

# A Vulnerability Assessment for the Great Barrier Reef



## Grey mackerel

Information valid as of Feb 2012

### Summary

#### Diversity

Single species – *Scomberomorus semifasciatus* (Family Scomberidae)

#### Susceptibility

Although the species is fast growing and highly fecund (high production of spawn), they form aggregations which are predictable enough (spatially and temporally) to be targeted by experienced fishers.

#### Major pressures

Commercial and recreational fishing, coastal development and catchment run-off (and various combinations of these).

#### Cumulative pressures

Grey mackerel are a species primarily associated with inshore habitats and are exposed to cumulative pressures resulting from commercial and recreational fishing, coastal development and declining water quality. If these pressures are not managed effectively they are able to act in combination and compound over time and/or when applied over the same area. They are often difficult to quantify due to the incremental nature of their effects which makes targeted management difficult. Climate change is predicted to add an additional dimension to these pressures, which are likely to impact both directly on the species and indirectly on their habitats and the availability of prey species.

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

Legislative management tools for the conservation of grey mackerel that occur in the Great Barrier Reef World Heritage Area (the World Heritage Area) include spatial

protection via the *Great Barrier Reef Marine Park Zoning Plan 2003* and *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004* (Qld) (provides complementary protection of coastal and some estuarine waters); inshore conservation areas such as the Queensland Government's Dugong Protection Areas and Fish Habitat Areas; other additional tools (refer Management table, p. 5).

#### Existing management actions

A number 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*
- Queensland Government management arrangements under the East Coast Inshore Finfish Fishery and implementation of a total allowable commercial catch (TACC) of 250 tonnes in 2009, size limits for commercial fishers (60 cm total length), size and bag limits for recreational fishers (60 cm total length and five in possession) under the *Fisheries Act 1994* (Qld)
- Addressing catchment water quality through the *Reef Water Quality Protection Plan 2009*
- The *Great Barrier Reef Biodiversity Conservation Strategy 2012* with suggested points of action for the conservation of grey mackerel as identified through the vulnerability assessment process.

#### Great Barrier Reef Outlook Report 2009 assessment

No assessment provided for this species.



Grey mackerel, *Scomberomorus semifasciatus*.  
Photo courtesy of Graham Cumming

## Vulnerability assessment: Medium, particularly the potential for localised depletion of spawning aggregations.

- Grey mackerel are sought after by commercial, recreational and Indigenous fishers.
- The minimum legal size (MLS) for retaining grey mackerel (60 cm total length (TL)) is significantly smaller than size at sexual maturity for females (65-70 cm fork length (FL)).<sup>1</sup> For males, size at sexual maturity is 55-60 cm (FL), which equates to a total length between 64 and 69.5 cm respectively.<sup>1</sup> This means that that a MLS of 60 cm TL allows for the retention of a proportion of the immature male and female population.
- Recent research indicates grey mackerel exist in two discrete populations on the east coast of Australia and there is further indication there may also be smaller meta-populations at the embayment scale. The possibility of embayment-scale meta-populations should be considered when undertaking stock assessments and the potential for localised stock depletions.
- Grey mackerel are likely to be impacted at the local level by coastal development and catchment run-off due to their dependence on coastal habitats. These impacts are closely linked with habitat loss and degradation associated with increasing coastal population, variable and extreme weather events associated with climate change and ongoing water quality issues due to catchment land-use practices.
- Anecdotal information indicates there may have been localised depletions of grey mackerel in some areas which may indicate the need to consider fishery management at the regional or local level.
- There is significant year to year variability in grey mackerel catches, which is likely to be attributed to fishery-dependent factors as well as seasonal and environmental factors, particularly rainfall variability. This may leave grey mackerel vulnerable to management arrangements that are not adaptive to seasonal or environmental variabilities.
- Climate change is recognised as a source of potential impacts for tropical coastal fish, which is likely to cause highly variable and unpredictable effects.<sup>2</sup> Grey mackerel may be a species directly affected by climate change through the effects of ocean warming on metabolic growth and development rates or indirectly via impacts on the inshore habitats and food webs they rely on (refer Key concerns, below).
- The Queensland Government determined the stock status of grey mackerel to be 'uncertain' in 2010.<sup>3,a</sup>

<sup>a</sup> The Queensland Government's determination of species stock status is updated annually and published to fulfil their annual reporting obligations.

<sup>b</sup> That is, that reflects the precautionary approach to ecosystem-based fisheries management that is provided for within the Food and Agricultural Organization of the United Nations' *Code of Conduct for Responsible Fisheries*<sup>26</sup> and as analysed by Garcia et al.(2003).<sup>27</sup>

## Suggested actions to address vulnerabilities

- The *Great Barrier Reef Outlook Report 2009*<sup>4</sup> has identified fishing of spawning aggregations is a 'high-risk' activity. It is suggested the potential impacts of targeted fishing of grey mackerel aggregations be considered in any stock assessment for the management of the species.
- Management must focus on those pressures that can be addressed such as habitat protection, reducing the remaining pressures from fishing, and implementing conservation actions for grey mackerel already at risk from other cumulative factors.
- A risk assessment for inshore biodiversity to inform priority management actions aimed at reducing the pressures experienced in these habitats would assist management of grey mackerel. The assessment needs to be informed by programs developed to better understand the cumulative impacts affecting grey mackerel (and many other species) in inshore habitats, including a better understanding of the remaining impacts of fishing and impacts of habitat loss and degradation caused by coastal development, climate change and declining water quality due to catchment run-off.
- Continue to develop management processes that engage stakeholders at a local or regional scale. Regional management arrangements provide a framework to address the varying pressures on coastal and estuarine habitats and increased fishing pressure.
- Consider regional management of stocks to address the separate and distinct management units of grey mackerel that are becoming apparent.
- Support and facilitate additional research on stock structure, catch and effort, size and age class composition of grey mackerel to inform stock assessments. Until such time, the current suite of management arrangements for grey mackerel should be regularly reviewed by fisheries management stakeholders with the degree of caution appropriate for the given level of science and information available.<sup>b</sup>
- Continue to use the latest information on the population ecology of grey mackerel to inform management when conducting assessments of port expansions and new development proposals within the World Heritage Area.
- Continue to support the Queensland Government in their on-going efforts to ensure commercial logbook data for catches of grey mackerel are validated using a fisheries-independent observer program and best practice recommendations from the *Independent review - proposed management arrangements for Queensland's East Coast Inshore Fin Fish Fishery*.<sup>5</sup>
- Work with fisheries managers and commercial fishers to better quantify discard rates and post-release mortality of grey mackerel.

## Background

### Brief description of grey mackerel

Grey mackerel (*Scomberomorus semifasciatus*, Family Scombridae), also known as broad-barred mackerel, are one of four species of small mackerel (including school, spotted and shark mackerel) that inhabit the Great Barrier Reef Marine Park (the Marine Park).<sup>6</sup> Grey mackerel have faint broad vertical bars on their flanks when dead which are much more prominent when freshly landed. However, to an inexperienced eye, it can be difficult to discriminate between grey mackerel and other small mackerels.

Grey mackerel grow rapidly, attaining a maximum size of 10 kg and 120 cm fork length (FL). Male and female fish attain sexual maturity at 55–60 cm and 65–70 cm FL respectively, at approximately two years of age.<sup>1</sup> At present, the minimum legal size (MLS) of grey mackerel is 60 cm total length (TL) and the recreational bag limit is five in possession.<sup>7</sup>

Grey mackerel are highly fecund (producing approximately 250,000 oocytes (egg cells) per spawning) and they appear to spawn repeatedly between October and February.<sup>1</sup> In areas within the far northern sector of the Marine Park there are anecdotal suggestions spawning can occur between June and September. During spawning, they often school together, and can be easily targeted by net fishing.

Grey mackerel comprise a significant part of the East Coast Inshore Fin Fish Fishery (ECIFFF). Approximately 90 to 95 per cent of the total harvest of grey mackerel is taken by the commercial sector, with the remaining five per cent taken by the recreational sector. This reflects the fact that grey mackerel, when available, are relatively easy to catch using set mesh nets but have been shown to be relatively difficult to consistently catch when angling.<sup>1</sup> Historically, most of the catch has been taken close to centres of human population, such as Cairns, Townsville, Mackay and Rockhampton.

### Geographical distribution

Grey mackerel have a restricted distribution and are confined to the waters of southern Papua New Guinea and around northern Australia from the Houtman Abrolhos Islands area on the west coast (23°30'S) to northern New South Wales on the east coast.<sup>8,9</sup>

Adult grey mackerel are known to commonly occur in turbid tropical and sub-tropical waters of approximately 3–30 m depth. This is usually in the vicinity of bottom structure in close proximity to rocky headlands and reefs (where pelagic baitfish such as tropical sardines and herrings are concentrated) and on sandy-mud and muddy-sand substrates. They rarely occur at the edge of the continental shelf to depths of 100 m.<sup>8</sup> Larval and juvenile life history stages of grey mackerel are found inshore, often in estuarine environments. The larvae of this species inhabit coastal bays and nearshore areas that are typically influenced by freshwater run-off and low salinity surface waters.<sup>10</sup>

Recent research on the parasite fauna and otolith stable isotope chemistry<sup>c</sup> of grey mackerel indicates the likely existence of at least four separate stocks across northern Australia. On the east coast there appears to be at least two stocks (a northern and southern stock),<sup>11,12</sup> with a separation between Townsville and Mackay.<sup>12</sup> Both the Newman and colleagues<sup>11</sup> study based on otolith stable isotope chemistry and Charters and colleagues<sup>12</sup> parasite fauna study found indications of further segregation of the eastern Queensland populations at the embayment scale.

### Population status in the Great Barrier Reef Marine Park

The commercial harvest of grey mackerel has fluctuated widely over the last two decades, from a low of 49 tonnes in 2000 to a high of 389 tonnes in 2008. The average catch over the period 2003 to 2008 has been 297 tonnes.<sup>13</sup> The catch per unit effort (CPUE) has also fluctuated widely, but there has been no obvious upward or downward trend. A total allowable commercial catch (TACC) of 250 tonnes was implemented in 2009<sup>7</sup> as part of a suite of revised management arrangements for the ECIFFF. The variability in grey mackerel catch is likely to be attributable to fishery-dependent factors as well as seasonal environmental factors including rainfall variability. Although the effects of habitat degradation and freshwater influence are thought to be significant, they are yet to be quantified.

In the Marine Park most grey mackerel are captured in commercial nets of a stretch mesh usually greater than 150 mm. Most grey mackerel captured in these sized nets are in excess of the length at first maturity.<sup>1</sup>

<sup>c</sup> Studies have used stable isotopes within the otolith (ear bone) carbonate of fish to delineate separate stocks or management units and thus the degree of mixing of fish populations among different areas.<sup>28,29,30,31,32,33</sup> Stable isotopes are neutral, nonradioactive variants of an element and, as a result of their slightly different atomic masses, their relative incorporation into fish otoliths can be modified by environmental conditions or biological activity (such as dietary intake).<sup>34</sup>

Fisheries Queensland assessed the stock status of grey mackerel to be 'uncertain' in 2010.<sup>3</sup> Fisheries Queensland's determination of species stock status is updated annually and published to fulfil their annual reporting obligations for the ECIFFF.

## Ecosystem role/function

Grey mackerel are mid-size, pelagic predators in tropical, coastal habitats. They feed exclusively on baitfish, such as sardines, anchovies and herring.<sup>14</sup> In some locations and at certain times of the year, they are relatively abundant. However, data relating to their ecological role and to their influence on other components of coastal ecosystems are lacking.

## 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).	<p>Grey mackerel are an important component of the Queensland East Coast Inshore Fin Fish Fishery. Capture methods are predominantly hook and line (recreational sector) and mesh net (commercial sector). Grey mackerel are regarded as an exceptional sportfish with excellent eating qualities which is reflected in the value of the species to the recreational sector. Likewise, the species' eating qualities drive its importance to the commercial sector. However, the commercial sector accounts for most of the catch (between 90 and 95 per cent), possibly illustrating the difficulty of consistently targeting the species by angling. The reported total commercial harvest of grey mackerel in the Great Barrier Reef Marine Park has averaged 297 tonnes during the period 2003-2008,<sup>13</sup> reaching a peak of almost 400 tonnes in 2008.<sup>15</sup> A total allowable commercial catch (TACC) of 250 tonnes was implemented in 2009.</p> <p>In 2002 and 2005, total recreational catch of grey mackerel was estimated to be three and 20 tonnes, respectively.<sup>16</sup></p> <p>Grey mackerel are caught by Indigenous fishers in the Marine Park, but the total catch is unknown.<sup>15,17</sup></p>
<b>Cultural services</b> (e.g. spiritual values, knowledge system, education and inspiration, recreation and aesthetic values, sense of place).	<p>The cultural importance of grey mackerel to Indigenous peoples are unknown in the mainstream though it is almost certain that they do hold significance as part of knowledge systems to some groups with sea country connections in the Marine Park.</p> <p>They are targeted and valued by commercial and recreational anglers.</p>
<b>Supporting services</b> (e.g. primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling).	<p>While there are limited data on the specific ecological role of grey mackerel, they are likely to provide nutrient cycling as secondary and tertiary level predators.</p>
<b>Regulating services</b> (e.g. invasion resistance, herbivory, seed dispersal, climate regulation, pest regulation, disease regulation, natural hazard protection, erosion regulation, water purification).	<p>The regulating services of grey mackerel within marine ecosystems are unknown; however it is likely to be low.</p>

## Pressures influencing grey mackerel in the Great Barrier Reef Marine Park

### Pressures

Grey mackerel in the Marine Park are exposed to a range of pressures including fishing, coastal development, declining water quality and climate change. These pressures act on a range of different life history stages. A more detailed description of the range of pressures that impact on grey mackerel in the Marine Park is provided in the vulnerability assessment matrix at Appendix 1.

### Vulnerability assessment matrix

The *Great Barrier Reef Outlook Report 2009*<sup>4</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, coastal development and declining water quality due to catchment run-off as the key priority issues reducing the resilience of the ecosystem.

From the *Great Barrier Reef Outlook Report 2009*<sup>4</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 future 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>18</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 grey mackerel 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 the species to reach a final assessment of the overall residual vulnerability of grey mackerel to that particular pressure. This allows for the formulation of suggested actions to minimise the impact of the pressures which grey mackerel are most vulnerable to.

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 grey mackerel

		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; state-wide	High	High	Poor	Moderate	High (around aggregation sites)	Moderate
	Recreational fishing	Yes; developing coast	High	Low	Poor	Moderate	Medium (around aggregation sites)	Moderate
	Ports and shipping	Yes; locally	Medium	Medium	Poor	Moderate	Medium	Poor
	Recreation (not fishing)	Yes; developing coast	Low	Low	Moderate	Good	Low	Poor
	Traditional use of marine resources	Yes; locally	Low	Low	Poor	Good	Low	Poor
	Climate change	Yes; Reef-wide	Very high	High (potential)	Moderate	Poor	High (potential)	Poor
	Coastal development	Yes; developing coast	High	High	Moderate	Moderate	High	Poor
	Declining water quality due to catchment run-off	Yes; developing coast	High	High	Moderate	Moderate	High	Moderate

## Key concerns

- There is some evidence larvae and juveniles are dependent on estuarine and coastal nursery habitats, and fishers report the availability of grey mackerel is correlated with freshwater flows from estuarine systems.<sup>10</sup> Thus, grey mackerel populations may be influenced by local land-use practices, stream flow regulation in river catchments and by estuary modifications associated with port developments and canal estates.
- Concern has been expressed that the abundance of grey mackerel has declined in some areas, such as around Port Douglas, reportedly due to commercial net fishing targeting spawning aggregations and the impacts this may have on local populations.
- Studies of eastern Queensland stocks of grey mackerel have investigated age and growth, size at maturity and stock structure. Nevertheless, there is limited information on their movements and both the Newman *et al.* (2010)<sup>11</sup> study based on otolith stable isotope chemistry and Charters *et al.* (2010)<sup>12</sup> parasite fauna study found indications of further segregation of the eastern Queensland populations at the embayment scale. The results suggest that localised management may need to be considered for the future sustainability of the grey mackerel stocks.<sup>12</sup> Further priorities include research on the stock structure and habitat requirements of grey mackerel at all life stages.
- Climate change is recognised as a source of potential impacts for tropical coastal fish likely to cause effects that are highly variable and unpredictable.<sup>2</sup> Grey mackerel may be a species directly affected by climate change through the effects of ocean warming, changes in rainfall patterns and acidification on pelagic larval stages or indirectly via impacts on the inshore habitats on which they rely. For example, fishes are ectotherms<sup>d</sup> and temperature changes of a few degrees celsius can influence their physiology, developmental and growth rates, reproductive performance and behaviour.<sup>2</sup> An increase in water temperature will affect the metabolic rates of fishes which could lead to starvation where their food supply becomes limited or may also reduce larval dispersal as recruitment occurs earlier as larval stage time frames decrease due to increased growth rates as a function of elevated metabolic rates.<sup>2</sup> The function of nearshore habitats may be altered as a result of predicted sea level rise<sup>19</sup> and extreme weather events may impact on the availability of habitat for juveniles and reduce food output.<sup>2</sup> These impacts will be spatially variable and highly unpredictable in relation to specific species. However, the effects of observed climate change need to be considered in combination with other cumulative and chronic pressures.

## Management of grey mackerel 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)

<sup>d</sup> An animal whose body temperature varies with the temperature of its surroundings, that is, cold blooded animals, or those who cannot regulate their body temperature (any animal except birds and mammals).

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 Programme (UNEP) – CBD Secretariat
<i>Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and Environment Protection and Biodiversity Conservation Regulations 2000</i>	<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> </ul>	<ul style="list-style-type: none"> <li>Application of 'controlled action' regulation for Matters of National Environmental Significance as required</li> <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>	Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)
<i>Guidelines for the ecologically sustainable management of fisheries - 2007</i>	<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></li> <li>Grey mackerel are caught within the East Coast Inshore Fin Fish Fishery (ECIFFF), which is a fishery managed under the <i>Queensland Fisheries Act 1994</i> with a current WTO accreditation.</li> </ul>	<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>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>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.</li> </ul>	<ul style="list-style-type: none"> <li>Minimum size limit (60 cm TL)</li> <li>Recreational possession limit - five (5)</li> <li>Total Allowable Commercial Catch of 250 tonnes</li> <li>Prescribed fishing gears and regulation on the way in which they may be used</li> <li>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</li> <li>Fish Habitat Areas help protect inshore habitats from impacts of coastal development.</li> </ul>	Queensland Government

		<p>These areas provide nursery grounds and habitat for fish species which are likely to be prey for grey mackerel and provide refugia for grey mackerel juveniles.</p> <ul style="list-style-type: none"> <li>• Compulsory logbook reporting for commercial fishers</li> <li>• Penalties for non-compliance.</li> </ul>	
East Coast Inshore Fin Fish Fishery (ECIFFF) management arrangements	<ul style="list-style-type: none"> <li>• Management arrangements are established under the <i>Fisheries Act 1994</i> (Qld) and <i>Fisheries Regulation 2008</i></li> <li>• Accredited WTO under <i>Environment Protection and Biodiversity Conservation Act 1999</i> managed by the Queensland Government</li> <li>• Commonwealth regulation requires reporting on management arrangements and conditions of the WTO through an annual status report</li> <li>• Reports on interactions with Species of Conservation Interest (SOCl). SOCI data is gathered through logbooks and the Queensland Shark Observer Program.</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>• Review of the Fishery under <i>Environment Protection and Biodiversity Conservation Act 1999</i>. Review completed February 2012. New WTO with conditions issued; valid to 2015.</li> </ul>	Queensland Government
Great Barrier Reef Marine Park Act 1975 and Great Barrier Reef Marine Park Regulations 1983	<ul style="list-style-type: none"> <li>• Legislative framework for the management of biodiversity conservation through zoning, issuing of permits and implementation of plans of management that collectively enable management of human activities.</li> </ul>	<ul style="list-style-type: none"> <li>• Regulation provides for the creation of Special Management Areas within the Marine Park</li> <li>• Regulation of scientific research in the Marine Park</li> <li>• Regulation of activities and development within the Marine Park</li> <li>• Regulation on the discharge of waste into the Marine Park</li> <li>• Penalties for non-compliance</li> <li>• Processes of review.</li> </ul>	Great Barrier Reef Marine Park Authority (GBRMPA)
Great Barrier Reef Marine Park Zoning Plan 2003	<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>• Thirty-four per cent of the Marine Park is dedicated as Marine National Park (Green) or Preservation (Pink) zones in which no extractive activities are permitted</li> <li>• Penalties for non-compliance</li> <li>• Processes of review.</li> </ul>	GBRMPA
Marine Parks Act 2004 (Qld) and Marine Parks Regulation 2006	<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 areas and highly protected areas within marine parks</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> <li>• Penalties for non-compliance</li> <li>• Processes of review.</li> </ul>	Queensland Government

	<ul style="list-style-type: none"> <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>		
<i>Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld)</i>	<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>• Complements spatial management zones and certain regulatory provisions established under the <i>Great Barrier Reef Marine Park Zoning Plan 2003</i>.</li> </ul>	Queensland Government
<i>Great Barrier Reef Biodiversity Conservation Strategy 2012</i>	<ul style="list-style-type: none"> <li>• Identifies grey mackerel as a species 'at risk' in the Marine Park</li> <li>• Grades the level of risk experienced by grey mackerel through a vulnerability assessment process.</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>	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>Reef Water Quality Protection Plan 2009</i>	<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 Great Barrier Reef lagoon.</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>	Joint Commonwealth and State of Queensland initiative
<i>Great Barrier Reef Protection Amendment Act 2009 (Qld)</i>	<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>	Queensland Government

<i>Coastal Protection and Management Act 1995 (Qld) and Coastal Protection and Management Regulation 2003</i>	<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>	Queensland Government
<i>Queensland Coastal Plan</i> (prepared under the <i>Coastal Protection and Management Act 1995</i> and includes a state planning policy under the <i>Sustainable Planning Act 2009</i> )	<ul style="list-style-type: none"> <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 criteria to direct land-use planning and development assessment decision making under the <i>Sustainable Planning Act 2009</i>.</li> </ul>	Queensland Government
<i>Sustainable Planning Act 2009 (Qld) and 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
Exposed to source of pressure (yes/no)	No	No	Yes; State-wide	Yes; developing coast predominantly south of Cooktown	Yes; locally	Yes; developing coast predominantly south of Cooktown	Yes; locally	Yes	Yes; developing coast predominantly south of Port Douglas	Yes; developing coast predominantly south of Cooktown
Degree of exposure to source of pressure (low, medium, high, very high)	Low. There is currently no known targeting of aggregation sites of grey mackerel for any form of commercial marine tourism.	Low. Defence activities are well managed and limited in extent, duration and geographic distribution.	High. High exposure of grey mackerel to both existing and potential impacts of commercial fishing in the ECIFFF.	High. High exposure for grey mackerel to both existing and potential impacts of recreational fishing.	Medium. Degree of exposure is likely to increase as the need for further shipping increases within the Great Barrier Reef..	Low. Recreational activities within the Marine Park have a low, indirect impact on grey mackerel populations	Low. Exposure exists but is yet to be quantified.	Very high. Very high degree of exposure to climate change, particularly through the effects of ocean warming and acidification on the survival of pelagic larval stages; loss and degradation of habitat due to extreme weather and sea level rise.	High. Grey mackerel are dependent on coastal foreshores, rives and estuaries for survival. Exposure to the impacts of coastal development is therefore very high.	High. Variable/altered catchment run-off due to altered flows and climate change effects has potential to impact grey mackerel.
Sensitivity to source of pressure (low, medium, high, very high)	Low. There is currently no known commercial marine tourism activities focussed around grey mackerel; 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 target aggregations (which are predictable spatially and temporally) to maximise catch rates of this species.	Low. Experienced recreational fishers can target aggregations (which are predictable spatially and temporally) to maximise their catch of this species.  However, the commercial sector accounts for most of the catch (between 90	Medium. Grey mackerel have a medium level of sensitivity to impacts from ports and shipping because they face habitat loss and degradation from port developments and diffuse pollution. Ports and shipping development may also impact on the productivity/	Low. Any use would be non-extractive and therefore sensitivity is assumed to be low.	Medium. Indigenous take of grey mackerel is likely to be low but there is the potential for localised depletion of stocks from concentrated localised fishing effort that may include traditional netting.	High. (potential). Climate change impacts may cause greater geographic confinement of stock structure due to shorter larval stages that limit dispersal as a result of elevated sea surface temperatures; and changes in the distribution and abundance of prey species as a result of changing ocean currents and sea surface	High. Grey mackerel are expected to be impacted by coastal development that contributes to cumulative impacts on near-shore habitats.	High. Declines in water quality are most noticeable in near-shore waters where this species inhabits. 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 grey mackerel rely on.

	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
				and 95 per cent), possibly illustrating the difficulty of consistently targeting the species by hook and line. This may indicate a low sensitivity to this source of pressure. Bag and size limits apply.	abundance of prey species for this species. However, ports and shipping activities are focussed around geographically-discrete locations away from known aggregations meaning impacts associated with this pressure are considered to effectively apply at the local scale.			temperatures. Extreme weather events may alter the functionality of coastal wetlands as food sources and nursery areas. <sup>20,21</sup>		
Adaptive capacity – natural  (poor, moderate, good)	Moderate. There is limited information as to whether grey mackerel aggregations would move or be able to adapt if commercial marine tourism activities were to become focussed around aggregation sites.	Moderate. There is limited information as to whether grey mackerel aggregations would move or be able to adapt if defence activities were to become focussed around aggregation sites.	Poor. Commercial fishers target aggregations (which are predictable spatially and temporally) to maximise catch rates. There is limited information on whether these aggregations move as a result of fishing disturbance.	Poor. Recreational fishers target aggregations (which are predictable spatially and temporally) to maximise their catch of this species. There is limited information on whether these aggregations move as a result of fishing disturbance.	Poor. There is limited information as to whether grey mackerel aggregations would move or be able to adapt if ports and shipping activities were to become, or found to be focussed around aggregation sites.	Moderate. Limited information exists on whether grey mackerel would move to avoid chronic disturbance caused by recreation activities. However, this is not expected to occur.	Poor. Grey mackerel are captured by Indigenous fishers. If baits are set to catch fish in habitats frequented by grey mackerel it is unlikely they will avoid them.	Moderate. Although it is possible that the distribution and structure of grey mackerel stocks will change under predicted climate change scenarios, the species may have the capacity to adapt to some impacts (may display phenotypic plasticity). Grey mackerel adaptive capacity to habitat loss or degradation due to climate change impacts is likely to be limited.	Moderate. Coastal development will impact habitat important for grey mackerel and their prey species. It is unknown whether grey mackerel have the required adaptive capacity (phenotypic plasticity) to exploit alternative prey and habitats. Their adaptive capacity to habitat loss or degradation due to coastal development impacts is likely to be limited.	Moderate. Declines in water quality will impact important habitat for grey mackerel and their prey species in near-shore waters. It is unknown whether grey mackerel have the required adaptive capacity (phenotypic plasticity) to exploit alternative prey and habitats. Their adaptive capacity to habitat loss or degradation due to declining water quality impacts is likely to be limited.

	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>Adaptive capacity – management</b> <i>(poor, moderate, good)</i>	Good. Further spatial and temporal management could be considered if required.	Good. Further spatial and temporal management could be considered if required.	Moderate. Further spatial and temporal management could be considered if scientific information and local knowledge indicate the need. Recognising the potential social and economic impacts of any proposed management actions on the viability of the fishery, the adaptive capacity of management is considered to be moderate.	Moderate. Further spatial and temporal management could be considered if scientific information and local knowledge indicate the need. Recognising the potential social and economic impacts of any proposed management actions on the viability of the fishery, the adaptive capacity of management is considered to be moderate.	Moderate. Management controls (e.g. spatial, temporal, and site-specific) can be considered. However, the location of ports are difficult to change because of specific requirements. There is also a lack of information that can provide an understanding of how cumulative impacts from coastal development, including ports and shipping, are impacting stocks of grey mackerel and their supporting habitat in the Marine Park. This information is required to support decisions on the management of ports and shipping expansion in the World Heritage Area.	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, not mitigate the impacts of climate change directly. If management actions that address other sources of pressure are implemented they do have the potential to succeed in enhancing ecosystem resilience.	Moderate. The Great Barrier Reef Marine Park Act 1975 provides limited scope to manage activities outside the Marine Park. To achieve good water quality and coastal ecosystem outcomes for the Great Barrier Reef, GBRMPA facilitates the development of partnerships with industry, the community, local and state government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures, developing and maintaining a culture of mutual obligation. This is undertaken by providing input into the Queensland Coastal 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.	Moderate. The Great Barrier Reef Marine Park Act 1975 provides limited scope to manage activities outside the Marine Park. To achieve good water quality and coastal ecosystem outcomes for the Great Barrier Reef, GBRMPA facilitates the development of partnerships with industry, the community, local and state government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures, developing and maintaining a culture of mutual obligation. This is undertaken by fostering partnerships through the <i>Reef Water Quality Protection Plan 2009</i> and <i>Reef Rescue Program</i> . The GBRMPA also provides input into environmental assessments for projects referred

	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
										under the EPBC Act.
<b>Residual vulnerability (low, medium, high)</b>	Low	Low	High (around aggregation sites)	Medium (around aggregation sites)	Medium	Low	Low	High (potential)	High	High
<b>Level of confidence in supporting evidence (poor, moderate, good)</b>	Good. Knowledge of current marine tourism operations.	Good. Knowledge of current defence operations in the Marine Park.	Moderate. Cameron and Begg 2002; <sup>1</sup> Cameron and Williams 2002. <sup>14</sup>	Moderate. Cameron and Begg 2002; <sup>1</sup> Cameron and Williams 2002. <sup>14</sup>	Good. Knowledge of current ports and shipping operations in the Marine Park.	Poor. Knowledge of grey mackerel stock structure and ecology in relation to pressure.	Moderate. Welch <i>et al.</i> , 2010. <sup>22</sup>	Poor. (species specific Munday <i>et al.</i> , 2007; <sup>21</sup> Richardson <i>et al.</i> , 2009; <sup>20</sup> Munday <i>et al.</i> 2009. <sup>2</sup>	Poor.	Moderate. Hutchings <i>et al.</i> 2005; <sup>23</sup> Brodie and Fabricius 2008. <sup>24</sup>

The pressures addressed in this Vulnerability Assessment were identified in the *Great Barrier Reef Outlook Report 2009*.<sup>4</sup>

Coastal habitats 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 or increase.<sup>25</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.

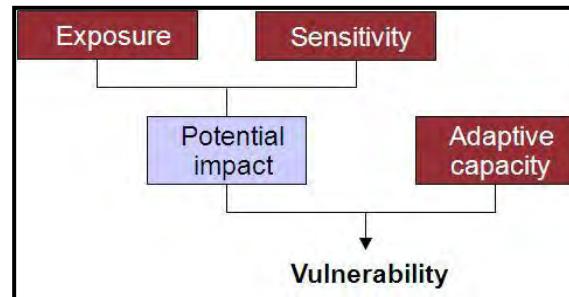


Figure 1. The key components of vulnerability assessments (Adapted from Wachenfeld *et al.*, 2007)

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

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