

A Vulnerability Assessment for the Great Barrier Reef



Snapper

Information valid as of June 2014

Summary

Diversity

Single species — snapper (*Pagrus auratus*, previously classified as *Chrysophrys auratus*)

Susceptibility

Life-history traits that predispose snapper to threats include being long-lived though highly prized species for commercial and recreational fishers and susceptible to incidental capture of juveniles in the East Coast Trawl Fishery.

Major pressures

Overfishing through recreational, commercial and charter fishing effort.

Cumulative pressures

Climate change impacts, coastal development, and declining water quality in combination with the major pressures snapper experience.

Applied or assessed separately, these pressures may not seem significant, but research indicates the combined and cumulative impact of these major pressures present significant concerns for the

conservation and management of snapper in the World Heritage Area.

Management in the Great Barrier Reef

Legislative management tools for the conservation of snapper that are in force in the World Heritage Area include:

- *Fisheries Act 1994* (Qld) and Fisheries Regulation 2008
- Rocky Reef Fin Fish Fishery (accredited Wildlife Trade Operation under the *Environment Protection and Biodiversity Conservation Act 1999* with associated controls)
- Great Barrier Reef Marine Park Zoning Plan 2003 provides spatial protection with only 34 percent of the Great Barrier Reef Marine Park (the Marine Park) open to general use
- the Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld) provides complementary protection of some coastal and estuarine waters
- the Queensland Coastal Plan guides coastal development
- other additional tools (refer to management table, p. 10).



Snapper, *Pagrus auratus*. Photo courtesy of G. Cumming

Existing management actions

Management actions in the World Heritage Area aim to be outcomes focused and in part put legislative management tools into effect. They also provide strategic direction or additional guidance to management operations in the Marine Park.

In 2014, a comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone was completed. There are two components to the assessment, a marine component and a coastal component, which were undertaken by the Australian and Queensland governments, respectively.

Recommendations from the marine component of the strategic assessment report informed a separate Program Report for the Great Barrier Reef Region. The Program Report is a detailed description of the GBRMPA's management arrangements and future commitments to protect and manage the Great Barrier Reef. The Program Report details how the GBRMPA's current foundational management will continue to adapt and be strengthened to achieve its responsibilities over the next 25 years.

The *Great Barrier Reef Outlook Report 2014*¹ highlights threats to the Great Barrier Reef and recognises that snapper are exposed to a range of pressures. Regional and local solutions to help reduce pressures on snapper will be guided by the Program Report and strategic direction provided by planning documents to improve conservation outcomes for snapper. These planning documents include:

- Reef Water Quality Protection Plan 2013
- Great Barrier Reef Biodiversity Conservation Strategy 2013
- Great Barrier Reef Climate Change Adaptation Strategy and Action Plan 2012–2017

A number of other management actions are in place in the World Heritage Area. These include:

Management actions in the World Heritage Area in part put legislative management tools into effect. They also provide additional guidance or strategic direction to management operations in the Marine Park. These include:

- In Queensland, snapper are managed as a single stock (this stock extends into New South Wales) — the Queensland Fisheries Regulation 2008 prescribes a minimum legal size of 35 cm total length. Commercial and recreational fishers are limited to a maximum three lines with six hooks. The commercial fishery has limited entry and there is a restriction on the length of vessel that can be used (20 metres).
- The Queensland Government implemented an interim six week closure of the fishery between 15 February and 31 March 2011. Following this measure, the recreational bag limit was subsequently reduced to four fish in possession per person (down from five) and a possession limit of one fish greater than 70 centimetres was also introduced for recreational fishers.

- A review of the management arrangements for the Rocky Reef Fin Fish Fishery, as well as an updated stock assessment for snapper, is now proposed for 2014
- There are no current spatial or temporal management arrangements within Queensland Fisheries Regulations specific to snapper that protect spawning aggregations or provide refugia for stock recovery, and there are no output controls that set a Total Allowable Catch for the snapper fishery.

Great Barrier Reef Outlook Report 2014

assessment: Species not assessed.

Vulnerability assessment: high

- Snapper are exposed to high levels of fishing pressure. As the human population on Queensland's coast grows, the pressures on snapper are likely to increase if management arrangements are not implemented to rebuild the stock.
- A 2009 stock assessment indicated the current exploitable biomass of snapper may be as low as 15 percent of the estimated virgin biomass and high as 50 percent, with most scenarios being less than 35 percent.¹ Fisheries managers classify a stock as being overfished when the estimated virgin biomass falls below 40 percent.
- In 2010, the Queensland stock of snapper was formally assessed as overfished by the Queensland Government. A review of Fisheries Queensland's management arrangements for snapper was undertaken in 2011 as part of the review of the Rocky Reef Fin Fish Fishery. There is a stated objective to rebuild the snapper stock to sustainable levels over a 10-year period. However, important published recommendations¹ on how to achieve this have not been properly addressed.
- The level of recreational catch of snapper is estimated at approximately 65 - 70 percent of the total annual catch, yet there is considerable uncertainty in catch and effort estimates for this sector. This creates uncertainty in stock assessment modelling and in identifying suitable input and output controls to manage the harvest within this sector.
- Current management methods focus on input controls such as minimum legal size limits, take limits, gear restrictions and entry limitations to the fishery, while other important and valid management tools including output controls such as a total allowable catch and spatial or temporal closures have not been supported. Management arrangements utilising current input controls in combination with catch quotas, spatial and temporal closures and more selective gears are likely to provide a more effective means for managing the impacts of fishing.²
- A significant proportion of recreationally-caught snapper in Queensland is undersize. Post-release mortality across the age classes is not completely

understood, but recent estimates of post-release survival are greater than 80 percent, providing best-practice handling and release procedures are adopted.³ However, in regions of high fishing effort a large proportion of specimens are captured and released undersized, and fish handling practice may be impacting the proportion of post-release mortality.

- Juvenile snapper are incidentally killed as the bycatch of otter trawlers within southern sectors of the East Coast Trawl Fishery that mostly operate south of the Great Barrier Reef Marine Park, particularly in Moreton Bay. Although trawl effort has reduced in Moreton Bay in recent times which is likely to have reduced the amount of juvenile snapper bycatch, mortality levels may remain
- Although virtually all harvest of snapper in Queensland is currently achieved through the use of hook and line methods, net fishing methods, which are highly effective at catching schooling fish, are currently permitted to target and catch snapper commercially. Concerns about hyperstability potentially masking likely stock reductions means commercial net fishing for snapper should be closely monitored.
- The potential impacts of climate change on snapper require consideration, though at present they're insufficiently understood to effectively inform management. However, there is sufficient information to justify a precautionary approach to forming management arrangements that account for potential impacts of climate change, considering the cumulative pressures the species is exposed to.

Background

Brief description of snapper

Snapper (*Pagrus auratus*) is the premier rocky reef fish species in southern Queensland. It is one of four primary target species within the Queensland Rocky Reef Finfish Fishery (including pearl perch, *Glaucosoma scapulare*; teraglin, *Atractoscion aequidens*; and cobia, *Rachycentron canadum*) and is heavily targeted by recreational fishers.

Snapper grow in excess of 100 centimetres (more than 10 kilograms) and can live to around 30 years⁴ in Queensland waters (they can live longer in more temperate waters). For east Australian populations, this species exhibits highly varied, though relatively rapid growth, through to maturity when their growth rate decreases. (S. Wesche 2010, pers. comm.) This variable growth rate has been correlated to water temperature (that is, snapper in subtropical waters tend to grow faster than those in temperate waters),⁵ in conjunction with the abundance of suitable prey.⁶ In Queensland, they are sexually mature at about three to four years of age, which corresponds to an approximate total length of about 30 centimetres⁴ (Wesche, S. 2010, pers. comm.).

Juvenile snapper (in Queensland, less than 30 centimetres in total length) typically occur in shallow inshore areas and are associated with most bottom types, including rocky reefs, rubble, seagrass beds, soft coral and algal beds and soft benthic habitats (S. Wesche 2010, pers. comm.).⁵ Population densities were not significantly different among the habitat types, though juveniles were more common in the shallower southern waters of Moreton Bay (less than 8 metres deep).⁵ As snapper grow, they migrate to deeper offshore habitats to depths of 200 metres and tend to aggregate about reefs and shoals (S. Wesche 2010, pers. comm.).⁷

Snapper are highly fecund and in Queensland a one kilogram, 38 centimetre female can produce 1.8 million eggs.⁴ Spawning periods for snapper are associated with water temperature. In Queensland, water temperatures during June to October provide preferred water conditions when larger fish move inshore and may form small aggregations to spawn (S. Wesche 2010, pers. comm.). During this period, snapper are most vulnerable to capture, as aside from the aggregation, the tide and weather conditions are more favourable to fishing.⁸ It is suspected that there is a concentration of fishing effort on spawning fish.⁹

Adult snapper have been recorded migrating considerable distances, for example, between Mallacoota, Victoria and southern Queensland.¹⁰ However, while there are some extensive movements of snapper, most stock is relatively localised and undergoes movements on the scale of tens, rather than hundreds or thousands, of kilometres.^{10,11}

The East Australian Current is believed to be largely responsible for maintaining the unit stock structure of the east coast snapper population.¹² The influence of the current in transporting larvae to the south, coupled with the general northward migration pattern of adults, is believed to be responsible for maintaining a genetically homogenous (panmictic) snapper population along much of Australia's east coast.¹² The snapper in Queensland are part of this larger unit stock that is shared between Queensland and New South Wales — a feature which presents cross-jurisdictional management and stock assessment complexities. In Queensland, the snapper population is managed as a single stock.⁹

An apparent weak genetic disjunction within the east Australian snapper stock occurs north of Sydney, which further highlights the need for fisheries management agencies in Queensland and New South Wales to work collaboratively to maintain current stock structures.¹²

Juvenile snapper feed in shallow waters on zooplankton and small invertebrates. Mature fish tend to be mid-water feeders and feed on bait fish such as pilchards and whiting. Although considered demersal feeders, across the seasonal variation in snapper's habitat use, from deep water to shallow habitats, they are considered to have a wide diet and feed from the benthos and the water column on invertebrates and bait fish (S. Wesche 2010, pers. comm.).

Geographical distribution

Snapper are widely distributed throughout the Indo-Pacific region, from Japan to the Philippines, India and Indonesia, and down to Australia and New Zealand. In Australia, snapper are commonly found from Mackay along the south coast and up to Barrow Island (Western Australia). Historically, snapper in the Great Barrier Reef have been found as far north as Hinchinbrook Island, though they are most commonly distributed from Mackay south, through the Swain Reefs (S. Wesche 2010, pers. comm.).

Population status in the Great Barrier Reef Marine Park

In 2005, the commercial catch of snapper within the Great Barrier Reef World Heritage Area was estimated at 23 tonnes with a gross value of product of \$183,800 produced by 43 boats over 473 combined fishing days.¹³ There is no more recent information available on this spatial dimension.

The commercial catch (in kilograms) within the Queensland snapper stock halved between 2005 and 2008 (from 264 tonnes to 121 tonnes), but a survey of recreational fishers has shown their catch has almost doubled

between 2002 and 2005 (from approximately 281 tonnes to 550 tonnes).¹⁴ In 2009, an assessment of the Queensland snapper stock was undertaken which led to it being formally assessed in 2010 as overfished by the Queensland Government.¹⁵

Ecosystem role/function

Snapper in the Marine Park are demersal¹ and mid-water predators that inhabit shallow coastal habitats to deep water rocky reefs and shoals. In some locations they have been relatively abundant. Data about their ecological role and their influence on other components of marine ecosystems is lacking, however as low to mid-order predators, snapper would play a role in nutrient cycling and regulation of lower order prey.

Ecosystem goods and services

Ecosystem goods and services category	Services provided by the species, taxa or habitat
<p>Provisioning services (e.g. food, fibre, genetic resources, bio-chemicals, fresh water)</p>	<p>Snapper are an important component of the Queensland Rocky Reef Finfish Fishery. They are highly sought after by recreational and commercial fishers. Capture methods are predominantly hook and line.</p> <p>The reported total commercial harvest of snapper in Queensland waters peaked at 264 tonnes in 2005. In 2008, the reported catch was 121 tonnes. In 2005, the total recreational catch of snapper was estimated to be 550 tonnes — double what it was in 2002.¹⁴ However, by 2010 this estimation had fallen to 130 tonnes¹⁶ and the commercial harvest had fallen to 78 tonnes.¹⁷</p> <p>Much of the commercial snapper harvest is sold as frozen fillets or gutted whole fish and is marketed in Queensland, interstate and overseas. The Gross Value of Product in the peak year of 2005 was \$1.98 million.¹³</p>
<p>Cultural services (e.g. spiritual values, knowledge system, education and inspiration, recreation and aesthetic values, sense of place)</p>	<p>Recreational fishing is a popular cultural activity in Queensland and contributes significantly to the Queensland economy, both directly and indirectly through its supporting industries. Snapper are regarded as an excellent sportfish with esteemed table qualities. As a result, snapper are specifically targeted by many recreational fishers and appears on target species lists in recreational fishing competitions.</p>
<p>Supporting services (e.g. primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling)</p>	<p>The supporting services of snapper within marine ecosystems are unknown but as low to mid-order predators they would play a role in nutrient cycling.</p>
<p>Regulating services (e.g. invasion resistance, herbivory, seed dispersal, climate regulation, pest regulation, disease regulation, natural hazard protection, erosion regulation, water purification)</p>	<p>The regulation services of snapper within marine ecosystems are unknown but as low to mid-order predators they would play a role in regulation of lower order prey.</p>

Pressures influencing snapper in the Great Barrier Reef Marine Park

Pressures

Snapper in the Great Barrier Reef Marine Park are exposed to a range of pressures including fishing (target and incidental capture),^{5,15} coastal development and population growth,¹⁸ declining water quality and climate change.^{18,19,20} These pressures act cumulatively across the habitats that snapper rely on, especially in inshore waters that are most important to juvenile snapper. A more detailed description of pressures that impact on snapper in the Great Barrier Reef is provided in the vulnerability assessment matrix in Appendix 1.

Vulnerability assessment matrix

According to the *Great Barrier Reef Outlook Report 2014*²¹, the key pressures reducing the resilience of the Reef ecosystem are a number of commercial and non-commercial uses of the Marine Park, along with habitat loss and degradation due to climate change, coastal development and declining water quality from land-based (catchment) run-off.

The report considered these pressures are the key factors that influence the current and projected condition of 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 to future impacts.

Using the vulnerability assessment framework adapted by Wachenfeld and colleagues,²² 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 snapper has 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 the species in order to reach a final assessment of the overall residual vulnerability of snapper to that particular pressure. This allows for suggested actions to be developed to minimise the impact of the pressures to which snapper are most vulnerable.

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

Vulnerability assessment matrix summary for snapper in the Great Barrier Reef Marine Park

		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	Moderate	Good	Low	Poor
	Defence activities	No	Low	Low	Moderate	Good	Low	Poor
	Commercial fishing	Yes, across the stock's state distribution	High (when also considering other trawl bycatch of juveniles outside the Marine Park)	High (around aggregation sites)	Poor	Moderate	High (around aggregation sites and considering other trawl impacts)	Moderate
	Recreational fishing	Yes, developing coast	Medium (when considering only the Marine Park)	High (around aggregation sites)	Poor	Moderate	Medium (around aggregation sites)	Moderate
	Ports and shipping	Yes, locally	Medium	Medium	Poor	Moderate	Medium	Poor
	Recreation (not fishing)	Yes, adjacent to population centres	Low	Low	Moderate	Good	Low	Poor
	Traditional use of marine resources	Yes, locally	Low	Low	Poor	Good	Low	Poor
	Climate change	Yes, across the stock's state distribution	Very high	High (potential)	Moderate	Poor	High (potential)	Poor
	Coastal development	Yes, across the stock's state distribution	High	High	Moderate	Moderate	High	Poor
	Declining water quality due to catchment run-off	Yes, across the stock's state distribution	High	High	Moderate	Moderate	High	Moderate

Key concerns

The effective conservation of snapper requires the protection of key habitats and management of key threats. The following matters are of key concern:

- The stock assessment undertaken in 2009 indicated that exploitable biomass levels of snapper could be as low as 15 to 50 percent of the virgin biomass.¹ The majority of analyses put biomass below 35 percent.¹ This is below the point considered to be the species' maximum sustainable harvest yield (by weight), and below the internationally recognised level of 40 percent which classifies a fishery as being overfished.^{1,14} In 2010, the Queensland Government formally assessed snapper as overfished.¹⁵
- Stock assessments (modelling) of the Queensland snapper fishery were undertaken in 2006⁹ and 2009.¹ Both outlined management strategies for improving the fishery's sustainability. It is suggested that only under optimistic (high) levels of stock recruitment will the current minimum legal size of 35 centimetres sustain annual harvests of 400 tonnes, whereas a 45 centimetre minimum legal size would be a precautionary measure that was predicted to provide for no further stock declines under any scenario, which included likely and worst-case estimates of discard mortality (10–50 percent).⁹

- Regulating the minimum legal size for snapper requires careful consideration. A number of these considerations are outlined in the Queensland Government stock assessment analyses.^{1,9} Modelled management options where the minimum legal size remains at 35 centimetres, but a 400 tonne total allowable catch quota is implemented, suggests the stock will recover to sustainable levels over a 10-year period. This is possible under a perhaps somewhat optimistic scenario where sufficient fishing effort is reduced and there is high recruitment into adult stock and low discard mortality. Under this scenario the probability of falling below target stock levels (40 percent of the virgin biomass) in the nominated 10-year rebuild period is 25 percent¹ and only a very small possibility that these controls may result in a fishery collapse (approximately one percent).⁹
- In contrast, by using somewhat less optimistic modelling inputs where recruitment is lower but minimum legal size remains at 35 centimetres, the same strategy of a 400 tonne quota would have a 46 percent risk of not meeting the target and a 10 percent risk of collapsing the fishery.¹
- A study of snapper in Western Australia, including modelling of egg-per-recruit fecundity, indicated the population's reproductive potential was substantially improved with higher minimum legal size (to between 40 and 50 centimetres), especially when fishing mortality was high.²³ Work in Queensland has previously identified that a 45–50cm minimum legal size was the optimal size limit to prevent growth overfishing (where fish are harvested prior to first spawning).⁴ This would provide greater yield by weight and a more fecund stock.
- Given the likelihood of increasing effort in the fishery and evidence that growth overfishing is occurring, there would be benefit in reviewing the implications from the stock assessment modelling that a 45 cm minimum legal size would provide greater protection for the stock under most circumstances. This would improve stock recruitment providing discard mortality rates are not too high (above 70 percent) and increase the yield (harvest by weight) that can be sustained at higher effort levels.^{1,4,9} In order to develop the necessary controls for the fishery, ongoing population monitoring is required to establish age structure (to determine recruitment rates), vulnerability schedules (to determine if older fish are less vulnerable to capture), spatial catch and fishing effort. This is particularly important for the recreational fishing sector of the Queensland snapper fishery, which takes an estimated 65 to 70 percent of the total annual harvest. Any modelling difficulties created by increasing the minimum legal size are likely to reduce over time as long-term monitoring data becomes sufficient to determine size-at-age structure. In this case there may be benefits to the snapper population and its management from increasing the minimum legal size sooner rather than later.
- Current management methods focus on input controls such as minimum legal size limits, take limits, gear restrictions and entry limitations to the fishery, while other important and valid management tools including output controls such as a total allowable catch and spatial or temporal closures have not been promoted. Research of the post-release mortality of snapper showed evidence of barotrauma when fished from depths greater than 11 metres and questioned the effective use of bag limits and minimum legal size regulations as stand-alone management tools. Management arrangements utilising current input controls in combination with catch quotas, spatial and temporal closures and more selective gears are likely to provide a more effective means for managing the impacts of fishing.²
- Despite suspected concentrations of fishing effort during the spawning season,⁹ there are currently no spatial or temporal management controls in place to protect the species during breeding aggregations or to provide refuges to support recovery and sustain populations. Although approximately 16 percent of the Moreton Bay Marine Park is protected by no-take marine areas, along with parts of the Great Sandy Marine Park and the Great Barrier Reef Marine Park, these no-take areas protect less than two percent of the snapper habitat in Queensland. In advising that this may not be sufficient to offer the protection needed to significantly reduce the fishing mortality necessary to enable the snapper stock to be rebuilt, the 2009 snapper stock assessment¹ has most certainly made a gross understatement of the potential protection offered by existing limited spatial closures.
- The published 2007 estimated total annual catch of 760 tonnes was 45 percent greater than the 400 tonnes that has been estimated to allow the snapper stock in Queensland to rebuild to sustainable levels.¹ More recently harvest estimates for the recreational sector appears to have fallen from an approximate 550 tonnes in 2005 to 130 tonnes in 2010.¹⁶ Concomitantly, the commercial harvest has fallen from 210 tonnes in 2006 to 78 tonnes in 2010 with a relatively stable charter sector harvest.¹⁷ Given it is likely recruitment variability has not been a factor in these harvest reductions and there have been no significant structural adjustments or control changes in the fishery up until present, this data appears to indicate the stock is either in decline (potentially towards collapse) or recreational effort has reduced considerably. The slightly reduced effort presented in the 2010 state wide survey of recreational fishers does not account for the considerable level of reduced recreational harvest and must also be considered in view of the continued rise in recreational speedboat vessel registrations²⁴ in Queensland. This would indicate that boat-based fishing effort has in fact increased and not reduced.^b

^b The 2010 State wide recreational fishing survey shows a decrease in recreational fishing effort from when the 2000 surveys were undertaken where most of the reduction occurred within the Brisbane residential region while the Mackay region and far northern region increased.¹⁶

- Commercial catch (in kilograms) has halved since 2005 but the estimate of recreational harvest almost doubled between 2002 and 2005.¹⁴ Although the recreational sector takes an estimated 65-70 percent of the total annual harvest¹⁶ there are currently no controls to manage total annual catch beyond an individual's in-possession bag limit. Such a management approach in similar fisheries in the Gulf of Mexico (United States) highlight the uncertainties in relying solely on input controls that aim to promote increased stock recruitment (catch limits, minimum legal size regulations, gear selectivity). (Walters in Allen *et al.*⁹) Such controls were sensitive to the level of discard mortality, as predicted gains in recruitment caused by increasing the minimum legal size is partially counteracted by increased discard mortality as the catch component of undersized fish increases.

It is suggested that effective total allowable catch (TAC) output controls are likely to be amongst the best options to achieve stock rebuilding and sustainable management (Walters in Allen *et al.*⁹).

- The decline of the snapper stock in recent years may be greater than expected due to effects of hyperstability within the commercial and recreational sectors. That is, high catch rates can be maintained when actual stock abundance has declined. This is because fishers have access to improved technology to find fish, or they spend more time searching for fish to maintain catch rates. Also, when located, aggregations can become rapidly diminished while catch rates appear 'normal'. As this increase in fishing efficiency is not reflected in commercial logbooks, catch rates can falsely appear constant. Catch and effort data for the recreational fishery is limited, which is concerning when considering the estimations of these metrics.
- Although virtually all harvest of snapper in Queensland is currently achieved through the use of hook and line methods, net fishing methods, which are highly effective at catching schooling fish, are currently permitted to target and catch snapper commercially. Concerns about hyperstability potentially masking likely stock reductions means commercial net fishing for snapper should be closely monitored.
- There are many complex factors that contribute to post-release mortality, including size class, gear used in capture, where the fish is hooked, water depth, how the fish is handled at the surface and how it is released. Recent research has shown post-release mortality of line-caught snapper is lower than previously estimated with more than 80 percent surviving across a wide range of depths (providing best practise handling and release procedures are adopted).³ However, offshore from Brisbane and the Gold Coast where fishing effort is high, a large proportion of specimens are captured and released undersized and fish handling practice may be impacting the proportion of post-release mortality (S. Wesche 2010, pers. comm).
- In 2011, the Queensland Government consulted fishers on options for implementing new management arrangements to rebuild the snapper stock over a 10-year period. These options were outlined in a Regulatory Impact Statement. Management tools tabled included implementing a recreational fishing permit to fund monitoring and management, reducing bag limits, temporal management options such as seasonal closures during spawning seasons, restricting fishing gear and/or regulating the Total Allowable Catch across the three sectors within the snapper fishery. After the completion of the Regulatory Impact Statement, the introduction of a total allowable catch, spatial or temporal closures or an increase to the minimum legal size of snapper have not been considered necessary to deliver the required management objectives for stock rebuilding.
- In a study in Moreton Bay, Queensland, juvenile snapper (predominantly 0+ year old and between 5–20 cm fork length) were an abundant incidental bycatch in prawn trawls with catch rates averaging 100 fish per hectare at some locations.⁵ Discard mortality of these juveniles was high (being more than 85 percent mortality after 15 minutes of air exposure) and under a worst-case scenario, models predicted that incidental capture of juvenile snapper in prawn trawls from southern Moreton Bay alone could be responsible for the loss of a greater tonnage of snapper than is taken by the total Queensland commercial line fishery.⁵ However, the predicted average loss of product was approximately 30 tonnes compared to an annual commercial line catch of 100 tonnes.⁵ Trawl discard mortality is unlikely to still be having this level of impact due to a considerable reduction in trawl fishing effort (50 percent) in areas including some preferred habitat for juvenile snapper within Moreton Bay and elsewhere since the time of Sumpton and Jackson's⁵ work.¹ However, current trawl discard mortality is likely to be causing mortality in the juvenile stock that needs to be considered.
- Campbell *et al.*'s 2009 stock assessment recommended 'that every effort should be taken to minimise the mortality of juvenile snapper incidentally taken in prawn otter trawls.'¹ Although bycatch reduction devices had reduced the level of incidental mortality experienced by juvenile snapper, there is scope for further improvement of bycatch reduction and hopper technology to benefit the snapper stock and further development work is required.¹ This would involve the continued use of bycatch reduction devices, but also the development of hopper technology to improve the survival of those juveniles retained in nets and sorted with the target catch.
- Climate change impacts are predicted to affect larval transport, larval connectivity, settlement and recruitment (early post-settlement survival), growth rates, range shifts, spawning and egg production, and habitats that support coastal fish species such as snapper.^{19,20} For example, climate change impacts such as increased sea surface temperature is expected to affect larval survival and growth rates with commensurate changes in stock structure and phenology (of spawning). There are indications that sea level rise may impact snapper within inshore habitats in pre- and post-larval recruitment phases.²⁵ Larval dispersal and recruitment of adult snapper are linked to the dynamics of the East Australian Current.¹² Changes in this current and the broader oceanographics within the Great Barrier Reef are predicted under different climate change scenarios.^{26,27}

Stronger southward flows²⁸ are likely to disperse larvae further to the south which may affect the northerly migration of adults.²⁰ Climate change impacts are also expected to affect the food webs that snapper rely on.^{19,20} Knowledge of such impacts on the bony fish of the Great Barrier Reef, including snapper, is at a very rudimentary stage and further research is required to provide information to sufficiently inform management.

Management of snapper in the Great Barrier Reef Marine Park

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

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
World Heritage Convention	<ul style="list-style-type: none"> • Four natural heritage criteria with associated conditions of integrity. Criteria focus on (i) geological processes and phenomena, including the evolution of the earth; (ii) ongoing ecological and biological processes; (iii) linked aesthetic components of the natural world; (iv) the biological diversity and habitats of threatened species • Natural Heritage Criteria iv states the natural heritage asset must contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation 	<ul style="list-style-type: none"> • Provides State Parties to the convention with definitions of natural and cultural heritage; measures for the protection of natural and cultural heritage; the means of administration and obligations of the convention; funding arrangements, educational programs and reporting obligations 	United Nations Educational, Scientific and Cultural Organization (UNESCO)
Convention on Biological Diversity	<ul style="list-style-type: none"> • The three main objectives of the Convention on Biological Diversity are: <ul style="list-style-type: none"> • the conservation of biological diversity • the sustainable use of the components of biological diversity • the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources 	<ul style="list-style-type: none"> • Provides State Parties to the convention with global principles, objectives and obligations for the conservation of biodiversity • Guides Australia's strategic planning to achieve national priority actions for biodiversity conservation through a range of objectives and targets for each 	United Nations Environment Programme — Convention on Biological Diversity Secretariat
<i>Environment Protection and Biodiversity Conservation Act 1999</i> (EPBC Act) and Environment Protection and Biodiversity Conservation Regulations 2000	<ul style="list-style-type: none"> • Legislative framework for environmental protection in Australia • Provides means of assessment of 'actions' within Australian marine and terrestrial environments • Legislative role includes the listing and regulation of threatened and protected species and communities, preparing recovery plans for threatened and protected species, identifying key threatening processes and, where appropriate, developing threat abatement plans and recovery plans 	<ul style="list-style-type: none"> • Application of 'controlled action' regulation for matters of national environmental significance as required • Assessment and export approval processes for all fisheries with an export component (or wildlife trade operation) • Review of the fishery under the EPBC Act. Wildlife Trade Operation with conditions issued 26 April 2012; valid to 26 April, 2013 • Penalties for non-compliance • Act is regularly reviewed 	Commonwealth Department of the Environment

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
Guidelines for the ecologically sustainable management of fisheries — 2007	<ul style="list-style-type: none"> Provides guidance to the assessment of Australian fisheries that seek to operate with a Wildlife Trade Operation accreditation under the <i>Environment Protection and Biodiversity Conservation Act 1999</i> Snapper are caught within the Rocky Reef Fin Fish Fishery which is managed under the <i>Queensland Fisheries Act 1994</i> with a Wildlife Trade Operation accreditation 	<ul style="list-style-type: none"> Fisheries under the EPBC Act Wildlife Trade Operation assessment must demonstrate that they operate under a management regime that meets two principles: <ol style="list-style-type: none"> A fishery must be conducted in a manner that does not lead to overfishing, or for those stocks that are overfished, the fishery must be conducted such that there is a high degree of probability the stock(s) will recover Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem 	Commonwealth Department of the Environment
<i>Fisheries Act 1994</i> (Qld) and Fisheries Regulation 2008	<ul style="list-style-type: none"> Provides the legislative framework and regulatory controls for managing fisheries in all Queensland waters and Commonwealth waters subject to the Offshore Constitutional Settlement for Queensland 	<ul style="list-style-type: none"> Minimum legal size limit of 35 cm total length Recreational bag limit of four per person with not more than one permitted to be greater than 70 cm total length Limit of three lines and six hooks per fisher Commercial sector is limited entry (1315 licences in 2010) and is a line only fishery Commercial boat size limit (less than 20 m) Dugong Protection Areas regulate and restrict the use of commercial set mesh nets within designated areas, which provides spatial protection for fish whilst in these areas Fish Habitat Areas help protect inshore habitats from impacts of coastal development. These areas provide nursery grounds and habitat for fish species likely to be prey for snapper and provide refugia for snapper juveniles Compulsory logbook reporting for commercial fishers Review of the <i>Queensland Fisheries Act</i> in 2011 Penalties for non-compliance 	Queensland Government
Rocky Reef Fin Fish Fishery management arrangements	<ul style="list-style-type: none"> Accredited Wildlife Trade Operation under the EPBC Act. Federal regulation requires reporting on management approach and conditions of the Wildlife Trade Operation 	<ul style="list-style-type: none"> Fishery observer program for commercial fishery Fishery-dependent long-term monitoring program to gather size/age class and sex data from all three sectors of the fishery (commercial, recreational and charter) Fishery-independent monitoring of pre-recruit snapper 	Queensland Government

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
		<ul style="list-style-type: none"> • Fishery was reviewed by the Queensland Government in 2011 by means of a Regulatory Impact Statement and new controls implemented 	
<p><i>Great Barrier Reef Marine Park Act 1975</i> and Great Barrier Reef Marine Park Regulations 1983</p>	<ul style="list-style-type: none"> • Legislative framework for managing biodiversity conservation through zoning, issuing of permits and implementing plans of management that collectively manage human activities 	<ul style="list-style-type: none"> • Regulation provides for the creation of Special Management Areas within the Marine Park • Regulation of scientific research in the Marine Park • Regulation of activities and development within the Marine Park • Regulation on the discharge of waste into the Marine Park • Penalties for non-compliance • Processes of review 	<p>Great Barrier Reef Marine Park Authority (GBRMPA)</p>
<p>Great Barrier Reef Marine Park Zoning Plan 2003</p>	<ul style="list-style-type: none"> • A multiple-use marine protected area management tool that protects biodiversity by regulating activities within the Great Barrier Reef Marine Park • The Representative Area Program provided the basis for the Zoning Plan spatial planning decisions, described 70 broadscale habitats (or bioregions), and as such provides the basis for ecosystem-based management in the Marine Park 	<ul style="list-style-type: none"> • Spatial management of activities within the Great Barrier Reef based on protection of habitat type representative areas • 34 percent of the Marine Park is dedicated as Marine National Park (green) or Preservation (pink) zones in which no extractive activities are permitted • Penalties for non-compliance • Processes of review 	<p>GBRMPA</p>
<p><i>Marine Parks Act 2004</i> (Qld) and Marine Parks Regulation 2006</p>	<ul style="list-style-type: none"> • The object of this Act is to provide for the conservation of the marine environment by: <ul style="list-style-type: none"> • declaring State marine parks • establishing zones, designated areas and highly protected areas within marine parks • developing zoning and management plans • recognising the cultural, economic, environmental and social relationships between marine parks and other areas 	<ul style="list-style-type: none"> • Aims to involve all stakeholders cooperatively • Coordination and integration with other conservation legislation • Penalties for non-compliance • Processes of review 	<p>Queensland Government</p>
<p>Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld)</p>	<ul style="list-style-type: none"> • A multiple-use marine protected area management tool that protects biodiversity by regulating activities within the Great Barrier Reef Coast Marine Park • The Representative Area Program provided the basis for Great Barrier Reef spatial planning decisions, described 70 broadscale habitats (or bioregions) and as such provides the basis for ecosystem-based management in the Great Barrier Reef Coast Marine Park 	<ul style="list-style-type: none"> • Spatial management of activities within state waters of the Great Barrier Reef based on protecting representative bioregions • Penalties for non-compliance • Complements spatial management zones and certain regulatory provisions in the Great Barrier Reef Marine Park Zoning Plan 2003 	<p>Queensland Government</p>

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
<p><i>Strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone</i></p>	<p>Assessment under the EPBC Act that provides the opportunity to achieve both conservation and planning outcomes at a much larger scale than can be reached through project-by-project assessments</p> <p>Two complimentary strategic assessments – a marine component undertaken by the GBRMPA and a coastal zone component undertaken by the Queensland Government</p>	<p>The two strategic assessments contain recommendations and inform separate Program Reports for the Great Barrier Reef Region. The Program Reports are a detailed description of the GBRMPA's and Queensland Government's management arrangements and future commitments to protect and manage matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area over the next 25 years</p>	<p>Australian and Queensland governments</p>
<p>Reef 2050 – Long-term Sustainability Plan</p>	<p>The Reef 2050 Long-term Sustainability Plan will inform future development by drawing together the marine and coastal components of the comprehensive strategic assessment, providing an over-arching framework to guide protection and management of the Great Barrier Reef World Heritage Area from 2015 to 2050</p>	<p>It will target identified areas of action from the strategic assessments and seek to address gaps for future management of the Great Barrier Reef World Heritage Area</p>	<p>Australian and Queensland governments</p>
<p>Great Barrier Reef Biodiversity Conservation Strategy 2013</p>	<ul style="list-style-type: none"> • Identifies snapper as an at-risk species in the Marine Park • Grades the level of risk experienced by snapper through a vulnerability assessment process 	<ul style="list-style-type: none"> • The strategy outlines a framework for action with three strategic objectives aimed at building or maintaining ecosystem resilience and protecting biodiversity: <ol style="list-style-type: none"> 1. Engage communities and foster stewardship 2. Building ecosystem resilience in a changing climate 3. Improved knowledge • Objectives are comprised of program-level outcomes with key actions and targets for measuring success • Implementation of the strategy will be undertaken through a multi-agency, multi-stakeholder collaborative approach 	<p>GBRMPA</p>
<p>Great Barrier Reef Climate Change Adaptation Strategy and Action Plan 2012–2017</p>	<ul style="list-style-type: none"> • Identification of specific measures to enhance resilience of the Great Barrier Reef ecosystem and support adaptation by regional communities and industries that depend on it 	<ul style="list-style-type: none"> • Allocation of dedicated funding to implement actions to improve the resilience of the Great Barrier Reef ecosystem 	<p>GBRMPA</p>
<p>Reef Water Quality Protection Plan 2013</p>	<ul style="list-style-type: none"> • An overarching framework to achieve a sustainable future for the Great Barrier Reef and industries in the Reef's catchment by improving water quality that flows into the Great Barrier Reef lagoon 	<ul style="list-style-type: none"> • Improve water quality that flows into the Reef by targeting priority outcomes, integrating industry and community initiatives, and incorporating new policy and regulatory frameworks 	<p>Joint Australian and Queensland government initiative</p>
<p>Great Barrier Reef Protection Amendment Act 2009 (Qld)</p>	<ul style="list-style-type: none"> • A framework for halving the levels of dangerous pesticides and fertilisers found in the waters 	<ul style="list-style-type: none"> • Mix of strict controls on farm chemicals and Regulations to improve farming practices 	<p>Queensland Government</p>

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
	of the Great Barrier Reef in four years		
<i>Coastal Protection and Management Act 1995</i> (Qld) and Coastal Protection and Management Regulation 2003	<ul style="list-style-type: none"> Provides the legislative framework and Regulations for the coordinated management of the diverse range of coastal resources and values in the coastal zone. This framework includes provisions that establish the Queensland Coastal Plan. 	<ul style="list-style-type: none"> Queensland Coastal Plan provides guidelines for effective protection and management of the coastal zone 	Queensland Government
<i>Sustainable Planning Act 2009</i> (Qld) and Sustainable Planning Regulation 2009	<ul style="list-style-type: none"> Establishes process for land-use planning and development assessments. Identifies state legislation that may be triggered by development assessments and the process by which developments must be assessed against each piece of legislation Establishes the framework for the development of regional plans. 	<ul style="list-style-type: none"> Coastal development generally requires impact assessment and a development approval under the <i>Sustainable Planning Act 2009</i>. Regional plans developed under the Act operate in conjunction with other state planning instruments, usually taking precedence over them Regional plans must conform to policies established within the Queensland Coastal Plan Regional plans identify: <ul style="list-style-type: none"> desired regional outcomes policies and actions for achieving these desired regional outcomes the future regional land use pattern regional infrastructure provision to service the future regional land use pattern key regional environmental, economic and cultural resources to be preserved, maintained or developed. 	Queensland Government
Queensland Coastal Plan (prepared under the <i>Coastal Protection and Management Act 1995</i>)	<ul style="list-style-type: none"> The Queensland Coastal Plan has two parts: State Policy for Coastal Management, and the Coastal Protection State Planning Regulatory Provision (following the suspension of the State Planning Policy 3/11 - Coastal Protection). 	<ul style="list-style-type: none"> Coastal activities that are not defined as development under the <i>Sustainable Planning Act 2009</i> are considered under the State policy for Coastal Management (currently under review following the change in government) The suspended State Planning Policy 3/11 provided policy direction and assessment criteria to direct land-use planning and development assessment decision making under the <i>Sustainable Planning Act 2009</i>. The Coastal Protection State Planning Regulatory Provision now offers much less specific guidance. 	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
Exposed to source of pressure (yes/no)	No	No	Yes, throughout distribution	Yes, throughout distribution	Yes, locally	Yes, regionally	Yes, locally	Yes	Yes, regionally	Yes, urban coast
Degree of exposure to source of pressure (low, medium, high, very high)	Low. There is currently no known targeting of snapper or their aggregations for any form of commercial marine tourism in the Great Barrier Reef.	Low. Defence activities are limited in extent, duration and geographic distribution. There is no known impact on snapper from defence activities in the Great Barrier Reef.	High. High exposure of snapper to both existing and potential impacts of commercial fishing in the Rocky Reef Fin Fish Fishery and the East Coast Trawl Fishery (where juveniles are incidentally captured in nursery areas, almost entirely outside the Marine Park).	Medium. Medium exposure of snapper to existing and potential impacts of recreational fishing within the Great Barrier Reef Marine Park as most of the snapper in the Marine Park occur well offshore where they are less exposed to recreational fishing pressure. Outside of the Marine Park, this stock experiences very high exposure to the impacts of recreational fishing. As the stock is a single population extending from New South Wales to Queensland,	Medium. Impacts of habitat degradation and loss of near-shore nursery and spawning habitats from ports and shipping activity is likely to increase as the need for further shipping increases within the Great Barrier Reef and throughout the stock's distribution. Local exposure to the risk of a pollution incident exists from shipping activity and could provide significant pressure if the size, location and duration of the incident correlated to present a worst-case scenario.	Low. Recreation (not fishing) activities within the Marine Park would have a low impact on snapper populations.	Low. The degree to which Indigenous groups target snapper in the Great Barrier Reef is unquantified but likely to be very low.	Very high. The northern extent of the Queensland/New South Wales snapper stock (within the Great Barrier Reef) has a very high degree of exposure to the impacts of climate change, particularly through the effects of ocean warming/changing oceanographic currents on larval dispersal and planktonic food web productivity. ²⁰ Increasing ocean acidity is predicted to impact on the regeneration and resilience of coral reef and shoal habitats that snapper rely on ¹⁹ and is expected to also reduce the productivity of some plankton species which are food sources for larval and juvenile snapper. ²⁹	High. Snapper are dependent on near-shore habitats during juvenile stages and these habitats are also used by adults during spawning aggregations.	High. Variable/alterd catchment run-off due to altered flows that result from climate change effects has the potential to impact snapper's near-shore and reefal habitats and food webs.

	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
				such pressure is bound to be affecting their abundance in the Great Barrier Reef.						
Sensitivity to source of pressure (low, medium, high, very high)	Low. There are no known commercial marine tourism activities focused around snapper; any use would be non-extractive and therefore sensitivity would be low.	Low. Defence activities are limited in extent, duration and geographic distribution and away from known aggregations ..	High. Commercial fishers can target aggregations (which are predictable spatially and temporally) to maximise catch rates of this species. Discard mortality of undersized fish captured and released may not be as high as previously thought, though to achieve 80 percent survival depends on best practice handling and release procedures being adopted. Although snapper are highly fecund, the stock has proven to be highly sensitive to the level of exposure it experiences from fishing pressure (from all sectors, including commercial fishers) under current management	High. Recreational fishers can target spawning seasons (which are predictable temporally) to maximise their catch of this species. Discard mortality of undersized fish captured and released may not be as high as previously thought, though to achieve 80 percent survival depends on best practice handling and release procedures being adopted. Although snapper are highly fecund, the stock has proven to be highly sensitive to the level of exposure it experiences from fishing pressure (from all sectors, including	Medium. Port activities are focused on geographically-discrete locations that do not necessarily correlate with snapper aggregation sites. A shipping incident could create pollution within preferred habitat of snapper within the Great Barrier Reef Marine Park. Snapper would be sensitive to the impacts of an oil or chemical spill as the stock has been reduced by fishing pressure.	Low. Any use would be non-extractive and therefore sensitivity would be low.	Low. Indigenous fishers can target aggregations (which are predictable spatially and temporally) but the level of targeted effort and harvest is likely to be very low.	High. Climate change impacts may cause a range shift in the species' distribution; there may be impacts on pelagic larval stages and changes in the distribution and abundance of prey species as a result of changing ocean currents and sea surface temperatures. ²⁹	High. Snapper are expected to be impacted most by coastal development that contributes to cumulative impacts on near-shore habitats. Cumulative impacts on near-shore nursery areas and spawning aggregation sites come from increased coastal development, climate change and declining water quality due to catchment run-off and the resultant loss and degradation of supporting habitat.	High. Declines in water quality are most noticeable in near-shore waters where this species aggregates to spawn and that provide nursery grounds for juveniles. Increased sedimentation, turbidity, decreased light, increased freshwater inflow/lower salinity and greater levels of toxins can all impact on the productivity and resilience of near-shore habitats that snapper rely on for provisioning and other ecosystem services.

	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
			controls.	recreational fishers) under current management controls.						
Adaptive capacity – natural (poor, moderate, good)	Moderate. Limited information exists on whether snapper aggregations would relocate as a result of chronic disturbance. Being a highly mobile species, snapper may be able to modify their behaviour and aggregate around new sites, if commercial marine tourism activities in the Great Barrier Reef were to create chronic disturbance to sites presently used. However, this is not expected to occur.	Moderate. Limited information exists on whether snapper aggregations would relocate as a result of chronic disturbance. If defence activities in the Great Barrier Reef were to create chronic disturbance to snapper aggregation sites their adaptive capacity to such pressure is likely to be moderate. However, this is not expected to occur.	Poor. Limited information exists on whether snapper aggregations would relocate as a result of chronic disturbance such as fishing. The current stock assessment by the Queensland Government states the snapper stock is overfished. This suggests the species has limited adaptive capacity to the current level of exposure it experiences from this pressure.	Poor. Limited information exists on whether snapper aggregations would relocate as a result of chronic disturbance such as fishing. The current stock assessment produced by the Queensland Government states the snapper stock is overfished. This suggests that the species has limited adaptive capacity to the current level of exposure it experiences from this pressure.	Poor. Limited information exists on whether snapper aggregations would relocate as a result of chronic disturbance. If ports and shipping activity was to create chronic disturbance to snapper aggregation sites their adaptive capacity to such pressure is likely to be moderate.	Moderate. Snapper form schools in order to spawn. These are numerous and spread over a very large part of their range in a reasonably unpredictable manner. It is unlikely that recreational activities would create chronic disturbance to their spawning ecology.	Poor. Limited information exists on whether snapper aggregations would relocate as a result of chronic disturbance such as fishing. Currently, Indigenous fishers can target aggregations (which are predictable spatially and temporally) to maximise catch rates but effort is considered to be very low.	Moderate. Although it is likely that the distribution and structure of the Queensland snapper population will change under predicted climate change scenarios, the species may have the capacity (for example, due to phenotypic plasticity) to adapt to some impacts. Snapper's adaptive capacity to habitat loss or degradation due to climate change impacts is likely to be limited.	Moderate. Coastal development may impact current aggregation sites and nursery grounds. However, being a highly mobile species, snapper may be able to modify their behaviour and aggregate around new sites. Cumulative impacts of fishing pressure, climate change, coastal development and declining water quality due to catchment run-off will challenge the overall adaptive capacity and resilience of snapper.	Moderate. Declines in water quality may impact current aggregation sites, nursery grounds and prey species in near-shore waters. Cumulative impacts of fishing pressure, climate change, coastal development and declining water quality due to catchment run-off will challenge the overall adaptive capacity and resilience of snapper.

	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
Adaptive capacity – management (poor, moderate, good)	Good. GBRMPA has developed best practice guidelines for tourism operators to interact with fish species in the Great Barrier Reef Marine Park. If important aggregation sites were to become threatened by commercial marine tourism activities, Special Management Areas under the Great Barrier Reef Marine Park Zoning Plan 2003 could be considered.	Good. Defence activities are well managed and limited in extent, duration and geographic distribution. Further spatial and temporal management could be considered if required.	Moderate. In 2011, an interim six-week closure was placed on the take of snapper while a regulatory impact statement was considered for this overfished stock. Since that time, further recreational input controls have been created. A minimum legal size increase, total allowable catch and protection of spawning aggregations are not being considered across the fishery. The capacity for GBRMPA to implement such controls relies on an ability to influence complex cross-jurisdictional and consultative processes. The Great Barrier Reef Marine Park Zoning Plan 2003 and the Queensland Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 provide spatial protection of habitat in the Great Barrier Reef Marine Park and	Moderate. The Queensland Government is trialling further input management controls (bag limits with size limits) for snapper within the Rocky Reef Finfish Fishery. A minimum legal size increase, total allowable catch and protection of spawning aggregations are not being considered. The capacity for GBRMPA to implement such controls relies on an ability to influence complex cross-jurisdictional and consultative processes. The Great Barrier Reef Marine Park Zoning Plan 2003 and the Queensland Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 provide spatial	Moderate. The location of ports is difficult to change because of specific requirements. Environmental impact assessments made under the EPBC Act provide a process to assess the impacts of proposed port developments and to suggest mechanisms for minimising risks. 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. Further spatial and temporal management could be considered if required.	Good. Spatial and temporal management could be considered in consultation with Traditional Owner groups if required.	Poor. Management will only be able to implement changes to address other sources of pressure to enhance ecosystem resilience, and not mitigate the impacts of climate change directly.	Moderate. The <i>Great Barrier Reef Marine Park Act 1975</i> provides limited scope to manage activities outside the Marine Park. To achieve good water quality and coastal ecosystem outcomes for the Reef, GBRMPA facilitates the development of partnerships with industry, the community, local and state government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures. It also develops and maintains a culture of mutual obligation. The aim is to achieve a broad-based and widely-accepted understanding of the diverse values, pressures, natural attributes, ecologically sustainable uses and interconnectivity between land and marine-based activities and their potential impacts on the ecological functions of the Great Barrier Reef. This is undertaken by providing input into the Queensland Coastal	Moderate. The <i>Great Barrier Reef Marine Park Act 1975</i> provides limited scope to manage activities outside the Marine Park. To achieve good water quality and coastal ecosystem outcomes for the Reef, GBRMPA facilitates the development of partnerships with industry, the community, local and state government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures. It also develops and maintains a culture of mutual obligation. The aim is to achieve a broad-based and widely-accepted understanding of the diverse values, pressures, natural attributes, ecologically sustainable uses and interconnectivity between land and marine-based activities and their

	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
			coastal waters.	protection of habitat in the Great Barrier Reef Marine Park and coastal waters.					Plan policies and statutory regional plans, which plan for coastal development in Queensland. Projected vessel traffic growth associated with coastal development projects and population growth creates greater challenges for the management of their associated impacts.	potential impacts on the ecological functions of the Great Barrier Reef. This is undertaken by fostering partnerships through the Reef Water Quality Protection Plan 2013 and Reef 2050 program.
Residual vulnerability (low, medium, high)	Low	Low	High, around aggregation sites and considering otter trawl impacts outside of the Marine Park	Medium, around aggregation sites	Medium	Low	Low	High	High	High
Level of confidence in supporting evidence (poor, moderate, good)	Poor. Knowledge of snapper ecology in relation to pressure. Good. Knowledge of current marine tourism operations.	Poor. Knowledge of snapper ecology in relation to pressure. Good. Knowledge of current Defence operations in the Marine Park.	Moderate. Allen <i>et al.</i> 2006; ⁹ Campbell <i>et al.</i> 2009 ¹	Moderate. Allen <i>et al.</i> 2006; ⁹ Campbell <i>et al.</i> 2009 ¹	Poor. Knowledge of snapper ecology in relation to pressure. Good. Knowledge of current ports and shipping operations in the Marine Park.	Poor. Knowledge of snapper ecology in relation to pressure. Good. Knowledge of current ports and shipping operations in the Marine Park.	Poor. Allen <i>et al.</i> 2006; ⁹ Campbell <i>et al.</i> 2009 ¹	Poor. Munday <i>et al.</i> 2007; ¹⁹ Sumpton <i>et al.</i> 2008; ¹² Booth <i>et al.</i> 2009; ²⁰ Steinberg <i>et al.</i> 2007 ²⁷	Poor.	Moderate. Hutchings <i>et al.</i> 2005; ³⁰ Brodie & Fabricius 2008 ³¹

The pressures addressed in this vulnerability assessment were identified in the *Great Barrier Reef Outlook Report 2014*.²¹

Coastal habitats (rivers, estuaries, seagrasses, mangroves and wetlands) are under increasing pressure from human activities. More than 85 percent of Queensland's population live on the coastal fringe. Predicted strong population growth means the intensity of activity and development in coastal zones is likely to persist.¹⁸

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

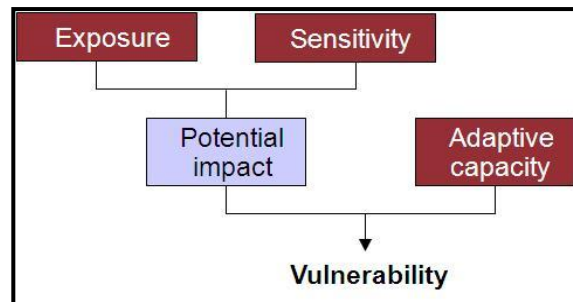


Figure 1. The key components of vulnerability assessments (Adapted from Wachenfeld *et al.*, 2007)

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^c to create a combined score for exposure and sensitivity, if an element of biodiversity has a very high level of exposure to a pressure but low sensitivity to it, it is scored as having a medium-high potential impact score. This medium-high score may be the same as determined for another assessment where there may be a low level of exposure but a very high level of sensitivity. This implies a linear relationship for the sensitivity a species or habitat has to a given level of exposure, which may not necessarily be the case. However, it does provide managers with the required level of resolution on these relationships for the purpose of the vulnerability assessments that inform the *Great Barrier Reef Biodiversity Conservation Strategy 2013*.

The natural capacity of snapper to adapt to pressures in the World Heritage Area, and the capacity of management to intervene (which in turn may assist snapper 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 snapper may be expected to experience due to the given pressure.

An explanation of the procedure by which the vulnerability assessment process (represented in Figure 1) has been applied, and qualifying statements for the assessment of exposure, sensitivity and adaptive capacity (natural and management) scores are provided within the vulnerability assessments page of the GBRMPA website.

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

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