

# A Vulnerability Assessment for the Great Barrier Reef



## Sawfish

Information valid as of Feb 2012

### Summary

#### Diversity

Four species of the family Pristidae, three within the genus *Pristis* (green sawfish, dwarf sawfish and freshwater sawfish) and one species in the genus *Anoxypristis* (narrow sawfish).

#### Susceptibility

Life-history traits of sawfish make them susceptible to a number of pressures occurring in the World Heritage Area. *Pristis*: Long-lived, slow growth rate, low reproduction rate, mature late, low abundance, can have high habitat and trophic specificity,<sup>a</sup> morphology and behaviour predisposes these species to incidental capture in mesh nets.

*Anoxypristis*: Relatively shorter lived, higher reproductive and growth rates, moderate abundance and more resilient to mortality from unnatural sources than *Pristis* species, though remain susceptible to pressures they face.

#### Major pressures

Commercial fishing, climate change, coastal development, habitat loss, 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. All species can inhabit inshore waters and estuaries and are therefore exposed to cumulative pressures resulting from climate change, coastal development, declining water quality and incidental capture in commercial (particularly set mesh net fisheries) and recreational fishing. These pressures are likely to impact on the species directly, on their habitats and available prey species.

#### Management in the Great Barrier Reef and adjacent areas in Queensland

Legislated management tools for the conservation of sawfish that occur in the Great Barrier Reef World Heritage Area (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 Marine Park Zoning Plan 2003* (34 per cent of the Marine Park protected from extractive use) and the *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004*; and others (refer Management table, p. 12). All species of Pristidae are now listed as protected species under *Great Barrier*



Freshwater sawfish, *Pristis microdon*. Photo courtesy of S. Peverell.

*Reef Marine Park Regulations 1983* and 'no-take' species under the *Fisheries Regulation 2008* (Qld).

#### 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 for Marine Park management operations. These include:

- The joint Great Barrier Reef Marine Park Authority (GBRMPA) and 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 provided via inshore habitat conservation areas such as Dugong Protection Areas and Fish Habitat Areas under Queensland fisheries regulations.

<sup>a</sup> Trophic specificity exists when an organism has highly selective dietary or nutritional requirements.



Green sawfish, *Pristis zijsron*, tagged for monitoring.  
Photo courtesy of S. Peverell.

- The *Reef Water Quality Protection Plan 2009* provides a framework to work with landholders to halt and reverse the decline of water quality entering the Marine Park.
- The *Reef Rescue Land and Sea Country Indigenous Partnerships Program* that enables collaborative management arrangements with Traditional Owners in the Marine Park to be developed.
- The *Great Barrier Reef Biodiversity Conservation Strategy 2012* with suggested points of action for the conservation of sawfish as identified through the vulnerability assessment process.
- The *GBRMPA Reef Guardian Program*, an education and stewardship program 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 that interact with sawfish including inshore habitat closures such as Dugong Protection Areas and the mandatory use of turtle excluder and by-catch reduction devices in trawl apparatus to reduce landings of sawfish.
- 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).

- Recovery Plans are in development for green, freshwater and dwarf sawfish classified as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*.

### **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.**

- Coastal/inshore and freshwater/estuarine sharks, including sawfish, are amongst the most vulnerable groups of sharks and rays within the World Heritage Area and adjacent waters.<sup>1,2</sup> The three *Pristis* species 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. Once populations are depleted, recovery could take several decades even if effective conservation measures are introduced.<sup>3</sup>
- Habitat loss and degradation from human-related activities in inshore areas and terrestrial waterways are likely to be impacting on the distribution and abundance of sawfish which are associated with those habitats. Pressure is being exerted by coastal development and population growth, including bunding or damming of rivers and streams, obstructions created by river and stream road crossings and run-off and erosion infilling stream beds and 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. The cumulative effects of these pressures combined are of particular concern.
- *Pristis* species within the Great Barrier Reef have been assessed as having 'moderate' to 'high' vulnerability to the major pressures they experience, although *Anoxypristis* is only 'moderate'. Both genus have a 'moderate' vulnerability to climate change.<sup>1</sup>
- A number of pressures are exerted upon sawfish in the World Heritage Area from fishing activities that are likely to be causing population declines. These pressures include mortality during incidental capture, post-release mortality of sawfish by-catch (captured incidentally while fishing for other target species), and habitat degradation due to trawling. The extent and total impact of these pressures is not completely clear and more species-specific information is required to confidently establish ecologically sustainable harvest levels and other management arrangements for sawfish and their habitats in the World Heritage Area.
- *Pristis* and *Anoxypristis* are captured incidentally 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 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 Species of Conservation Interest (SOI) logbooks.

- Currently, species-specific research and fishery-independent and fishery-dependent data gathering is being improved in Queensland's fisheries that interact with sawfish. However, current species-specific knowledge of sawfish in the World Heritage Area may not be sufficient to provide confidence in the ecologically sustainable management of sawfish species (particularly the three *Pristis* species) in the World Heritage Area. The limit of available information may therefore leave these species exposed, and thus more vulnerable, to management arrangements that may not apply appropriate levels of precaution to their conservation.

## 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 sawfish which have been assessed as having a 'moderate' vulnerability to climate change as per Chin and colleagues.<sup>1</sup> Programs should be guided by the outcomes of a resilience analysis for these species.
- Undertake a coordinated program to address pressures on sawfish. This should comprise:
  - A risk assessment for inshore biodiversity to inform priority management actions aimed at reducing the pressures experienced by sawfish in these habitats.
  - This needs to inform programs developed to better understand the cumulative impacts affecting sawfish 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's ongoing collaboration with the Queensland Government will be important to continue to improve accuracy in the gathering, reporting, and transparency of information collected within state fisheries that incidentally capture sawfish in the World Heritage Area. This information is vital in helping managers understand the stock structure of sawfish populations and allows for informed decisions on how to reduce cumulative pressures managed across different jurisdictions and a true metric for monitoring the success or otherwise of management actions.
- Support the Queensland Government to further improve their fisheries-independent observer program so it can be considered sufficiently robust to validate commercial logbook data for incidental capture of sawfish and provide statistically representative coverage of vessel effort from the East Coast Inshore Fin Fish Fishery (ECIFFF), East Coast Otter 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 sawfish to species level.
- Additional research on the biology, behaviour and habitat requirements of sawfish 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.

## Background

### Brief description of sawfish

Sawfish are chondrichthyan (cartilaginous) fishes, as are sharks, rays, skates and chimeras. All chondrichthyans reproduce via internal fertilisation, with 60 per cent of shark species being viviparous (producing live young from within the body of the parent female).<sup>4</sup> The physical constraints of internal fertilisation and embryonic development limit an individual animal's reproductive productivity (or fecundity). From what little published information is available on Pristid biology and life history, it is evident that they share the same characteristics of many other large cartilaginous fishes, including long gestation periods, giving birth to live and often large offspring, late sexual maturation, long life and intermittent breeding.<sup>5,6,7,8,9,b</sup>

Their inshore and estuarine habitats are often subject to the cumulative effects of habitat loss and degradation from coastal, riverine and catchment developments,<sup>2,10,11</sup> effects which may be exacerbated by the effects of climate change.<sup>1,12</sup> These life-history traits combined with their foraging behaviour and a heavily toothed rostrum makes them extremely prone to incidental capture in net fisheries, both set and trawled.<sup>c</sup> The extent of traditional use of sawfish in the World Heritage Area by Indigenous peoples is not known though is likely to exist. There is also likely to be an element of illegal harvest. Sawfish in the World Heritage Area are therefore highly vulnerable to overfishing.<sup>3,13</sup> These effects combined contribute to the vulnerability that sawfish have to extirpation (localised extinction of species) within the World Heritage Area and adjacent east coast waters.

Research by Stevens and colleagues<sup>13</sup> on the dwarf and green sawfish suggests that these estuarine/marine species have limited, tidally influenced movements and occupy a restricted range of only a few square kilometres within the coastal fringe. In mangrove areas, data showed they often spend high tide resting within the inundated vegetation, relatively protected from fishing activities. However, on the moving tide they are relatively active on the mud and sand flats, presumably feeding. At this time, they are particularly vulnerable to any net fishing operations and this has implications for their conservation and management.

Sawfish are aplacental viviparous, meaning their pups are born live having been internally developed and nourished only from stored yolk in the eggs. Peverell's<sup>10</sup> observations on reproductive staging and the capture of neonate (new born) specimens of sawfishes suggest that pupping occurs through the wet season until the beginning of the dry season in May. This study found that the sex ratio for all four species of Pristids sampled was almost 1:1 and that larger specimens were caught offshore and smaller ones inshore. Research commissioned by the then Department of the Environment, Water, Heritage and the Arts found there was significant positive correlation between river discharge and the survivorship of freshwater sawfish.<sup>5,6</sup> These studies suggest that water levels influence survivability of freshwater sawfish juveniles. The authors suggest it is reasonable to hypothesise that a sustained increase in water levels would increase the survivability of newborn freshwater sawfish by increasing available habitat and ecosystem productivity as well as decreasing predation.<sup>5</sup>

Diet, being habitat dependent, shows prey-species variation amongst the sawfish, but essentially all the sawfish feed on fishes and benthic invertebrates. The rostrum is used to stun schooling fish, such as mullet, and for extracting molluscs and small crustaceans from the benthic sediment.<sup>14</sup>

### Species specific information

#### *Pristis microdon* – Freshwater sawfish

Local records of the freshwater sawfish are mainly of juveniles from freshwater drainages and the upper reaches of estuaries (up to 400 km from the sea). They are usually found in turbid channels of large rivers over soft mud bottoms more than 1 m deep, but they will move into shallow waters when travelling upstream or while hunting prey.<sup>15</sup> Thorburn and colleagues<sup>16</sup> found that freshwater sawfish caught as part of their northern Australian distribution study were most often associated with deeper sections of a river adjacent to a sand or silt shallow, such as a sandbar or shallow backwater. There are also indications that there is habitat partitioning for different size classes, with research suggesting that older age classes show a preference for deeper water.<sup>17,18,6</sup> Phillips and colleagues study showed that larger (more than one year old) fish also display predictable vertical migration movements correlated with tide cycles, inhabiting deeper water at dawn before moving to shallower depths in the afternoon.<sup>17</sup> Habitat (depth) partitioning of age classes has been a suggested function of foraging behaviour

<sup>b</sup> It appears that the fecundity of narrow sawfish (*Anoxypristis cuspidata*) may not be as limited as the three *Pristis* species that also occur in the World Heritage Area indicated by a higher comparative abundance in studies undertaken in other northern Australian waters.<sup>10,28</sup>

<sup>c</sup> In their 2009 report to the then Department of the Environment, Water, Heritage and the Arts, the Freshwater Sawfish Expert Review Committee considered that while susceptible to capture and mortality in set mesh nets, freshwater sawfish can be released alive with a high chance of survival if appropriate release methods are used (as they are hardier than some other sawfish species).<sup>53</sup> The report suggests this can be demonstrated by research that shows recapture of tagged specimens following release from set mesh nets.<sup>53</sup> The committee conceded that sawfish survival after the release from trawl nets was likely to be significantly lower.<sup>53</sup>

and/or predator avoidance, where larger animals are more able to manoeuvre themselves to capture prey in deeper water while smaller animals have a priority to avoid predation (freshwater sawfish have been shown to be preyed upon by bull sharks in the Fitzroy River, Western Australia<sup>19</sup>) and may experience increased growth rates from inhabiting these warmer shallower waters in early juvenile life-stages.<sup>20</sup>

Peverell<sup>10</sup> has suggested a hypothesis that adult freshwater sawfish inhabit marine environments during dry months and move into freshwater systems in the wet season to pup and/or to exploit the abundance of prey species such as freshwater prawns (*Macrobrachium australiense*, *M. rosenbergi* and *M. handschii*). Peverell<sup>10</sup> found that most of the rivers which freshwater sawfish use as nursery areas fragment into a series of pools in the dry season, reducing the habitat available to juveniles. Phillips and colleagues<sup>6</sup> suggest that high residency time in the upper estuarine pools may cause freshwater sawfish to be more susceptible to fishers and increased competition for resources amongst individuals during the late dry season and that this provides considerations for management of the species during that seasonal period. During these times, fishing in this area may need to be more restricted, to reduce by-catch levels of freshwater sawfish (noting that freshwater sawfish are not directly targeted by fishers).

Juveniles (up to 280 cm) may remain in the rivers for 4–5 years before utilising marine environments,<sup>21</sup> individuals exceeding 200 cm are known to migrate between river systems. Freshwater sawfish give birth to live young after a five month gestation and have a litter size of between 1–12 offspring.<sup>9,22</sup> Born at 70–90 cm, individuals attain reproductive maturity at about 300 cm after about 7–9 years and attain a length in Australia of about 600 cm.<sup>9</sup>

Freshwater sawfish diet consists of fishes (particularly ariid catfish, *Arius graeffei*), molluscs and crustaceans (such as cherabin, *M. rosenbergii*).<sup>17,9</sup>

#### *Pristis clavata* – Dwarf sawfish

The dwarf sawfish inhabit shallow (2–3 m) coastal waters and estuarine habitats. Unlike the freshwater sawfish, the dwarf sawfish does not move into purely freshwater areas – the species' range is restricted to brackish and salt water.<sup>7</sup> In north-western Australia, estuarine habitats are used as nursery areas by dwarf sawfish, with immature juveniles remaining in these areas up until three years of age.<sup>7</sup> Adults inhabit marine waters and are known to seasonally migrate back into inshore waters.<sup>10</sup> It is unclear how far offshore the adults travel, as captures in offshore surveys are very uncommon.<sup>23</sup>

Catch records of dwarf sawfish in the Gulf of Carpentaria (the Gulf) show a pattern of relative abundance that is characterised by low numbers and with a highly variable frequency of occurrence.<sup>10</sup> As with green sawfish, preliminary northern Australian studies of the genetic diversity of dwarf sawfish may show declines in their abundance and genetic diversity in the gulf<sup>17</sup>. Such research is required to determine the population structure and any similar declines in genetic diversity of east coast Great Barrier Reef populations of dwarf sawfish.

There is no data on rates of reproduction in the dwarf sawfish. *Pristis clavata* is born at about 65 cm and attains at least 310 cm. Males mature at about 255–260 cm. Litter sizes are not known.<sup>9</sup>

Dwarf sawfish feed predominantly on prawns and fish. The main prey species is popeye mullet (*Rhinomugil nasutus*).<sup>7</sup>

#### *Pristis zijsron* – Green sawfish

The green sawfish has been recorded in coastal and inshore environments, including estuaries and river mouths in slightly reduced salinities, but it does not penetrate into freshwater.<sup>8,16,22</sup> It has been recorded in very shallow water (<1 m) to offshore trawl grounds in over 70 m of water.<sup>8</sup> Stead<sup>24</sup> also reported that this species was frequently found in shallow water. Data from an individual tracked for 27 hours in Port Musgrave,<sup>25</sup> showed that it moved continuously throughout the track and did not rest on the bottom. This behaviour makes green sawfish even more vulnerable to capture in gillnets as animals are more likely to encounter fishing gear if they are moving around an area as opposed to being inactive for long periods.

Catch records of green sawfish in the Gulf of Carpentaria show a pattern of relative abundance that is characterised by low numbers and with a highly variable frequency of occurrence, which is similar to that of dwarf sawfish for the same region.<sup>10</sup> DNA studies of green sawfish in the Gulf of Carpentaria suggest that the abundance of this species in the region has been substantially reduced and the assemblage of this species in the Gulf may warrant special protection to prevent any further decline in abundance and genetic diversity.<sup>26</sup> The same study indicates that at least the east and west coast populations must be treated as different management units, with same being likely for the Gulf population.<sup>26</sup> Such mitochondrial and nuclear DNA studies are required to determine the population structure and any similar declines in genetic diversity of east coast Great Barrier Reef populations of green sawfish.

Data indicates that smaller specimens (<2.5 m) are more common in foreshore and offshore coastal waters.<sup>16</sup> Larger individuals (>2.5 m) are found in both inshore and offshore waters. Their apparent preference for shallow inshore waters as nursery areas increases the likelihood of interaction with inshore gillnets.<sup>8</sup>

The green sawfish appears to reach 95 per cent of its maximum total length (500–600 cm) at approximately 24 years of age and reach age at maturity (from direct observation) in nine years when they are around half their

maximum length (Peverell, James Cook University, unpublished Master of Science thesis, cited in Stevens *et al.* 2005<sup>8</sup>). Litter sizes are of about 12.<sup>9</sup>

The diet of green sawfish is as for other Pristids. Importantly, green sawfish are not ambush predators but actively pursue schools of baitfish and prawns.

#### *Anoxypristis cuspidata* – Narrow sawfish

A marine or marginal (brackish water) species found from inshore waters to a depth of 40 m. Though details of its ecology are not precisely known, it probably spends most of its time on or near the bottom in shallow coastal waters and estuaries.<sup>27</sup> Peverell's study<sup>10</sup> showed the narrow sawfish to be the most abundant amongst the sawfish sampled in the Gulf of Carpentaria which holds some consistency with the offshore distribution of the species as shown by a study of Northern Prawn Fishery by-catch.<sup>28</sup> Unpublished data from Fisheries Queensland East Coast Inshore Fin Fish Fishery observer program may suggest a similar east coast situation. Peverell<sup>10</sup> also used catch data of offshore surface net fisheries to conclude that narrow sawfish also inhabit the mid-water column and can thus be described as a benthopelagic animal.

As with all sawfish, narrow sawfish are aplacental viviparous. Pups are born at an approximate length of 70 cm in litters of about 15 after a gestation of 4-5 months. The narrow sawfish is known to form aggregations of mature females during the months of October to November. The age of maturation is about four years and 225 cm for females and five years and 200 cm for males.<sup>9</sup> In Australia there is record of a female of 380 cm.<sup>10</sup>

## Geographical distribution

#### *Pristis microdon* – Freshwater sawfish

The freshwater sawfish is native to the Indo-Pacific and western Pacific, western Indian Ocean and eastern Pacific regions. Populations are becoming increasingly rare and fragmented and all those known are severely threatened by target and by-catch fisheries and deterioration of habitats. Many populations have been extirpated (become locally extinct) or nearly extirpated from large areas of their former range, with no or only very few observations reported in most range states since the 1960s, although they were reportedly common in many inshore waters at the end of the 19<sup>th</sup> century and early 20<sup>th</sup> century.<sup>29</sup>

In Australia they have been recorded from many of the northern drainages in both fresh to weakly saline environments from north west Australia, Northern Territory, Gulf of Carpentaria and northern Cape York Peninsula rivers to Princess Charlotte Bay.<sup>9</sup>

#### *Pristis clavata* – Dwarf sawfish

The dwarf sawfish historically ranges from Cairns and along the northern coastline to Eighty Mile Beach, the southern-most point of its Western Australia range.<sup>9,13</sup> Although there is record of dwarf sawfish from the Pine River in north-western Cape York Peninsula, there are no recent records of the species from the eastern coast of the Cape York Peninsula.<sup>10</sup> While eastern Queensland populations of dwarf sawfish cannot be confirmed, if the species was historically present in these waters, these populations may now have been extirpated, representing a contraction of range.<sup>30</sup> An assessment for the IUCN in 2006 inferred that if the species occurred outside Australian waters then it is likely to be nearing extirpation in those waters.<sup>31</sup>

#### *Pristis zijsron* – Green sawfish

The green sawfish was once widely distributed in the northern Indian Ocean, westwards to South Africa, around south and south east Asia and around northern Australia. Available catch records suggest that the species may now be virtually extinct in south east Asia, and that northern Australia may be the last region where significant populations of green sawfish exist.<sup>8</sup> Presently in Australian waters, green sawfish are distributed from about Cairns north and around to Shark Bay in Western Australia.<sup>8</sup> It is most commonly known from the Gulf of Carpentaria, Queensland.<sup>8</sup> With the green sawfish no longer found in New South Wales or southern Queensland waters, the species appears to have experienced a contraction of range of around 30 per cent in Australian waters.<sup>8</sup>

#### *Anoxypristis cuspidata* – Narrow sawfish

The narrow sawfish has a recorded distribution through the Indo-Pacific from the Red Sea to Australia and north to Japan and mainland China (though not in the Philippines).<sup>27</sup>

Its Australian distribution is unclear though it is most common in the Gulf of Carpentaria with southward ranges extending to Broad Sound in Queensland and the Pilbara Coast (circa 116°E), Western Australia.<sup>9</sup>



## Population status in the Great Barrier Reef Marine Park

Sawfish populations are becoming increasingly rare and fragmented locally in Australia and globally, and all those known are severely threatened by by-catch fisheries (or target fisheries in countries where their take is unregulated) and deterioration of habitats. The scientific community has recognised a decline in sawfish populations across their entire range.<sup>32</sup> The true extent of this decline is extremely difficult to quantify due to lack of reliable historical catch and biological data. There is no quantitative data available on the local or global population size of any of the *Pristis* species.<sup>9</sup>

*Pristis* by-catch from the Queensland Shark Control Program comprises a large dataset over about 30 years of beach meshing around major Queensland population centres during the summer months. Although species identifications or biological data are lacking, these data show a clear decline in sawfish catch from 1970-1990, over which period the fishing effort was relatively constant (Giles *et al.*, CSIRO Marine Research, unpublished report cited in Stevens *et al.* 2005<sup>8</sup>).

Sawfish vulnerability to overfishing and habitat loss and degradation in their coastal and estuarine habitats is demonstrated by the fact that all four species that occur in Australia are listed under the International Union for the Conservation of Nature and Natural Resources Red List of Threatened Species as critically endangered globally.<sup>33</sup> The International Union on the Conservation of Nature (IUCN) shark specialist group<sup>32</sup> categorised Australian sawfishes as endangered in 2003 on the basis of their rapid decline in range.<sup>32</sup> 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.

While there are few quantitative species-specific data on sawfish abundance in Australia, their numbers appear to have declined drastically along the east coast with sawfish now virtually extinct in New South Wales and south east Queensland.<sup>9</sup> Anecdotal reports from recreational fishers as far north as Townsville suggest that freshwater sawfish were once 'very common in the Ross River but over the past 10-15 years have not been recorded.'<sup>8</sup> Information from a number of recent projects suggests that sawfish populations in some areas (such as the Kimberley region of Western Australia) are still healthy while in other regions (such as the Great Barrier Reef World Heritage Area) populations have been fished down. Resulting information also suggests that sawfish have very specific habitat requirements, and that there is an urgent need to understand these requirements to be able to interpret abundance estimates and population status.<sup>8</sup> This information is imperative for establishing baseline information in order to be able monitor and review the effectiveness of management tools such as Marine Park zoning and closing waters to fishing.

In view of the likely (generally) restricted movements of *Pristids*, it is probable that Australian populations can be considered geographically separate; certainly in a management sense.<sup>10</sup> DNA studies by Phillips and colleagues<sup>17</sup> have confirmed this with regards to freshwater sawfish. Whilst the total population of the freshwater sawfish is unknown, their study suggested that the species, though highly mobile when adult, should be considered in Australian waters as 'independent demographic units' (populations) rather than a single population.<sup>17,5,6</sup> Similar structuring is considered to apply to populations of the other sawfish species of northern Australia.<sup>8,17,5,6</sup>

For green sawfish, any remaining populations on the east coast can be considered 'near the edge of the species range' and as such are extremely important to maintain genetic diversity along the east coast.<sup>8</sup> Mortality in all remaining populations in northern Australia also needs to be reduced in order to maintain genetic diversity within this region.<sup>8</sup> Information on long-term movements, as well as data on population genetic structure, is required to determine the status of the northern stock of green sawfish<sup>8</sup> and other *Pristids*. Initial such research has been undertaken for green, freshwater and dwarf sawfish in parts of northern Australia outside the World Heritage Area, though further research is required.<sup>6,17</sup>

In the listing advice for dwarf sawfish under the *Environment Protection and Biodiversity Conservation Act 1999*, the Threatened Species Scientific Committee stated, "while eastern Queensland populations of dwarf sawfish cannot be confirmed, if the species was historically present in these waters, these populations may now have been extirpated, representing a contraction of range. This potential contraction of range would also represent a decline in numbers, but there are insufficient data to quantify this decline."<sup>30</sup> There are limited data of dwarf sawfish caught in the southern Gulf of Carpentaria and north-western Cape York Peninsula.<sup>10</sup> Catches of dwarf sawfish in northern Australia are very low and are highly variable.<sup>10</sup>

Remnant populations of sawfish along the east coast may be partially protected in the Great Barrier Reef Marine Park by the dugong protection areas declared within Queensland Fisheries and Great Barrier Reef Marine Park legislation implemented in 1998 and coastal Marine National Park (Green) and Conservation Park (Yellow) Zones declared in 2003. In a conservation assessment of sawfish, Stevens and colleagues stated that additional closures to gill netting of suitable inshore coastal habitat will be required in order to prevent these species from disappearing from the east coast.<sup>8</sup> In response to these understandings, three rivers flowing into Princess Charlotte Bay identified as sawfish habitat (Kennedy, Bizant and Normanby Rivers) were recently closed to

commercial netting by the then Queensland Department of Employment, Economic Development and Innovation, Fisheries Queensland.

## Ecosystem role/function

Pristids appear to fill a generalist top predator role within the ecosystems they inhabit. Consequently, they may perform regulating functions with regard to lower trophic levels and may indeed help provide balance within the ecosystem. However, detail on the role and function of Pristids within their ecosystems is largely unknown and is a recognised knowledge gap both within the scientific literature.

## Ecosystem goods and services

Ecosystem goods and services category	Services provided by the species, taxa or habitat
<b>Provisioning services</b> (e.g. food, fibre, genetic resources, bio-chemicals, fresh water).	In Australia, all species of <i>Pristis</i> and <i>Anoxypristis</i> are listed as threatened and are protected in all states in which they are distributed. In Queensland the <i>Fisheries Regulation 2008</i> lists the Pristids as no-take.  These species have been landed intensively in broad spectrum fisheries from India to Thailand and most other locales where they occur in the Indo-Pacific. They are caught for their flesh in parts of Asia, and have an oil-rich liver. The rostrum has been reported ground up for use in traditional Chinese medicine. <sup>34</sup>  Fins are also of high value.
<b>Cultural services</b> (e.g. spiritual values, knowledge system, education and inspiration, recreation and aesthetic values, sense of place).	Sawfish are an iconic group that have extensive cultural and intrinsic conservation values for different societies around the world. <sup>34</sup> For decades their rostrums have been collected as curio and trophy items. <sup>34</sup>  Sawfish have a significant cultural and spiritual relevance to Indigenous Australians around northern Australia. For example, communities on Groote Eylandt believe an ancestral sawfish was the creator of the Angurugu River. <sup>34</sup>  There is increasing demand for live sawfish to put on display in public aquaria for aesthetic and educational purposes. Globally, the mortality rates associated with securing live sawfishes for this use is not well known. <sup>27</sup>
<b>Supporting services</b> (e.g. primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling).	The supporting services of chondrichthyans within marine ecosystems are largely unknown. With sawfish being higher order predators, it is expected that they play an important role in nutrient cycling within the ecosystems in which they occur.
<b>Regulating services</b> (e.g. invasion resistance, herbivory, pollination, climate regulation, pest regulation, disease regulation, natural hazard protection, erosion regulation, water purification).	Pristids are generalist high level predators and may help to regulate populations of prey species and maintain ecosystem balance. <sup>35,36</sup> The removal of high-level predators can also have unexpected lower order effects on non-prey species in what is referred to as trophic cascading. <sup>37,38</sup> The characteristics and extent of these effects with regard to sawfish are largely unknown.

## Pressures influencing sawfish in the Great Barrier Reef Marine Park

### Pressures

Sawfish in the Great Barrier Reef are exposed to a range of pressures including fishing,<sup>3,39,40,13,41</sup> coastal development and declining water quality<sup>2</sup> and climate change.<sup>12,1</sup> These pressures act on a range of different species and act cumulatively in some habitats, such as the inshore waters that Pristids inhabit.<sup>11</sup> A more detailed description of the range of pressures that impact on Pristids in the Great Barrier Reef is provided in the vulnerability assessment matrix at Appendix 1.

### Vulnerability assessment matrix

The *Great Barrier Reef Outlook Report 2009*<sup>42</sup> 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 impacts, 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*<sup>42</sup> 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,<sup>43</sup> 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 that sawfish 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 sawfish to that particular pressure. This allows for the formulation of suggested actions to minimise the impact of the pressures which sawfish 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.

### Vulnerability assessment matrix summary for sawfish

		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	No	Low	Low	Good	Good	Low	Poor
	Defence activities	Yes; locally	Low	Low	Good	Good	Low	Poor
	Commercial fishing	Yes; state-wide, nearshore	Very high	High	Poor	Moderate	High	Good
	Recreational fishing	Yes; regionally	Medium	Medium	Moderate	Good	Medium	Moderate
	Ports and shipping	Yes; locally	Medium	Medium	Moderate	Moderate	Medium	Poor
	Recreation (not fishing)	Yes; regionally	Low	Low	Good	Good	Low	Poor
	Traditional use of marine resources	Yes; locally	Low	Medium	Moderate	Good	Low	Poor
	Climate change	Yes	Very high	High	Poor	Poor	High	Moderate
	Coastal development	Yes; developing coast	High	High	Poor	Moderate	High	Moderate
	Declining water quality due to catchment run-off	Yes; developing coast	High	High	Moderate	Moderate	High	Poor

## Key concerns

- Sawfish of the genus *Pristis* are long-lived and have a slow growth rate, low reproduction rate and mature late. Indications show depleted populations with low relative abundance (relative to prey). This combination of life history traits predisposes *Pristis* to being susceptible to overfishing and slow to recover if overfished.<sup>3,13</sup> During periods of their life history, sawfish display high levels of habitat and trophic specificity.<sup>2,10,16,7,8</sup> While all sawfish are no-take species in Queensland waters and protected in the Marine Park, habitat specificity, foraging behaviours and morphological (body form) attributes expose sawfish to interactions with net fisheries. These factors should be considered when assessing threats to this species group and when developing management strategies for at-risk sawfish species in the World Heritage Area.<sup>d</sup>
- Sawfish inhabit coastal/inshore and freshwater/estuarine habitats for a large proportion of their life history and are amongst the most vulnerable groups of sharks and rays within the World Heritage Area and adjacent waters. When local and regional anthropogenic (human-related) pressures, such as coastal development, declining water quality and recreational and commercial fishing pressure are considered along with the effects of climate change, the effects on the most vulnerable amongst the Great Barrier Reef's sharks and rays indicate a strong tendency towards significant population decline.<sup>32</sup> These cumulative impacts must be considered when developing management strategies for sawfish species in the World Heritage Area.
- Habitat loss and degradation from human-related activities in inshore areas and terrestrial waterways are likely to be impacting on the distribution and abundance of sawfish which are associated with those habitats. Of particular concern is the habitat loss and degradation resulting from bunding or damming of rivers and streams, obstructions created by river and stream road crossings and run-off and erosion infilling stream beds. An audit of such developments in the Great Barrier Reef catchment could provide an initial understanding of possible mitigation avenues.
- There is a need to manage the cumulative impacts affecting sawfish in near and inshore habitats. This should take the form of a risk assessment for inshore biodiversity, as the factors impacting sawfish in near 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.
- *Pristis* species within the Great Barrier Reef have been assessed as having 'high' to 'very high' vulnerability to the major pressures they experience in combination with a 'moderate' vulnerability to climate change.<sup>1</sup> Management should be focused on those pressures that can be addressed, such as habitat protection, reducing remaining pressures from fishing, improving water quality and implementing conservation actions for those sawfish species already at risk from other factors.
- The Indigenous take of sawfish in the World Heritage Area is currently unknown. Within east coast Queensland sawfish management units, there is little understanding on the level of take, the size class or sex ratio of the take, nor of what Indigenous fishing practices are that might influence these aspects of the take (for example there is limited understanding of whether sawfish are targeted and if they are, whether it is at a time of year and at locations that tends to capture certain sex or size classes).
- Sawfish are incidentally captured in a number of the different fisheries operating in the Great Barrier Reef World Heritage Area (commercial and recreational). Accurate identification of species in east coast fisheries may still be lacking, along with broad confidence in the validity of interaction data available for commercial, recreational and Indigenous fisheries due to under-reporting.<sup>44</sup> Fisheries observer programs in the Gulf of Carpentaria have provided valuable information on offshore net fishery interactions with sawfish. However observer program coverage of the east coast set mesh net and trawl fisheries may not provide confidence in the validation of current fishery interaction and post-release data for sawfish (or species of conservation interest and exploited shark species). Accurate species identification is vital for determining stock structure and population subdivision.<sup>45</sup> This fisheries-independent data is vital for stock assessment and ecological risk assessment work and is required to continually refine management strategies.
- It is recognised that there is a paucity of information on the biology and ecology of the sawfish in the World Heritage Area and on what is required to maintain their habitats and populations. The *Great Barrier Reef Outlook Report 2009*<sup>42</sup> highlighted these concerns and the difficulties that this presents for informed management of sawfish in the Great Barrier Reef. Management arrangements should be developed with levels of precaution that sufficiently reflect the paucity of information.
- Although excellent work has been undertaken in parts of northern Australia,<sup>45,46,47,48,5,6</sup> currently available species-specific research and fishery-independent and fishery-dependent data is widely recognised as introductory and more work is required. This may mean that the extent of information currently available may be limited in its ability to provide confidence to management decisions for sawfish captured as non-retained by-catch within Queensland fisheries and which are likely to be experiencing other cumulative pressures.

<sup>d</sup> *Anoxypritis* (narrow sawfish), in comparison, is more resilient to fishing pressure, having only a moderate ecological risk, though remain vulnerable to this pressure.

This is highlighted by growing evidence on the stock structures of freshwater, green and dwarf sawfish across northern Australia.<sup>5,6,17</sup> Information suggests stock partitioning in sawfish in Australian waters and calls for a consideration of Australian stocks as 'independent demographic units' (populations) rather than a single population.<sup>5,6,17</sup> As with similar research for other shark and ray species,<sup>45</sup> this may suggest further protection of important sawfish habitat once identified<sup>2,17</sup> and a move towards a more regional scale management approach to near and inshore fisheries that reflects findings from ongoing stock structure and life history research.<sup>45</sup> The importance of such approaches have been recognised by the previous Queensland Department of Employment, Economic Development and Innovation, Fisheries Queensland with the recent closure to fishing of three rivers that flow into Princess Charlotte Bay after they were identified as important sawfish habitat.

- Current species-specific knowledge of sawfish in the World Heritage Area may not be sufficient to inform the nonspecific management arrangements being used, such as Total Allowable Commercial Catch (TACC) quotas within set mesh net fisheries that interact with sawfish.<sup>45</sup> Although TACC quotas undoubtedly affect the amount of effort applied by a fishery, they do not comprise a more spatial approach to management that accounts for variabilities in stock structure or population distribution 'hotspots', once they have been identified. More species-specific information is required to confidently establish sustainable management practices for these species and their habitats.
- Conclusions on population structure for freshwater sawfish are based on variation in mitochondrial DNA which reflects female-mediated gene flow. Thus it is important to recognise the freshwater sawfish might exhibit sex-based dispersal, with female residency at the place of birth and male dispersal.<sup>17,26</sup> This has implications for management in that a decline in the number of females in a particular region would not be replenished by the immigration of females from another region (as females remain resident to their place of birth), coupled with the fact that a decline in the abundance of this species in one region could have a direct effect on its abundance in another region (as males may disperse between regions).<sup>26</sup> Further DNA analysis of geographically separate populations of the other sawfish species that occur in northern Australia are required to determine if dispersal is also male-biased.
- It will also be important to determine better information on post-release survival of sawfish captured as by-catch in commercial and recreational fisheries. It should also be recognised that 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.<sup>49</sup> This could cause death some time after release following incidental capture.
- Gunn and colleagues<sup>39</sup> note that SOCI reported interactions in Queensland fisheries suggest most animals are released alive, whereas the limited observer data suggest that many animals die. They state that this produces uncertainty in the reliability of unverified data from SOCI logbooks especially with consideration of the scale of coverage of the observer program.
- The independent review of the proposed management arrangements for the ECIFFF<sup>39</sup> made the point that when a performance measure, such as the level of interaction with protected species such as sawfish, is reached and a management response triggered, good practice would provide a management response that should ideally prevent (or least firmly control) any further increase in the level of interaction. 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 colleagues<sup>39</sup> suggest that although these may be appropriate responses, clear indications of what the level of interaction 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.<sup>39</sup>
- Good practice suggests that measures to minimise fishery by-catch of sawfish be continually developed and reviewed. Despite the introduction of by-catch reduction devices and turtle exclusion devices in the prawn trawl fleet, sawfish continue to be caught by trawlers in the Northern Prawn Fishery and these devices have had little impact on the mortality of sawfishes in that fishery.<sup>22</sup> This is likely to be applicable to sawfish incidentally captured in the East Coast Trawl Fishery.
- There is increasing recognition that 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, 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.<sup>39</sup> It is suggested that metrics could monitor aspects such as the effects of the removal of predators (including sawfish) 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<sup>50</sup> of the ECIFFF 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. Such issues remain as concerns to be considered through a risk assessment for inshore biodiversity.

## Management of sawfish 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"> <li>Four natural heritage criteria with associated conditions of integrity. Criteria focus on (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</li> <li>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.</li> </ul>	<ul style="list-style-type: none"> <li>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.</li> </ul>	United Nations Educational, Scientific and Cultural Organization (UNESCO)
Convention on Biological diversity (CBD)	<ul style="list-style-type: none"> <li>The three main objectives of the CBD are: <ul style="list-style-type: none"> <li>The conservation of biological diversity</li> <li>The sustainable use of the components of biological diversity</li> <li>The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Provides State Parties to the Convention with global principles, objectives and obligations for the conservation of biodiversity</li> <li>Guides Australia's strategic planning to achieve national priority actions for biodiversity conservation through a range of objectives and targets for each.</li> </ul>	United Nations Environment Program (UNEP) – CBD Secretariat
International Union for Conservation of Nature and Natural Resources Redlist of Threatened Species	<ul style="list-style-type: none"> <li><i>Pristis microdon</i>, <i>P. clavata</i>, <i>P. zijsron</i> and <i>Anoxypristis Cuspidata</i> all listed as critically endangered.</li> </ul>	<ul style="list-style-type: none"> <li>Establishes the conservation status of species based on the assessment of their global population and trends.</li> </ul>	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"> <li>All species in the Pristidae family (except <i>P. microdon</i>) are listed under Appendix I</li> <li><i>P. microdon</i> listed in Appendix II.</li> </ul>	<ul style="list-style-type: none"> <li>Provide input into regulatory processes</li> <li>Animals listed under Appendix 1 are considered threatened with extinction and CITES prohibits international trade in</li> </ul>	UNEP – CITES Secretariat CITES permits for international trade of <i>P. microdon</i> administered by the Department of

		<p>specimens of these species</p> <ul style="list-style-type: none"> <li>• International trade is allowed under permit for the exclusive purpose of international trade in live animals to appropriate and acceptable aquaria for primarily conservation purposes.</li> </ul>	<p>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 3 nm limits of state waters).</p>
<p><i>United Nations International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks)</i></p>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Ratified by Australian Government in 2004</li> <li>• Guides the development of the National Plan of Action for the Conservation of Sharks</li> <li>• Processes of review.</li> </ul>	<p>Food and Agriculture Organization (FOA) of the United Nations – Fisheries and Aquaculture Department.</p>
<p><i>National Plan of Action for the Conservation of Sharks (Shark Plan)</i><sup>51</sup></p>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• 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"> <li>• Reviewing existing conservation and management measures</li> <li>• Improving conservation and management measures</li> <li>• Changes to data collection and handling</li> <li>• Research and development</li> <li>• Education or awareness raising</li> <li>• Improved coordination and consultation.</li> </ul> </li> <li>• Processes of review of Plan. Revised plan has been drafted and released for public comment (Shark Plan 2).</li> </ul>	<p>Department of Agriculture, Fisheries and Forestry (DAFF), Department of Sustainability, Environment, Water, Population and Communities in partnership with relevant state and Northern Territory fisheries management and conservation agencies.</p>
<p><i>Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and Environment Protection and Biodiversity Conservation Regulations 2000.</i></p>	<ul style="list-style-type: none"> <li>• Legislative framework for environmental protection in Australia</li> <li>• Provides means of assessment of 'actions' within Australian marine and terrestrial environments</li> <li>• 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</li> <li>• <i>P. microdon</i>, <i>P. clavata</i>, <i>P. zizsron</i> listed as vulnerable</li> </ul>	<ul style="list-style-type: none"> <li>• Recovery Plan for sawfish listed as Vulnerable currently under development</li> <li>• Listed threatened species and ecological communities are recognised as a matter 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 must be referred to the Minister and undergo an environmental assessment and approval process</li> <li>• Application of 'controlled action' regulation for Matters of National Environmental Significance as required</li> </ul>	<p>DSEWPaC</p>

	<ul style="list-style-type: none"> <li>• <i>A. cuspidata</i> unlisted.</li> </ul>	<ul style="list-style-type: none"> <li>• Assessment and export approval processes for all fisheries with an export component (or Wildlife Trade Operation)</li> <li>• Penalties for non-compliance</li> <li>• Act is regularly reviewed.</li> </ul>	
Guidelines for the ecologically sustainable management of fisheries -2007	<ul style="list-style-type: none"> <li>• Provides guidance to the assessment of Australian fisheries that seek to operate with a Wildlife Trade Operation (WTO) accreditation under the <i>Environment Protection and Biodiversity Conservation Act 1999</i>. Sharks and rays are caught within the ECIFFF, which is a fishery with a current WTO accreditation</li> </ul> <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"> <li>• 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"> <li>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</li> <li>2. Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.</li> </ol> </li> </ul>	DSEWPaC
<i>Fisheries Act 1994 (Qld) and Fisheries Regulation 2008</i>	<ul style="list-style-type: none"> <li>• 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. This includes the ECIFFF management arrangements.</li> </ul>	<ul style="list-style-type: none"> <li>• Pristidae species listed as 'no-take' and Species of Conservation Interest</li> <li>• Net attendance rules in set mesh net fisheries (must be in attendance at all times)</li> <li>• Rules (<math>N_1</math>, <math>N_2</math>, <math>N_4</math>, <math>N_{11}</math>, S mesh net, line fishery, trawl regulations) 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).</li> <li>• Species of Conservation Interest (SOI) logbook reporting requirements</li> <li>• 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 in these apparatus</li> <li>• Review of the Act in 2011.</li> <li>• Penalties for non-compliance.</li> </ul>	Queensland Government
East Coast Inshore Fin Fish Fishery (ECIFFF) management arrangements	<ul style="list-style-type: none"> <li>• Accredited WTO under <i>Environment Protection and Biodiversity Conservation Act 1999</i> managed by Fisheries Queensland. Commonwealth regulation requires reporting on management arrangements and conditions of the WTO through an annual status report. Reports on interactions with Species of</li> </ul>	<ul style="list-style-type: none"> <li>• 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</li> <li>• Published <i>Shark identification guide for Queensland fishers</i> to assist with improving species identification for</li> </ul>	Queensland Government



	<p>Conservation Interest (SOI) including sawfish species. SOI data is gathered through logbooks and the Queensland Government Shark Observer Program. Regulations are established under the <i>Fisheries Act 1994</i> (Qld) and <i>Fisheries Regulation 2008</i>.</p>	<p>fishery logbook recording. Accompanied by non-mandatory industry training</p> <ul style="list-style-type: none"> <li>• Published <i>Guide to releasing sawfish and Looking after protected species in Queensland – a comprehensive guide for commercial fishers</i> to assist fishers in interactions with sawfish and other protected species</li> <li>• Regulation on turtle exclusion and by-catch reduction devices in trawl fishery. Provides limited benefit to sawfish with toothed rostrum</li> <li>• Review of the Fishery under EPBC Act. Review completed February 2012. New WTO with conditions issued; valid to 2015.</li> <li>• Independent Shark Panel established by Fisheries Queensland 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.</li> </ul>	
<p>Queensland Shark Control Program (QSCP)</p>	<ul style="list-style-type: none"> <li>• Community Education and Protection Policy under <i>Fisheries Act 1994</i> (Qld)</li> <li>• Thirty-five nets at localities in Cairns, Mackay, Rainbow Beach, Sunshine Coast, and the Gold Coast<sup>52</sup></li> <li>• 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.<sup>52</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Nets designed to capture sharks 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</li> <li>• Ten shark nets remain in the Marine Park: five off Cairns beaches; five off Mackay beaches. Remainder have been replaced by drumlines</li> <li>• Drumline arrays consist of up to six or more shark hooks with fresh bait suspended individually from large plastic floats. (Roughly one net equals six drumlines)</li> <li>• Equipment checked every second day, weather permitting</li> <li>• Other measures employed to reduce interactions with threatened species.</li> </ul>	<p>Queensland Government</p>
<p><i>Great Barrier Reef Marine Park Act 1975</i> and <i>Great Barrier Reef Marine Park Regulations 1983</i></p>	<ul style="list-style-type: none"> <li>• Regulation 29, Table 29 of the Regulation provides a list of Protected Species including all four Pristid species</li> <li>• Regulation provides for the creation of Special Management</li> </ul>	<ul style="list-style-type: none"> <li>• Special Management Areas can be created under certain conditions</li> <li>• Penalties for non-compliance</li> <li>• Review of Act and Regulation.</li> </ul>	<p>Great Barrier Reef Marine Park Authority (GBRMPA)</p>

	<p>Areas within the Marine Park</p> <ul style="list-style-type: none"> <li>• Regulation of activities within the Marine Park</li> <li>• Regulation of scientific research in the Marine Park.</li> </ul>		
<p><i>Great Barrier Reef Marine Park Zoning Plan 2003</i></p>	<ul style="list-style-type: none"> <li>• A multiple-use marine protected area management tool that protects biodiversity by the regulation of activities within the Great Barrier Reef Marine Park.</li> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Spatial management of activities within the Great Barrier Reef based on protection of habitat type representative areas</li> <li>• Penalties for non-compliance</li> <li>• Processes of review.</li> </ul>	<p>GBRMPA</p>
<p><i>Great Barrier Reef Biodiversity Conservation Strategy 2012</i></p>	<ul style="list-style-type: none"> <li>• Identifies sawfish as species 'at risk' in the Marine Park</li> <li>• Grades the level of risk experienced by sawfish to the range of pressures they experience through a vulnerability assessment process. Vulnerability assessed as high.</li> </ul>	<ul style="list-style-type: none"> <li>• 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"> <li>1. Engage communities and foster stewardship</li> <li>2. Building ecosystem resilience in a changing climate</li> <li>3. Improved knowledge</li> </ol> </li> <li>• Objectives are comprised of program-level outcomes with key actions and contain targets for measuring success</li> <li>• Implementation of the Strategy will be undertaken through a multi-agency, multi-stakeholder collaborative approach.</li> </ul>	<p>GBRMPA</p>
<p><i>Reef Rescue Land and Sea Country Indigenous Partnerships Program</i></p>	<ul style="list-style-type: none"> <li>• Expand the Traditional Use of Marine Resource Agreement (TUMRA) program across the Reef catchment</li> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Expansion of the TUMRA program, which complements dugong and green turtle management along with other species of conservation and cultural significance, including sawfish species</li> <li>• Enhanced compliance to address illegal activities in high risk areas that threaten cultural and natural heritage values and culturally important species</li> <li>• Engaging with communities to empower traditional owners in the context of sea country management</li> <li>• Providing grants and sponsorships to increase the knowledge and skills base of traditional owners and enable them to better manage sea</li> </ul>	<p>GBRMPA</p>

		<p>country</p> <ul style="list-style-type: none"> <li>• Strengthening communications and knowledge sharing between Traditional Owners, management agencies and the broader community.</li> </ul>	
<i>Reef Guardian Stewardship program</i>	<ul style="list-style-type: none"> <li>• 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 sawfish across the Great Barrier Reef communities where they occur.</li> </ul>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>	GBRMPA
<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. June 2007.</i>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Provides guidance on how the Marine Park Authority frames its management decisions with regards to sharks and rays</li> <li>• Processes of review.</li> </ul>	GBRMPA
<i>Policy on managing activities that include the direct take of a Protected Species from the Great Barrier Reef Marine Park. June 2005. Additions September 2008.</i>	<ul style="list-style-type: none"> <li>• Provides a framework for the consistent and effective management of activities that include the direct take of a protected species from the Great Barrier Reef Marine Park.</li> </ul>	<ul style="list-style-type: none"> <li>• Justifications and assessment guidelines on the take of protected species for certain anticipated (and unanticipated) uses</li> <li>• Processes of policy review.</li> </ul>	GBRMPA
<i>Great Barrier Reef Climate Change Action Plan 2007-2012</i>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Allocation of dedicated funding to implement actions to improve the resilience of the Great Barrier Reef ecosystem.</li> </ul>	GBRMPA
<i>Nature Conservation Act 1992 (Qld) and Nature Conservation (Wildlife) Regulation 2006.</i>	<ul style="list-style-type: none"> <li>• Legislative framework for the conservation of nature in Queensland</li> <li>• Protecting native wildlife and its habitat</li> <li>• Providing for the ecologically sustainable use of protected wildlife and areas</li> <li>• Provides a list of threatened and protected species in Queensland</li> <li>• No sawfish species listed under any conservation status in the regulation.</li> </ul>	<ul style="list-style-type: none"> <li>• Provides regulation of, and management responsibilities for, protected areas and listed species</li> <li>• Penalties for non-compliance</li> <li>• Review of Act and Regulation.</li> </ul>	Queensland Government
<i>Marine Parks Act 2004 (Qld) and Marine Parks Regulation 2006</i>	<ul style="list-style-type: none"> <li>• The object of this Act is to provide for the conservation of the marine environment by: <ul style="list-style-type: none"> <li>• declaring State marine parks</li> <li>• establishing zones, designated</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Aims to involve all stakeholders cooperatively</li> <li>• Coordination and integration with other conservation legislation</li> </ul>	Queensland Government



	<ul style="list-style-type: none"> <li>• areas and highly protected areas within marine parks</li> <li>• developing zoning and management plans</li> <li>• recognising the cultural, economic, environmental and social relationships between marine parks and other areas</li> <li>• applying the precautionary principle.</li> </ul>	<ul style="list-style-type: none"> <li>• Penalties for non-compliance</li> <li>• Processes of review.</li> </ul>	
<p><i>Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld)</i></p>	<ul style="list-style-type: none"> <li>• A multiple-use marine protected area management tool that protects biodiversity by the regulation of activities within the Great Barrier Reef Coast Marine Park</li> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Spatial management of activities within State waters of the Great Barrier Reef based on protection of representative bioregions</li> <li>• Penalties for non-compliance.</li> <li>• Compliments spatial management zones and certain regulatory provisions established under the <i>Great Barrier Reef Marine Park Zoning Plan 2003</i>.</li> </ul>	<p>Queensland Government</p>
<p>Back on Track Biodiversity Action Plans</p>	<ul style="list-style-type: none"> <li>• The Back on Track Species Prioritisation Framework identifies priority species for conservation management, regional threats, and suggested recovery actions</li> <li>• Includes green, dwarf, freshwater and narrow sawfish in Natural Resource Management Regions of central and northern Queensland.</li> </ul>	<ul style="list-style-type: none"> <li>• Identifies regionally-appropriate management actions to mitigate the risks to these species</li> <li>• Processes of review.</li> </ul>	<p>Queensland Government with regional Natural Resource Management groups and other stakeholders for implementation of identified management actions</p>
<p><i>Reef Water Quality Protection Plan 2009 (Qld)</i></p>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Improve water quality that flows into the Reef by targeting priority outcomes, integrating industry and community initiatives and incorporating new policy and regulatory frameworks.</li> </ul>	<p>Queensland Government (jointly funded by the Australian Government and the State of Queensland)</p>
<p><i>Great Barrier Reef Protection Amendment Act 2009 (Qld)</i></p>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Mix of strict controls on farm chemicals and regulations to improve farming practices.</li> </ul>	<p>Queensland Government</p>
<p><i>Coastal Protection and Management Act 1995 (Qld) and Coastal Protection and Management Regulation 2003</i></p>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Queensland Coastal Plan outlines directions for effective protection and management of the coastal zone.</li> </ul>	<p>Queensland Government</p>
<p><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</i></p>	<ul style="list-style-type: none"> <li>• The Queensland Coastal Plan has two parts: State Policy for Coastal Management and the State Planning Policy 3/11: Coastal Protection (SPP).</li> </ul>	<ul style="list-style-type: none"> <li>• 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</li> <li>• The SPP provides policy direction and assessment</li> </ul>	<p>Queensland Government</p>

Act 2009)		criteria to direct land-use planning and development assessment decision making under the <i>Sustainable Planning Act 2009</i> .	
<i>Sustainable Planning Act 2009</i> (Qld) and <i>Sustainable Planning Regulation 2009</i>	<ul style="list-style-type: none"> <li>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</li> <li>Establishes the framework for the development of Regional Plans.</li> </ul>	<ul style="list-style-type: none"> <li>Regional plans operate in conjunction with other state planning instruments, usually taking precedence over them</li> <li>Regional plans must conform to policies established within the Queensland Coastal Plan</li> <li>Regional plans identify: <ul style="list-style-type: none"> <li>desired regional outcomes</li> <li>policies and actions for achieving these desired regional outcomes</li> <li>the future regional land use pattern</li> <li>regional infrastructure provision to service the future regional land use pattern</li> <li>key regional environmental, economic and cultural resources to be preserved, maintained or developed.</li> </ul> </li> </ul>	Queensland Government

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## Appendix 1. Vulnerability 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
<b>Exposed to source of pressure (yes/no)</b>	No	Yes; locally	Yes; State-wide, near shore	Yes; regionally	Yes; locally	Yes; regionally	Yes; locally	Yes	Yes; predominantly developing coast of Queensland south of Port Douglas	Yes; predominantly developing coast of Queensland south of Cooktown
<b>Degree of exposure to source of pressure (low, medium, high, very high)</b>	Low. Low relative abundance in areas frequented by tourists and no dedicated activity involving sawfish equates to low exposure.	Low. Defence activities conducted in habitat likely to support sawfish are limited in scope and duration and restricted spatially and temporally.	Very high. Very high exposure of sawfish to the trawl and commercial net fishery as well as safety under the Queensland Shark Control Program.	Medium. Recreational fishing does occur in habitats likely to support sawfish. However, as they are a no-take species, retention rates are considered to be very low. Sawfish are likely to have high post-release survivorship from line fishing, although this is largely undetermined. Although retention rates are very low, the level of interaction between recreational fishing activities and sawfish is likely to be higher and is likely to be a source of mortality.	Medium. Degree of exposure is considered medium as much of the port and shipping activity occurs in inshore habitats likely to support surviving populations of sawfish. This is particularly applicable at local scales in the southern part of their distributions, south Impacts combine cumulatively with other sources of vulnerability in these areas.	Low. Recreational activities within the Marine Park are unlikely to expose Pristids to significant pressure.	Low. Traditional Owners are able to catch and retain sawfish but it's likely that take is very low.	Very high. 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).	High. Sawfish inhabit freshwater, estuarine, inshore and nearshore habitats and are highly exposed to coastal development pressure due to habitat loss and degradation (including those impacts from ports and shipping expansion). Sawfish (particularly freshwater sawfish) also suffer loss of significant nursery habitat with the development of dams, weirs, barrages or river crossings.	High. Sawfish inhabit freshwater, estuarine, inshore and nearshore habitats and are highly exposed to declining water quality pressures due to health impacts from pollution and habitat loss and degradation.

	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><b>Sensitivity to source of pressure</b> (low, medium, high, very high)</p>	<p>Low. No commercial marine tourism activities based around sawfish.</p>	<p>Low. Defence activities limited spatially and temporally. Low exposure determines the level of sensitivity towards this pressure on Reef-wide scales.</p>	<p>High. Morphology and behaviour of sawfish predisposes them to capture in mesh nets. Sawfish are a listed no-take species so all individuals must be returned to the water. Post –release survivorship is expected to be high from line fishing (better for some species than others) if handled correctly, but lower following interactions with otter trawling.<sup>53</sup> Although post-release survivorship may be high, the level of interaction between commercial fishing activities and sharks and rays is higher and is a source of mortality.</p>	<p>Medium. Sawfish will take baits but post-release survivorship is likely to be very high if handled correctly and hooks have not been ingested. 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 derelict hooks may puncture the stomach, pericardial cavity and oesophagus causing infection and death.<sup>49</sup> This could cause death some time after release. Very little data available on recreational fishing interactions with sawfish making it difficult to determine their sensitivity to this pressure.</p>	<p>Medium. Sawfish are most sensitive to impacts from ports and shipping because they utilise inshore habitats and therefore 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 sawfish.</p>	<p>Low. Low exposure determines the level of sensitivity towards this pressure on Reef-wide scales.</p>	<p>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.</p>	<p>High. Sawfish assessed as being moderately (to highly) vulnerable to climate change impacts.<sup>1</sup></p>	<p>High. Eighty five per cent of the state's population lives in the coastal fringe where strong population growth is predicted. This combination of factors exposes these species as being highly sensitive to coastal development impacts and other cumulative impacts. Sawfish (particularly freshwater sawfish) require the use of upstream freshwater habitat which provides foraging areas offering protection from predators in early juvenile life-stages. These areas become isolated over the dry winter months. Any loss of such habitat due to instream development preventing upstream migrations may be critical for sawfish, especially freshwater sawfish.</p>	<p>High. Little is known on the sensitivity of sawfish to declining water quality due to catchment run-off. Habitat and trophic specificity in combination with conservative life histories may make sawfish highly sensitive to declining water quality due to catchment run-off and the indirect impacts from corollary effects of habitat loss and degradation.</p>



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<b>Adaptive capacity – natural</b> (poor, moderate, good)	Good. Sawfish would be able to move away from temporary sources of disturbance.	Good. Sawfish would be able to move away from temporary sources of disturbance.	Poor. Morphology and behaviour of sawfish predisposes them to capture in mesh nets. Sawfish are unlikely to be able to avoid mesh nets set in nearshore and inshore habitats.	Moderate. If sawfish are present in areas fished by recreational fishers it is unlikely they will avoid baits set to catch other species. However, as no-take species with likely high post-release survivorship, their adaptive capacity to recreational fishing is moderate.	Moderate. Sawfish would be able to move away from sources of disturbance but their conservative life histories mean they are highly susceptible to loss of shallow inshore habitats where prey is located.	Good. Sawfish would be able to move away from temporary sources of disturbance.	Moderate. If sawfish are present in areas fished by Traditional Owners it is unlikely they will avoid baits set to catch other species. Sawfish susceptible to capture in set mesh nets used as customary practice which is more common to Traditional Owners in the northern parts of sawfish distributions in the Great Barrier Reef.	Poor. Conservative life histories mean that sawfish have poor adaptive capacity to the physical, chemical and ecological effects caused by climate change.	Poor. Habitat and trophic specificity in combination with conservative life histories are likely to mean that sawfish have poor adaptive capacity to habitat degradation/loss from coastal development.	Moderate. It is unknown if sawfish have a natural adaptive capacity/resilience to reduced water quality due to pollutants, nutrients and elevated sediment loads as a result of catchment run-off. Habitat and trophic specificity in combination with conservative life histories may mean that sawfish only have moderate adaptive capacity to declining water quality due to catchment run-off and the indirect impacts from corollary effects of habitat loss and degradation.
<b>Adaptive capacity – management</b> (poor, moderate, good)	Good. Commercial tourism in the Great Barrier Reef is well managed through a permit system guided by established spatial management tools applied under	Good. Defence activities are well managed and limited in extent, duration and geographic distribution. In consultation with the Defence department, management	Moderate. Sawfish are now a listed 'no-take' species and gain a degree of spatial and temporal protection from Marine Park zoning and Fisheries closures. Further such measures are possible to introduce following rigorous	Good. Sawfish are now a listed 'no-take' species and gain a degree of spatial and temporal protection from Marine Park zoning and Fisheries closures. Further such measures are possible to introduce	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.	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.	Good. Traditional Owners unlikely to target sawfish. Regional engagement and Indigenous community stewardship programs operated by GBRMPA provide an avenue to	Poor. Options for local or regional scale management of climate impacts on sawfish remain limited because most impacts are directly linked to large-scale global climate phenomena rather than more local threatening processes. Currently available information on	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	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

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	legislative provisions. This allows a certain degree of flexibility in the management of emergent impacts from this pressure.	arrangement could be adapted to suit changing conservation requirements .	processes of assessment and wide stakeholder consultations making such processes complex and open to interpretation. Limited biological and ecological information on sawfish may leave these species vulnerable to management arrangements that do not apply appropriate levels of precaution to their conservation.	following rigorous processes of assessment and wide stakeholder consultations making such processes complex and open to interpretation. Raising the awareness of the vulnerabilities and conservation status of sawfish will be required to improve their conservation.	Environmental impact assessments made under the EPBC Act provide a process to assess the impacts of proposed port developments.		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.	climate change impacts on sawfish are being implemented into management actions within the World Heritage Area. However, long-term studies that take account of temporal and spatial variability and provide key determining correlations between climate change impacts and sawfish 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 information as it becomes available.	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 providing input into the Queensland Coastal 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 environmental assessments for projects referred under the EPBC Act.	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 providing input into State Coastal Management Plan policies and statutory Regional Plans which plan for coastal development in Queensland. The GBRMPA also provides input into environmental assessments for projects referred under the EPBC Act.
<b>Residual vulnerability (low, medium, high)</b>	Low	Low	High	Medium	Medium	Low	Low	High	High	High

	Pressures									
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<b>Level of confidence in supporting evidence</b> (poor, moderate, good)	Poor. Limited published supporting evidence.	Poor. Limited published supporting evidence.	Good. Cavenagh <i>et al.</i> 2003; <sup>32</sup> Gunn <i>et al.</i> 2008, <sup>39</sup> Stevens <i>et al.</i> 2005; <sup>8</sup> Salini 2007. <sup>40</sup>	Moderate. Lynch <i>et al.</i> 2010. <sup>41</sup>	Poor. Limited published supporting evidence.	Poor. Limited published supporting evidence.	Poor. Coleman <i>et al.</i> <sup>54</sup> cited in Henry and Lyle 2003. <sup>55</sup>	Moderate. Chin and Kyne 2007; <sup>12</sup> Chin <i>et al.</i> 2010. <sup>1</sup>	Moderate. Peverell 2005; <sup>10</sup> Chin and Kyne 2007; <sup>12</sup> Knip <i>et al.</i> 2010; <sup>2</sup> Hutchings <i>et al.</i> 2005. <sup>11</sup>	Poor. Peverell 2005; <sup>10</sup> Chin and Kyne 2007; <sup>12</sup> Knip <i>et al.</i> 2010; <sup>2</sup> Hutchings <i>et al.</i> 2005. <sup>11</sup>

The pressures addressed in this Vulnerability Assessment were identified in the *Great Barrier Reef Outlook Report 2009*.<sup>42</sup>

Coastal habitats (rivers, estuaries, seagrasses, mangroves and wetlands) are under increasing pressure from human activities. More than 85 per cent of Queensland's population live on the coastal fringe. Predicted strong population growth means that the intensity of activity and development in coastal zones is likely to persist.<sup>56</sup>

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.

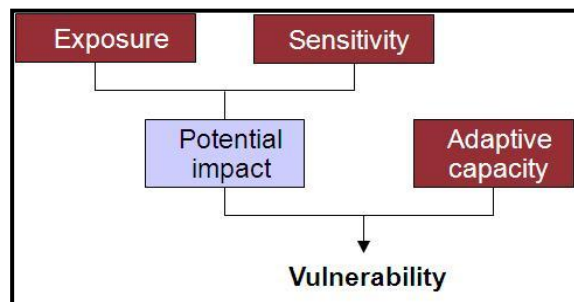


Figure 1. The key components of vulnerability assessments (Adapted from Wachenfeld *et al.*, 2007)

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<sup>e</sup> 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

<sup>e</sup> The potential impact matrix is described within the vulnerability assessments page of the GBRMPA website.

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 sawfish 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 sawfish to adapt to pressures in the Great Barrier Reef, and the capacity of management to intervene (which in turn may assist sawfish 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 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 sawfish 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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