,45} currently available species-specific research and fishery-independent and fishery-dependent data is widely recognised as lacking and more work is required. This may mean the extent of information available may be limited in its ability to provide confidence to management decisions for shark and ray species in the World Heritage Area that are either targeted or captured as retained by-product and non-retained by-catch within Queensland fisheries. This is highlighted by growing evidence on the stock structures of some of the more exploited species of shark within Queensland fisheries⁶ that are also likely to be experiencing other cumulative pressures. This information suggests stock partitioning for some of these species in Queensland's east coast fisheries and recommends a move towards a more regional scale management approach to near and inshore fisheries that reflect findings from ongoing stock structure and life-history research.⁶
- Stock structure research also reveals that certain shark species are likely to require cross-jurisdictional cooperative management. Sharks and rays managed as different stocks across jurisdictional borders may require greater cooperation among jurisdictions, as these management units extend beyond their borders.⁶
- It will also be important to determine better information on post-release survival of sharks and rays captured as by-catch in commercial and recreational fisheries. It should also be recognised, post-release survival is not always easy to detect. For example, necropsies performed on grey nurse sharks in aquaria have indicated that derelict hooks may puncture the stomach, pericardial cavity and oesophagus causing infection and death.⁴⁶ This could cause death some time after release.
- Good practice may suggest that measures to minimise the by-catch of sharks and rays be continually developed and reviewed in line with stock assessments and any risk assessments that may follow.
- Work by Welch and colleagues⁶ to date, has established the need to use a variety of complimentary stock assessment techniques to provide the necessary information on spatial structure (effective management units) that is required for the management of the commercial exploitation of the highly-valued shark fishery in north-eastern Australia to be demonstrably ecologically sustainable. This information is essential to ensure management is conducted to ensure the sustainability of the catch in the context of fishery, biodiversity and ecosystem-based management objectives.
- There is increasing recognition there needs to be a greater emphasis on an ecosystem-based approach to fisheries and marine park management. This is a challenging objective and the ecosystem impacts performance measure within the ECIFFF Performance Measurement System is a move towards this as it recognises the need to maintain ecosystem structure, using species diversity (species composition and relative abundance) in the catch and by-catch by sub-fishery as an indicator. However, Gunn and colleagues comment that it would be prudent to develop a suite of potential indicators and make use of a wide range of data sources and not just fisheries data, but also survey or other monitoring data, including data from other institutions.¹⁶ It is suggested that metrics could monitor aspects such as the effects of the removal of predators (including sharks) or the depletion of important prey species from the ecosystem at local or broader spatial scales.
- Concerns remain for compliance with Fisheries and Marine Park regulations and a risk-based process should be used to determine priorities for compliance and enforcement. Concerns were raised in the Department of Environment and Heritage 2006 Assessment of the East Coast Inshore Fin Fish Fishery and surround commercial catch limits, including shark catch controls, monitoring of recreational and charter boat catches (including black marketing); and controls to minimise interactions with protected species, subsequent reporting of interactions with protected species and assessment of fate of animals after such interactions and remain as concerns to be considered through a risk assessment for inshore biodiversity.
- The independent review of the proposed management arrangements for the ECIFFF¹⁶ made the point that when a performance measure, such as a level of effort or catch, is reached and a management response triggered, good practice would be the implementation of a management response that should ideally prevent (or at least firmly control) any further increase in the effort or catch. The current Performance Measurement System has actions following triggers that constitute reviews, timetables for management changes or considerations of 'what to do next'. Gunn and colleagues¹⁶ suggest that although these may be appropriate responses, clear indications of what the catch or effort should be and how they will be achieved while reviews are being conducted are also required. They continue by saying that these responses should be pre-agreed and transparent so that fishers know what will happen when a trigger point is reached.¹⁶
- There is a need to manage the cumulative impacts affecting sharks and rays in near and inshore habitats. This should take the form of a risk assessment for inshore biodiversity, as the factors impacting sharks and rays in near and inshore habitats are also impacting species like marine turtles, dugong and inshore dolphins, which also rely on these habitats. This risk assessment should also include risk-based mapping to identify areas of high conservation value where specific management actions can be implemented. Such management actions would include the prioritisation of compliance and enforcement.
- When local and regional anthropogenic pressures, such as coastal development, declining water quality and recreational and commercial fishing are considered along with the effects of climate change, the cumulative

effects on the most vulnerable amongst the Great Barrier Reef's sharks and rays indicate a strong tendency towards population decline. These cumulative impacts must be considered when developing management strategies for at-risk shark and ray species in the World Heritage Area.

- Thirty species of shark and ray from the Great Barrier Reef have been assessed as having a 'high' or 'moderate' vulnerability to climate change and are assessed in consideration of cumulative impacts of fishing pressures and habitat loss and degradation from coastal development.¹ These species mainly populate the Freshwater and Estuarine and Coastal and Inshore functional groups, with some species from the Reef group (and few from the Shelf group), as defined by Chin and Kyne.⁴ Management should be focused on those pressures that can be addressed, such as the protection of habitat from coastal development, reducing pressures remaining from fishing, and implementing conservation actions for those species already at risk from other factors.
- There are emerging concerns surrounding the susceptibility of deepwater sharks to the deepwater line fishery due to their habitat specificity, life-history traits and low abundance and the increased effectiveness of the modern fishery. Some deepwater chondrichthyans also appear as by-catch in the East Coast Trawl Fishery.⁵ If unmanaged, sustained intensive deep-sea fishing could potentially lead to species extinctions,⁴⁷ a loss of biodiversity and ecosystem level changes as a result of the loss of high level predators from the food web. There are few data on the effects of fishing on deep-sea chondrichthyans, but those studies available typically show substantial declines (i.e. Graham *et al.* 2001⁴⁸). These attributes emphasise the importance of a precautionary approach to the management of deep-sea fisheries (most importantly by-catch reduction), not only because of the inability of many deep-sea sharks and rays to sustain fishing pressure, but also the very long recovery times that are required for such species from even short periods of fishing.⁴²

Management of sharks and rays in the Great Barrier Reef Marine Park

Management agencies with responsibilities for managing these species or impacts on these species within the Great Barrier Reef World Heritage Area and the statutory and non-statutory tools that influence the conservation management of these species.

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
World Heritage Convention	<ul style="list-style-type: none"> • Four natural heritage criteria with associated conditions of integrity. Criteria focus on: <ul style="list-style-type: none"> (i) geological processes and phenomena, including the evolution of the earth; (ii) ongoing ecological and biological processes; (iii) linked aesthetic components of the natural world; (iv) the biological diversity and habitats of threatened species • Natural Heritage Criteria iv states that the natural heritage asset must contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation. 	<ul style="list-style-type: none"> • Provides State Parties to the Convention with definitions of natural and cultural heritage, measures for the protection of natural and cultural heritage; the means of administration and obligations of the Convention; funding arrangements, educational programs and reporting obligations. 	United Nations Educational, Scientific and Cultural Organization (UNESCO)
Convention on Biological Diversity (CBD)	<ul style="list-style-type: none"> • The three main objectives of the CBD are: <ul style="list-style-type: none"> • The conservation of biological diversity • The sustainable use of the components of biological diversity • The fair and equitable sharing of the benefits arising out of 	<ul style="list-style-type: none"> • Provides State Parties to the Convention with global principles, objectives and obligations for the conservation of biodiversity. • Guides Australia's strategic planning to achieve national priority actions for biodiversity conservation through a range of objectives and targets for each. 	United Nations Environment Program (UNEP) – CBD Secretariat

	the utilisation of genetic resources.		
International Union for Conservation of Nature and Natural Resources Redlist of Threatened Species	<ul style="list-style-type: none"> • <i>Pristis microdon</i> (freshwater sawfish), <i>P. clavata</i> (dwarf sawfish), <i>P. zijsron</i> (green sawfish) and <i>Anoxypristis cuspidata</i> (narrow sawfish) all listed as critically endangered • <i>Glyphis glyphis</i> (speartooth shark) listed as Endangered • Other Australian species that are listed as threatened under the EPBC Act are listed as vulnerable on the IUCN Redlist. 	<ul style="list-style-type: none"> • Establishes the conservation status of species based on the assessment of their global population and trends. 	International Union for the Conservation of Nature and Natural Resources (IUCN)
Convention on International Trade in Endangered Species of Fauna and Flora (CITES)	<ul style="list-style-type: none"> • All species in the family Pristidae (except <i>P. microdon</i>) are listed under Appendix I • <i>P. microdon</i>, white shark (<i>Carcharodon carcharias</i>) and the whale shark (<i>Rhincodon typus</i>) listed in Appendix II 	<ul style="list-style-type: none"> • Animals listed under Appendix I are considered threatened with extinction and CITES prohibits international trade in specimens of these species • International trade of animals listed under Appendix II is allowed under permit for the exclusive purpose of international trade in live animals to appropriate and acceptable aquaria for primarily conservation purposes. 	<p>UNEP – CITES Secretariat</p> <p>CITES permits for international trade of sharks and rays listed on appendix II are administered by the Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC)</p> <p>(Permits to remove Pristids from the wild in Queensland for domestic purposes are administered by the Queensland Government if sourced inside the three nautical mile limits of state waters)</p>
Bonn Convention – Convention on Migratory Species (CMS)	<ul style="list-style-type: none"> • Provides a basis for forming international agreement on the protection, conservation and management of migratory species • White shark (<i>Carcharodon carcharias</i>) listed in Appendix I • Whale shark (<i>Rhincodon typus</i>) listed in Appendix II. 	<ul style="list-style-type: none"> • The Parties to the Convention agree to: <ol style="list-style-type: none"> a) promote, co-operate in and support research relating to migratory species; b) endeavour to provide immediate protection for migratory species included in Appendix I; and c) endeavour to conclude Agreements covering the conservation and management of migratory species included in Appendix II. 	United Nations Environment Program (UNEP) – CMS Secretariat
United Nations International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks)	<ul style="list-style-type: none"> • The IPOA-Sharks is a voluntary international instrument developed to guide signatory nations in the development of positive action to ensure the conservation and management of sharks and their long-term sustainable use. 	<ul style="list-style-type: none"> • Ratified by Australian government in 2004 • Processes of review of Plan. 	Food and Agriculture Organization (FOA) of the United Nations – Fisheries and Aquaculture Department.
National Plan of Action for the Conservation of Sharks (Shark Plan) ⁴⁹	<ul style="list-style-type: none"> • The Shark Plan provides advice and guidance to the general public, fisheries managers, and conservation managers on actions required to ensure Australia's shark populations are managed sustainably now and into the future. 	<ul style="list-style-type: none"> • The Shark Plan aims to address national shark conservation and management issues (mapped against the 10 objectives of the Plan) through six key themes: <ul style="list-style-type: none"> • Reviewing existing conservation and management measures 	Department of Agriculture, Fisheries and Forestry (DAFF), Department of Sustainability, Environment, Water, Population and Communities in partnership with

		<ul style="list-style-type: none"> • Improving conservation and management measures • Changes to data collection and handling • Research and development • Education or awareness raising • Improved coordination and consultation. • Processes of review of Plan. Revised plan being prepared for release in 2011 (Shark Plan II). 	<p>relevant state and Northern Territory fisheries management and conservation agencies.</p>
<p><i>Environment Protection and Biodiversity Conservation Act 1999</i> (EPBC Act) and <i>Environment Protection and Biodiversity Conservation Regulations 2000</i>.</p>	<ul style="list-style-type: none"> • Legislative framework for environmental protection in Australia • Provides means of assessment of 'actions' within Australian marine and terrestrial environments • Legislative role includes the listing and regulation of threatened and protected species and communities, the preparation of recovery plans for threatened and protected species, the identification of key threatening processes and, where appropriate, the development of threat abatement plans and recovery plans • Listed as vulnerable and migratory <ul style="list-style-type: none"> • White shark – <i>Carcharodon carcharias</i> • Whale shark – <i>Rhincodon typus</i> Listed as critically endangered <ul style="list-style-type: none"> • Speartooth shark – <i>Glyphis glyphis</i> • Grey nurse shark - <i>Carcharias taurus</i> • Listed as vulnerable – <ul style="list-style-type: none"> • <i>Pristis</i> species - fresh, green and dwarf sawfish. 	<ul style="list-style-type: none"> • Listed threatened species and ecological communities are recognised as a Matters of National Environmental Significance. Consequently, any action that is likely to have a significant impact on listed threatened species and ecological communities under the EPBC Act are subject to referral and assessment under the Act • An action affecting threatened shark and ray species that would otherwise be in breach of the EPBC Act could be deemed to be a 'controlled action' and require a greater scrutiny of environmental impact assessment and, if approved, conditions for control of the action • Recovery Plans for grey nurse, great white and whale sharks developed • Recovery Plans for sawfish listed as Vulnerable and <i>Glyphis</i> sp. sharks currently under development • Assessment and export approval processes for all fisheries with an export component (or Wildlife Trade Operation). • Penalties for non-compliance • Act is regularly reviewed. 	<p>DSEWPaC</p>
<p>Guidelines for the ecologically sustainable management of fisheries -2007</p>	<ul style="list-style-type: none"> • Provides guidance to the assessment of Australian fisheries that seek to operate with a Wildlife Trade Operation (WTO) accreditation under the EPBC Act <p>All the Queensland fisheries that have a shark component, either as target catch, by-product or by-catch, currently have obligations under Wildlife Trade Operation permits under the EPBC Act .</p>	<ul style="list-style-type: none"> • Fisheries under EPBC Act, WTO assessment must demonstrate that they operate under a management regime that meets two principles. <ol style="list-style-type: none"> 1. A fishery must be conducted in a manner that does not lead to over-fishing, or for those stocks that are over-fished, the fishery must be conducted such that there is a high degree of probability the stock(s) will recover; and 2. Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem. 	<p>DSEWPaC</p>

<p><i>Great Barrier Reef Marine Park Act 1975 and Great Barrier Reef Marine Park Regulations 1983</i></p>	<ul style="list-style-type: none"> • Regulation 29, Table 29 of the Regulation provides a list of Protected Species including elasmobranch species. • Regulation provides for the creation of Special Management Areas within the Marine Park. • Regulation of scientific research in the Marine Park • Regulation of activities within the Marine Park. 	<ul style="list-style-type: none"> • Special Management Areas can be created under certain conditions • Penalties for non-compliance • Review of Act and Regulation. 	<p>Great Barrier Reef Marine Park Authority (GBRMPA)</p>
<p><i>Great Barrier Reef Marine Park Zoning Plan 2003</i></p>	<ul style="list-style-type: none"> • A multiple-use marine protected area management tool that protects biodiversity by the regulation of activities within the Great Barrier Reef Marine Park. • The Representative Area Program that provided the basis for the Zoning Plan spatial planning decisions, described 70 broad-scale habitats, or bioregions, and as such provides the basis for ecosystem-based management in the Marine Park. 	<ul style="list-style-type: none"> • Spatial management of activities within the Great Barrier Reef based on protection of habitat type representative areas • Thirty-four per cent of the Marine Park is dedicated as Marine National Park (green) or Preservation (pink) zones in which no extractive activities are permitted • Restricted Access Special Management Areas (SMA) can be created for the protection of sharks and rays and their habitats under special circumstances • Dugong Protection Areas (spatial restrictions on commercial mesh netting) also provide subsequent protection for sharks and rays (e.g. Hinchinbrook Island Area Dugong Protection Area) • Processes of review • Penalties for non-compliance. 	<p>GBRMPA</p>
<p><i>Great Barrier Reef Biodiversity Conservation Strategy 2012</i></p>	<ul style="list-style-type: none"> • Identifies sharks and rays as a group of species 'at risk' in the Marine Park • Grades the level of risk experienced by sharks and rays through a vulnerability assessment process. 	<ul style="list-style-type: none"> • The Biodiversity Conservation Strategy outlines a Framework for Action with three strategic objectives aimed at building or maintaining ecosystem resilience and protecting biodiversity: <ol style="list-style-type: none"> 1. Engage communities and foster stewardship 2. Building ecosystem resilience in a changing climate 3. Improved knowledge. • Objectives are comprised of program-level outcomes with key actions and contain targets for measuring success • Implementation of the Strategy will be undertaken through a multi-agency, multi-stakeholder collaborative approach. 	<p>GBRMPA</p>
<p><i>Great Barrier Reef Climate Change Action Plan 2007-2012</i></p>	<ul style="list-style-type: none"> • Identification of specific measures to enhance resilience of the Great Barrier Reef ecosystem and support adaptation by regional communities and industries that depend on it. 	<ul style="list-style-type: none"> • Allocation of dedicated funding to implement actions to improve the resilience of the Great Barrier Reef ecosystem. 	<p>GBRMPA</p>

<p><i>Reef Rescue Land and Sea Country Indigenous Partnerships Program</i></p>	<ul style="list-style-type: none"> • Expand the Traditional Use of Marine Resource Agreement (TUMRA) program across the Reef catchment • Strengthen communication between local communities, managers and Reef stakeholders and build better understanding of Traditional Owner issues about the management of the Great Barrier Reef Marine Park. 	<ul style="list-style-type: none"> • Expansion of the TUMRA program, which complements dugong and green turtle management along with other species of conservation and cultural significance, including shark and ray species • Enhanced compliance to address illegal activities in high risk areas that threaten cultural and natural heritage values and culturally important species • Engaging with communities to empower traditional owners in the context of sea country management • Providing grants and sponsorships to increase the knowledge and skills base of traditional owners and enable them to better manage sea country, and • Strengthening communications and knowledge sharing between Traditional Owners, management agencies and the broader community. 	<p>GBRMPA</p>
<p><i>Reef Guardian Stewardship program</i></p>	<ul style="list-style-type: none"> • The Reef Guardian Stewardship program is playing a critical role in ensuring that the values of the Great Barrier Reef are appreciated and that community actions support management of the Marine Park so that it is well placed to meet the challenges ahead. This stewardship program has been identified by the GBRMPA as a vehicle for progressing conservation actions for sharks and rays across the Great Barrier Reef communities where they occur. 	<ul style="list-style-type: none"> • The community-based initiative facilitates the environmental actions being undertaken within coastal communities and industries both in the Great Barrier Reef catchment and in the Marine Park. 	<p>GBRMPA</p>
<p><i>Fisheries Act 1994 (Qld) and Fisheries Regulation 2008</i></p>	<ul style="list-style-type: none"> • Provides the legislative framework and regulatory controls for managing fisheries in all Queensland waters and Commonwealth waters subject to the Offshore Constitutional Settlement for the state of Queensland. 	<ul style="list-style-type: none"> • Rules (N₁, N₂, N₄, N₁₁, S and line fishery) for the commercial take of sharks and rays (includes net apparatus parameters designed to limit shark interactions to animals below 1.5m for non-shark target symbol operators) • 'S' symbol shark logbook and Species of Conservation Interest (SOI) logbook reporting requirements • No-take and vulnerable species take limits, including elasmobranch species • Net attendance rules in set mesh net fisheries (must be in attendance at all times) • Dugong Protection Areas regulate and restrict the use of commercial set mesh nets within designated areas, which provides spatial protection for animals susceptible to incidental capture • Recreational bag limit of one 	<p>Queensland Government</p>

		<ul style="list-style-type: none"> • Maximum size limit 1.5m for all fishers except those with the 'S' fishery symbol and an accompanying net fishery symbol • Bag limit of 10 shark or ray for net and four for line for commercial fishers in the ECIFFF without an 'S' symbol • Bag limit of four sharks in CRFFF (taken by line – all sectors) • Regulation on turtle exclusion and by-catch reduction devices in trawl fishery with benefits to larger elasmobranchs • No sharks or rays allowed to be retained by trawl fishery • Setting a Total Allowable Commercial Catch of 600 t for all sharks and rays • No discarding of finned shark bodies (trunks must be retained) • No finning at sea of guitarfish, shovelnose rays and grey reef and white tip reef sharks • Licence conditions on S symbol holders requiring carriage of Queensland Government fisheries observers on request • Penalties for non-compliance • Review of the Act in 2011. 	
East Coast Inshore Fin Fish Fishery (ECIFFF) management arrangements	<ul style="list-style-type: none"> • Regulations are established under the <i>Fisheries Act 1994</i> (Qld) and <i>Fisheries Regulation 2008</i> • Accredited WTO under <i>Environment Protection and Biodiversity Conservation Act 1999</i> managed by the Queensland Government • Commonwealth regulation requires reporting on management arrangements and conditions of the WTO through an annual status report • Reports on interactions with Species of Conservation Interest (SOI) including elasmobranch species. 	<ul style="list-style-type: none"> • Independent Shark Panel established by the Queensland Government to deal with specific management issues within the ECIFFF regarding shark. Panel provides a significant role guiding the implementation of conditions and recommendations associated with the ECIFFF WTO accreditation and future assessments. Panel provides advice on future direction of research to address fishery management knowledge gaps • SOCI data is gathered through logbooks and the Queensland Shark Observer Program • Published <i>Guidelines for commercial operators in the East Coast Inshore Fin Fish Fishery</i> to provide commercial fishers with a summary of management arrangements • Published <i>Shark identification guide for Queensland fishers</i> to assist with improving species identification for recording into fishery logbooks. Accompanied by non-mandatory industry training • Review of the Fishery under <i>Environment Protection and Biodiversity Conservation Act 1999</i>. Review completed February 2012. New WTO with conditions issued; valid to 2015. 	Queensland Government
Queensland Shark	• Community Education and	• Nets designed to capture sharks	Queensland

<p>Control Program (QSCP)</p>	<p>Protection Policy under <i>Fisheries Act 1994</i> (Qld)</p> <ul style="list-style-type: none"> • Thirty-five nets at localities in Cairns, Mackay, Rainbow Beach, Sunshine Coast, and the Gold Coast.⁵⁰ • Three hundred and forty-four drumlines at localities across Cairns, Townsville, Mackay, Capricorn Coast, Gladstone, Bundaberg, Rainbow Beach, Sunshine Coast, North Stradbroke Island and the Gold Coast.⁵⁰ 	<p>greater than 2 m in length. Nets are 186 m long. Most nets have a depth of 6 m and a mesh size of 500 mm</p> <ul style="list-style-type: none"> • Ten shark nets remain in the Marine Park: five off Cairns beaches; five off Mackay beaches. Remainder have been replaced by drumlines • Drumline arrays consist of up to six or more shark hooks with fresh bait suspended individually from large plastic floats. (Roughly one net = six drumlines) • Equipment checked every second day, weather permitting • Other measures employed to reduce interactions with threatened species. 	<p>Government</p>
<p><i>Great Barrier Reef Marine Park Authority Position Statement on the conservation and management of sharks and rays in the Queensland East Coast Inshore Finfish Fishery.</i> June 2007.</p>	<ul style="list-style-type: none"> • Great Barrier Reef Marine Park Authority Position Statement on the conservation and management of sharks and rays in the Queensland East Coast Inshore Fin Fish Fishery 	<ul style="list-style-type: none"> • Provides guidance on how the Marine Park Authority frames its management decisions with regards to sharks and rays • Review of Position Statement. 	<p>GBRMPA</p>
<p><i>Policy on managing activities that include the direct take of a Protected Species from the Great Barrier Reef Marine Park.</i> June 2005. Additions September 2008.</p>	<ul style="list-style-type: none"> • Provides a framework for the consistent and effective management of activities that include the direct take of a Protected Species from the Great Barrier Marine Park. 	<ul style="list-style-type: none"> • Justifications and assessment guidelines on the take of protected species for certain anticipated (and unanticipated) uses • Processes of Policy review. 	<p>GBRMPA</p>
<p><i>Nature Conservation Act 1992</i> (Qld) and <i>Nature Conservation (Wildlife) Regulation 2006.</i></p>	<ul style="list-style-type: none"> • Legislative framework for the conservation of nature in Queensland • Protecting native wildlife and its habitat • Providing for the ecologically sustainable use of protected wildlife and areas • Provides a list of threatened and protected species in Queensland • The grey nurse shark (<i>Carcharias taurus</i>) listed as endangered. 	<ul style="list-style-type: none"> • Provides regulation of, and management responsibilities for, protected areas and listed species • Penalties for non-compliance • Review of Act and Regulation. 	<p>Queensland Government</p>
<p><i>Marine Parks Act 2004</i> (Qld) and <i>Marine Parks Regulation 2006</i></p>	<ul style="list-style-type: none"> • The object of this Act is to provide for the conservation of the marine environment by: <ul style="list-style-type: none"> • declaring State marine parks • establishing zones, designated areas and highly protected areas within marine parks • developing zoning and management plans • recognising the cultural, economic, environmental and social relationships between marine parks and other areas • applying the precautionary 	<ul style="list-style-type: none"> • Aims to involve all stakeholders cooperatively • Coordination and integration with other conservation legislation • Penalties for non-compliance • Processes of review. 	<p>Queensland Government</p>

	principle.		
<i>Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld)</i>	<ul style="list-style-type: none"> • A multiple-use marine protected area management tool that protects biodiversity by the regulation of activities within the Great Barrier Reef Coast Marine Park • The Representative Area Program that provided the basis for Great Barrier Reef spatial planning decisions described 70 broad-scale habitats, or bioregions and as such provides the basis for ecosystem-based management in the Great Barrier Reef Coast Marine Park. 	<ul style="list-style-type: none"> • Spatial management of activities within State waters of the Great Barrier Reef based on protection of representative bioregions • Penalties for non-compliance • Complements spatial management zones and certain regulatory provisions established under the <i>Great Barrier Reef Marine Park Zoning Plan 2003</i> 	Queensland Government
Marine Wildlife Stranding Program	<ul style="list-style-type: none"> • Collects and reports on stranding and mortality information of threatened marine wildlife species within Queensland, including some species of sharks and rays. 	<ul style="list-style-type: none"> • Provides critical information to aid and inform research and management initiatives 	Queensland Government (jointly funded by the GBRMPA through the Field Management Program)
Back on Track Biodiversity Action Plans	<ul style="list-style-type: none"> • The Back on Track Species Prioritisation Framework identifies priority species for conservation management, regional threats, and suggested recovery actions. • Includes some species of sharks and rays. 	<ul style="list-style-type: none"> • Identifies regionally-appropriate management actions to mitigate the risks to these species • Processes of review. 	Queensland Government (with regional Natural Resource Management groups and other stakeholders for implementation of identified management actions)
<i>Reef Water Quality Protection Plan 2009 (Qld)</i>	<ul style="list-style-type: none"> • An overarching framework to achieve a sustainable future for the Great Barrier Reef and the industries in the Reef's catchment by improving water quality that flows into the Reef. 	<ul style="list-style-type: none"> • Improve water quality that flows into the Reef by targeting priority outcomes, integrating industry and community initiatives and incorporating new policy and regulatory frameworks. 	Queensland Government (jointly funded by the Commonwealth Government and the State of Queensland)
<i>Great Barrier Reef Protection Amendment Act 2009 (Qld)</i>	<ul style="list-style-type: none"> • A framework for reducing the levels of dangerous pesticides and fertilisers found in the waters of the Great Barrier Reef by 50 per cent in four years. 	<ul style="list-style-type: none"> • Mix of strict controls on farm chemicals and regulations to improve farming practices. 	Queensland Government
<i>Coastal Protection and Management Act 1995 (Qld) and Coastal Protection and Management Regulation 2003</i>	<ul style="list-style-type: none"> • Provides the legislative framework and regulations for the coordinated management of the diverse range of coastal resources and values in the coastal zone. This framework includes provisions that establish the Queensland Coastal Plan. 	<ul style="list-style-type: none"> • Queensland Coastal Plan outlines directions for effective protection and management of the coastal zone. 	Queensland Government
<i>Queensland Coastal Plan</i> (prepared under the <i>Coastal Protection and Management Act 1995</i> and includes a state planning policy under the <i>Sustainable Planning Act 2009</i>)	<ul style="list-style-type: none"> • The Queensland Coastal Plan has two parts: State Policy for Coastal Management and the State Planning Policy 3/11: Coastal Protection (SPP). 	<ul style="list-style-type: none"> • The State Policy for Coastal Management provides policy direction for natural resource management decision-makers about land on the coast, such as coastal reserves, beaches, esplanades and tidal areas • The SPP provides policy direction and assessment criteria to direct land-use planning and development assessment decision making under the <i>Sustainable Planning Act 2009</i>. 	Queensland Government

<p><i>Sustainable Planning Act 2009 (Qld) and Sustainable Planning Regulation 2009</i></p>	<ul style="list-style-type: none"> • Establishes process for land-use planning and development assessments. Identifies state legislation that may be triggered by development assessments and the process by which developments must be assessed against each piece of legislation • Establishes the framework for the development of Regional Plans. 	<ul style="list-style-type: none"> • Regional plans operate in conjunction with other state planning instruments, usually taking precedence over them • Regional plans must conform to policies established within the Queensland Coastal Plan • Regional plans identify: <ul style="list-style-type: none"> • desired regional outcomes • policies and actions for achieving these desired regional outcomes • the future regional land use pattern • regional infrastructure provision to service the future regional land use pattern • key regional environmental, economic and cultural resources to be preserved, maintained or developed. 	<p>Queensland Government</p>
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References

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Appendix 1. Pressure assessment matrix

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to catchment run-off
Exposed to source of pressure (yes/no)	Yes; locally	Yes; locally	Yes; State-wide	Yes; regionally	Yes; locally	Yes; regionally	Yes; locally	Yes	Yes; along the developing coast of Queensland, predominantly nearshore and south of Port Douglas	Yes; along the developing coast of Queensland, predominantly nearshore and south of Cooktown
Degree of exposure to source of pressure (low, medium, high, very high)	Low. Potential exposure within certain high-use regions of the Marine Park is high, though Great Barrier Reef -wide exposure is low.	Low. Great Barrier Reef -wide exposure is low. The Outlook Report 2009 found that Defence activities are well managed and limited in extent, duration and geographic distribution.	High. High exposure of shark species from all functional groups to both existing and potential impacts of commercial fishing, especially in the ECIFFF, the east coast line fisheries (coral reef, spanish mackerel) and the East Coast Otter Trawl Fishery (ECOTF). There are also emerging concerns for the impacts that fishing can incur on deepwater chondrichthyans. Species such as sawfish, spartooth shark and the estuarine stingray are particularly exposed due to their highly specific use of estuarine and inshore habitats.	High. High exposure of shark and ray species from all functional groups to both existing and potential impacts of recreational fishing. Rules are in place which restrict recreational take to one shark and available information indicates that the retention of sharks and rays by recreational fishers is low. Although retention rates may be low, the level of interaction between recreational fishing	Medium. Degree of exposure is likely to increase as the need for further shipping increases within the Great Barrier Reef. Impacts combine cumulatively with other sources of pressure.	Low. Recreational activities within the Marine Park do not expose sharks and rays to significant impacts.	Low. Exposure exists but is not considered to be high.	Very High. Coastal/ inshore and freshwater/ estuarine groups have a very high degree of exposure to the multi-faceted impacts of climate change. Direct effects are changes in the physiochemical environment in which the species live (increases in ocean temperature and ocean acidification and altered rainfall regimes) and indirect effects which will influence the health and distribution of habitats as well as the geophysical, biological and ecological processes occurring within them (ocean circulation, temperature, sea level rise, severe weather events, freshwater input and changed light regimes). With 50 per cent of the species most vulnerable to climate change impacts	High. Coastal/ inshore and freshwater/ estuarine groups most exposed due to habitat loss resulting from impacts of coastal development (including ports and shipping expansion). Other functional groups ⁴ are not likely to be as highly exposed to this pressure.	High. Coastal/ inshore and freshwater/ estuarine groups most exposed due to habitat loss and degradation resulting from impacts of declining water quality due to catchment run-off. Other functional groups ⁴ are not likely to be as highly exposed to this pressure.

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to catchment run-off
				activities and sharks and rays is higher and is a source of mortality.				populating inshore habitats, the combination of threats faced by these species makes them highly sensitive to cumulative impacts. Other functional groups ³ (not linked to bibliography ³) are not likely to be as highly exposed to this pressure.		
Sensitivity to source of pressure (low, medium, high, very high)	Low. Research has shown that certain reef shark species that hunt at night, and which are targeted by marine tourism activities during the day, are disturbed from day time resting habits. This disturbance may have an effect on energy deficits available for biological functions. However, sensitivity to low levels of exposure to this pressure is low.	Low. Defence activities limited spatially and temporally. Low exposure determines the level of sensitivity towards this pressure on Reef-wide scales.	High. There is limited ability to select for low-risk species of shark and ray. Post-release mortality of discarded specimens is not well understood for all sectors of the shark and ray fishery. Fisheries-dependent standardised catch rate information that provides indices of abundance is improving. On-going fisheries-independent risk assessments will help inform stock assessments of key species of sharks and rays taken in Queensland fisheries and assist the formulation of	Medium. It is considered that sharks and rays are captured by recreational fishers but information indicates the majority are released and post-release survivorship may be high, thus decreasing the sensitivity to this pressure. However, post-release survival is not always easy to detect and is largely undetermined. For example, necropsies performed on grey nurse sharks in aquaria have indicated that	Medium. Shark and ray species most sensitive to impacts from ports and shipping are those within the freshwater and estuarine and inshore and coastal functional groups that face habitat loss and degradation from port developments and diffuse pollution. Ports and shipping development may also impact on the productivity/ abundance of prey species for these species of sharks and rays.	Low. Low exposure determines the level of sensitivity towards this pressure on Reef-wide scales.	Medium. Sensitivity of individuals would be high as it is likely they would be retained for food if captured. However, levels of exposure to this pressure in the World Heritage Area are considered to be low, so Reef-wide sensitivity to this pressure is medium.	High. Sharks and rays most sensitive to impacts of climate change exist within the inshore and coastal functional group. Every species within the freshwater and estuarine group (other than the bull shark (<i>C. leucas</i>) that populates a number of habitats) is also assessed as being highly or moderately vulnerable to climate change impacts. Species are also represented from the shelf and reefal groups.	High, Estuarine and inshore species predominantly on the developing coast south of Port Douglas. Sharks and rays that inhabit inshore areas are likely to be most sensitive to habitat loss and degradation that results from coastal development. Some species within these functional groups are not expected to be significantly impacted (e.g. bull shark, <i>Charcharinus leucas</i>). However, 51 shark and ray species occur in these functional groups ⁴ and as a group are considered highly sensitive to impacts from this pressure in combination with other cumulative	High, Estuarine and inshore species predominantly on the developing coast south of Cooktown. 51 species of shark and rays inhabit estuarine and inshore waters of the Great Barrier Reef. ⁴ In addition, 85 per cent of the state's human population lives in the coastal fringe where strong population growth is predicted. Such impacts as eutrophication, which reduces oxygen levels, can cause declines in the health of coastal communities and affects how species use these environments. ¹⁷ Pollution has been reported to lower

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to catchment run-off
			management arrangements. Guided by the Shark Panel forum, this approach will should be applied to assess any emerging concerns. Species such as sawfish, speartooth shark and the estuarine stingray are particularly sensitive due to the morphology, life-history traits and low abundance.	derelict hooks may puncture the stomach, pericardial cavity and oesophagus causing infection and death. ⁴⁶ This could cause death some time after release.					pressures in the inshore zone.	productivity and damage prey populations within nearshore ecosystems. ¹⁷ Seagrass meadows degraded by reduced water quality can impact survivability of juvenile recruits. ¹⁷ For certain nearshore shark and ray species, this combination of factors may make them highly sensitive to reduced water quality from catchment run-off.
Adaptive capacity – natural (poor, moderate, good)	Good. Some reef sharks most commonly targeted by the tourism industry show site fidelity within reefs as juveniles, whereas adults are more dispersed over larger areas. Adaptive capacity to low levels of exposure and sensitivity is good.	Good. Natural adaptive capacity of sharks and rays to low levels of exposure and sensitivity to this pressure is good.	Poor. Sharks and rays are unlikely to be able to modify their behaviours to avoid commercial fishing operations. They are also unlikely to be able to adapt their post-release survival capacities. This needs to be considered in the context of the limited ability of the fishery to select for low-risk species.	Poor. As sharks and rays are present in areas fished by recreational fishers it is unlikely they will be able to avoid baits set to catch other species.	Poor. Conservative life histories mean that coastal/ inshore and estuarine groups of sharks and rays are unlikely to avoid port areas, unless sources of prey decline and they have to move to find prey.	Good. Natural adaptive capacity of sharks and rays to low levels of exposure and sensitivity to this pressure is good.	Good. Traditional take of sharks and rays limited in geographical extent, the species targeted and the quantity taken. This equates to a lower level of adaptive capacity required by sharks and rays to this pressure.	Poor. Conservative life histories mean that sharks and rays have poor adaptive capacity to the physical, chemical and ecological effects caused by climate change.	Poor. For many of the estuarine and inshore species most likely to be impacted, habitat and trophic specificity in combination with conservative life histories can mean that certain sharks and rays have poor adaptive capacity to habitat degradation or loss as a result of coastal development. ^{1,5,17}	Poor. For many of the estuarine and inshore species most likely to be impacted, habitat and trophic specificity in combination with conservative life histories can mean that certain sharks and rays have poor adaptive capacity to habitat degradation/loss as a result of reduced water quality from catchment run-off. ¹⁷

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to catchment run-off
<p>Adaptive capacity – management (poor, moderate, good)</p>	<p>Good. Commercial tourism in the Great Barrier Reef is managed through a permit system guided by established spatial management tools that can be applied through legislative procedure. This allows a certain degree of flexibility in the management of emergent impacts from this pressure.</p>	<p>Good. Defence activities are well managed and limited in extent, duration and geographic distribution (Outlook Report 2009).</p>	<p>Moderate. Recent management changes in the ECIFFF, such as implementing a 600 t total allowable commercial catch and restricting size to 1.5 m for commercial fishers without a shark licence has reduced some of the impacts of the fishery. Some estuaries are closed to commercial fishing under state fisheries regulations. The ability to make informed decisions from fishery-dependent and fishery-independent information is improving under the guidance of the independent Shark Panel. Current methods for attaining that information has previously been assessed as inadequate¹⁶ as is access to existing information from the fishery. A more collaborate approach is required between</p>	<p>Moderate. Recreational fishers are restricted to a bag limit of one shark or ray only with a maximum size limit of 1.5m under Queensland fisheries Regulations. The harvest of sharks and rays by the recreational fishing sector is considered to be low with the by-catch of sharks and rays also thought to be low, though requires consideration in the context of biodiversity conservation. Post-release mortality is also thought to be low, though is largely undetermined. The <i>Great Barrier Reef Marine Park Zoning Plan 2003</i> is providing protection of habitat that is used by sharks</p>	<p>Moderate. GBRMPA has strategies (e.g. Environmental Management Plans) and statutory tools to lower the risk of vessel related oil spills and pollution incidents. However, the risks can only be lowered and not eliminated. Environmental impact assessments made under the EPBC Act provide a process to assess the impacts of proposed port developments though are subject to political processes.</p>	<p>Good. Statutory tools and guidelines and stewardship and education programs developed by the GBRMPA are actively developing public ownership of and compliance with reef management best practice. This is ongoing core business for the GBRMPA. These can be adapted to suit changing management needs through processes of review.</p>	<p>Moderate. Traditional owners could be engaged to discuss an adaption of their hunting practices if concerns regarding the conservation status of sharks and rays were raised. Regional engagement and Indigenous community stewardship programs operated by GBRMPA provide an avenue to develop shared learning opportunities with regards to Great Barrier Reef management. Monitoring programs attached to Traditional Use of Marine Resources Agreements may provide similar future opportunities to share</p>	<p>Poor. Options for local or regional scale management of climate impacts on sharks and rays remain limited because most impacts are directly linked to large-scale global climate phenomena rather than more local threatening processes. Current available information on climate change impacts on sharks and rays are being implemented into management actions within the World Heritage Area. However, long-term studies that take account of temporal and spatial variabilities and provide key determining correlations between climate change impacts and shark and ray populations at the species-specific level continue to be required to inform management. GBRMPA's current framework for managing climate change impacts and building the resilience of species and habitats to those impacts has been developed to implement new</p>	<p>Moderate. The <i>Great Barrier Reef Marine Park Act 1975</i> provides limited scope to manage activities outside the Marine Park. Capacity to address effects of habitat loss exists through partnership and educational arrangements with state authorities, non-government and community groups and schools. For state coastal planning process this is undertaken by providing input into State Coastal Management Plan policies and statutory Regional Plans which plan for coastal development in Queensland. The <i>Sustainable Planning Act 2009</i> (Qld) legislates on state planning approval processes and requires triggered proposals to be assessed under considerations such as the <i>Fisheries Act 1994</i> habitat management capabilities. The GBRMPA also provides input into project environmental</p>	<p>Moderate. The <i>Great Barrier Reef Marine Park Act 1975</i> provides limited scope to manage activities outside the Marine Park. To improve coastal ecosystem outcomes for the Great Barrier Reef, GBRMPA facilitates the development of partnerships with industry, the community, local and state government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures, developing and maintaining a culture of mutual obligation. This is undertaken by fostering partnerships through the <i>Reef Water Quality Protection Plan 2009</i> and <i>Reef Rescue Program</i>. The GBRMPA also provides input into environmental assessments of coastal zone projects that come under the EPBC</p>

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to catchment run-off
			<p>state and federal management agencies in order to develop improved outcomes for biodiversity conservation and economic sustainability.</p> <p>The <i>Great Barrier Reef Marine Park Zoning Plan 2003</i> is providing protection of habitat that is used by sharks and rays in the Great Barrier Reef. 66 per cent of the Great Barrier Reef Marine Park is closed to otter trawling. Thirty-four per cent of the Marine Park is closed to all extractive uses. Inshore zonings of Marine National Parks and Conservation Parks used by many at-risk species of sharks and rays provide some restriction to the extent of habitat available to inshore netters and crabbers.</p> <p>The <i>Queensland Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004</i></p>	<p>and rays in the Great Barrier Reef. Thirty three per cent of the Marine Park is closed to extractive uses. Inshore zoning of Marine National Parks and Conservation Parks in combination with provisions under the <i>Queensland Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004</i> provide some restriction to the extent of habitat available to crabbers and fishers.</p>			<p>information and enable Traditional Owners to become active agents in the conservation and sustainable use of sharks and rays.</p>	<p>information as it becomes available.</p>	<p>assessments that come under the EPBC Act.</p>	<p>Act.</p>

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to catchment run-off
			provides complementary protection of some estuarine waters. However, the capacity to adapt the Zoning Plans to meet changing spatial management requirements is limited.							
Residual vulnerability (low, medium, high)	Low	Low	High (at-risk species 1,2,4,5,6) Moderate (remaining species)	Medium	Medium (primarily for nearshore species)	Low	Low	High (across the taxa)	High (primarily for nearshore species)	High (primarily for nearshore species)
Level of confidence in supporting evidence (poor, moderate, good)	Poor. Semeniuk <i>et al.</i> 2009. ⁴⁰ Limited published supporting evidence.	Poor. Limited published supporting evidence.	Good for some elements of interactions with fisheries, but poor for others such as biological and behavioural information to underpin stock assessments. Stevens <i>et al.</i> 2000; ⁴¹ Salini 2007; ²¹ Chin & Kyne 2007; ⁴ Kyne 2008; ⁵ Gunn <i>et al.</i> 2008; ¹⁶ Simpfendorfer & Kyne 2009; ⁴² Chin <i>et al.</i> 2010; ¹ Pears <i>et al.</i> (in	Moderate. Henry & Lyle 2003; ⁵¹ Lynch <i>et al.</i> 2010 ¹⁸	Poor. Limited published supporting evidence.	Poor. Limited published supporting evidence.	Poor. Coleman <i>et al.</i> ³⁶ cited in Henry & Lyle 2003	Moderate. Chin & Kyne 2007; ⁴ Chin <i>et al.</i> 2010 ¹	Good. Stevens <i>et al.</i> 2005; ⁵² Chin & Kyne 2007; ⁴ Knip <i>et al.</i> 2010 ¹⁷	Good. Chin & Kyne 2007; ⁴ Knip <i>et al.</i> 2010; ¹⁷ Hutchings <i>et al.</i> 2005 ⁵³

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to catchment run-off
			review) ²							

The pressures addressed in this Vulnerability Assessment were identified in the *Great Barrier Reef Outlook Report 2009*.⁴³

Coastal habitats (reefs, foreshores, rivers and estuaries) are under increasing pressure from human activities. More than 85 per cent of Queensland's population lives on the coastal fringe. Predicted strong population growth means the intensity of activity and development in coastal zones is likely to persist or increase.⁵⁴

The purpose of the vulnerability assessment process is to provide a mechanism to highlight key concerns and make assessments of the vulnerabilities that species, groups of species or habitats have to known sources of pressure within the Great Barrier Reef World Heritage Area (the World Heritage Area) using a standardised and transparent process. This was undertaken using a standard approach to assess exposure and sensitivity and adaptive capacity to potential impacts (Figure 1) based on the best-available information on that particular habitat, species or group of species.

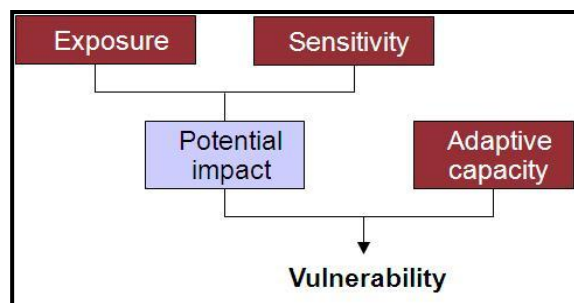


Figure 1. The key components of vulnerability assessments (Adapted from Wachenfeld *et al.*, 2007)

To achieve this objective it has been necessary to apply a linear relationship to comparisons that are sometimes non-linear by nature. For example, when applying the potential impact matrix^e to create a combined score for exposure and sensitivity, if a species, group of species or habitat has a very high level of exposure to a pressure but low sensitivity to it, it is scored as having a medium-high potential impact score. This medium-high score may be the same as determined for another assessment where there may be a low level of exposure but a very high level of sensitivity. This implies a linear relationship for the sensitivity a species or habitat has to a given level of exposure, which may not necessarily be the case. However, it does provide managers with the required level of resolution on these relationships for the purpose of the vulnerability assessments that inform the *Great Barrier Reef Biodiversity Conservation Strategy 2012*.

The methods used to determine the degree of exposure or sensitivity of sharks and rays of the World Heritage Area against each source of pressure are described within the vulnerability assessments page of the GBRMPA website.

The natural capacity of sharks and rays to adapt to pressures in the Great Barrier Reef, and the capacity of management to intervene (which in turn may assist sharks and rays to adapt to these pressures), are considered as two dynamics that affect their residual vulnerability to any of the identified pressures. These two dynamics are then

^e The potential impact matrix is described within the vulnerability assessments page of the GBRMPA website.

combined to produce an overall rating for adaptive capacity and then applied to the potential impact rating to provide a score for the residual vulnerability that sharks and rays may be expected to experience for the given pressure. An explanation of the procedure by which this process has been applied and qualifying statements for the assessment of adaptive capacity (natural and management) scores are provided within the vulnerability assessments page of the GBRMPA website.

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