Australian Government
Great Barrier Reef Marine Park Authority

Threadfin salmon

Information valid as of Feb 2012

Summary

Diversity

Two species – blue threadfin (*Eleutheronema tetradactylum*) and king threadfin (*Polydactylus macrochir*), also known as blue salmon and king salmon, respectively.

Susceptibility

Life-history traits of threadfin salmon make them susceptible to a number of pressures occurring in the World Heritage Area. These traits include: being long-lived (rely on low natural mortality), late maturing (particularly for king threadfin), protandrous reproductive mode,[a] and high mortality from by-catch.

Major pressures

Commercial and recreational fishing, loss of habitats from coastal development and reduced water quality from increased catchment run-off and the combined effects of these.

Cumulative pressures

Both species of threadfin salmon are primarily found in inshore habitats and are exposed to cumulative pressures 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 within 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 exacerbate the impacts of these pressures, which are likely to impact on the species directly, on their habitats and the availability of prey species.

Blue threadfin, *Eleutheronema tetradactylum*
Photo courtesy of Graham Cumming

King threadfin, *Polydactylus macrochir.*
Photo courtesy of Graham Cumming

[a, b] Refer to brief description of threadfin salmon on page 4 of this document.

Management in the Great Barrier Reef and adjacent areas in Queensland

Legislative management tools for the conservation of threadfin salmon 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* (34 per cent of the Marine Park zoned as no-take with a further five per cent highly protected)
- *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004* (Qld) (provides complementary protection of coastal and some estuarine waters)
- Inshore habitat closures such as Fisheries Queensland Dugong Protection Areas and Fish Habitat Areas
- Specific management arrangements within the East Coast Inshore Fin Fish Fishery (ECIFFF) under the Queensland *Fisheries Act 1994* and subordinate legislation; and others (refer Management table, p. 9).

Existing management actions

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

- The joint Great Barrier Reef Marine Park Authority (GBRMPA) – Queensland Government Field Management Program that enforces spatial protection provided by the *Great Barrier Reef Marine Park Zoning Plan 2003*
- Queensland Government management arrangements under the East Coast Inshore Fin Fish Fishery, a minimum size limit of 60 cm for king threadfin and 40 cm for blue threadfin; recreational bag limit of five for king threadfin and 10 for blue threadfin
- Addressing declining catchment water quality through the *Reef Water Quality Protection Plan 2009*.

Great Barrier Reef Outlook Report 2009 assessment

No assessment provided for these species.

Vulnerability assessment: High

- Threadfin species are sought after by recreational, Indigenous and commercial fishers.
- The minimum legal size for king threadfin is smaller than reported sizes at first maturity, exposing this species to fishing pressure before it can breed as threadfins exhibit a protandrous reproductive mode.[b] This management arrangement is unlikely to be effective in protecting spawing female fish from fishing pressure.
- Considering the stock struture of blue threadfin along the east coast stock,[1] there are also indications that the minimum legal size for blue threadfin may not be sufficiently precautionary to protect a proportion of the breeding stock from harvest prior to first maturity.[1]
- Recent research using multiple methods (genetics, otolith chemistry, parasite abundance, life history and mark-recapture data) shows that threadfins can be very long lived (20+ years[1]) and exist as discrete local populations at spatial scales of less than 100 km.[1] In parts of northern Australia, king threadfin stocks are showing signs of overexploitation. These findings should be considered when undertaking stock assessments and developing management responses as intensive localised fishing pressure may have the potential to cause localised depletions in parts of their east coast range.
- Threadfins die quickly when netted, so mortality of undersized individuals as by-catch may be high. Catch records may significantly underestimate fishing mortality, due to mortality of discarded fish.
- Climate change is recognised as providing potential impacts for tropical coastal fish that are highly variable and unpredictable.[2] Threadfin salmon may be species directly affected by climate change through the effects of ocean warming and acidification on pelagic larval stages or indirectly via impacts on the inshore habitats on which, they rely (refer to the key concerns section, p. 7).
- Threadfin salmon are likely to be locally impacted by coastal development and catchment run-off due to their dependence on coastal habitats. These impacts are closely correlated with habitat loss and degradation associated with increasing coastal population, port expansions and developments, variable and extreme weather events associated with climate change and ongoing water quality issues due to catchment land-use practices.
- The Queensland Government determined the status of blue threadfin in 2010 to be 'sustainably fished' and the status of king threadfin was 'uncertain.'[3 c]

Suggested actions to address vulnerabilities

- 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 threadfins already at risk from other cumulative factors.
- Management of threadfins needs to be informed by programs developed to better understand the cumulative impacts affecting threadfins 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.

[a, b] Refer to brief description of threadfin salmon on page 4 of this document.
[c] The Queensland Government's determination of species stock status is updated annually and published to fulfil their annual reporting obligations.

- Support and facilitate additional research on stock structure, catch and effort, size and age-class composition of threadfins to inform stock assessments. Until such time, the current suite of management arrangements for threadfin salmon should be regularly reviewed by fisheries management stakeholders with the degree of caution appropriate for the given level of science and information available.[d]
- Consider regional management of stocks to address the multiple separate and distinct management units of threadfin salmon that are becoming apparent.
- Continue to develop management processes that engage stakeholders at a local or regional scale. Regional management arrangements are considered to provide a framework to address the varying pressures on coastal and estuarine habitats and increased fishing pressure.
- Validate commercial logbook data for catches of threadfin salmon using a fisheries-independent observer program in line with best practice recommendations from the *Independent review - proposed management arrangements for Queensland's East Coast Inshore Fin Fish Fishery*.[4]
- Based on the best available science, assess whether current minimum legal size limit regulations for threadfin salmon provide for sustainable management of these species.
- Develop programs to better understand the cumulative impacts affecting threadfin salmon in inshore habitats, including assessing the impacts of coastal development, climate change and declining water quality.
- Work with fisheries managers and commercial fishers to better quantify discard rates and post-release mortality of threadfin salmon.
- Continue to use the latest information on the population ecology of threadfin salmon to inform management positions concerning port expansion and development proposals within the World Heritage Area.
- Work with fisheries managers to better understand what contribution of the total catch of threadfin comes from the recreational sector.

[d] That is, it 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*[20] and as analysed by Garcia *et al.*(2003)[21]

Background

Brief description of threadfin salmon

Two species of threadfin salmon are found in the Great Barrier Reef Marine Park (the Marine Park) - the blue threadfin (*Eleutheronema tetradactylum*) and king threadfin (*Polydactylus macrochir*), also referred to as blue salmon and king salmon (respectively).[1] They are fast-growing predatory fishes that feed on small fishes, prawns and other crustaceans along sandy shores and muddy estuaries. Both species are members of the Family Polynemidae (tasselfishes) and both species are highly sought-after by commercial (net) and recreational (line) sectors of the ECIFFF and by Indigenous fishers.[1] Threadfins are often regarded as a by-product of barramundi net fishing.[5] Peak inshore harvests of king threadfin often coincide with a shift from river netting (which targets barramundi) to foreshore netting. This generally occurs in autumn as water temperatures and freshwater flows decrease.

Threadfins, although tolerant of salinity changes, are essentially marine fish. They can be caught throughout the year in river mouths and inshore habitats, and will penetrate into the uppermost tidal sections of rivers. Both species spawn in inshore waters, but do so well away from freshwater flows. Fish in spawning condition may be found inshore throughout most months of the year, but are most often encountered between late winter and early summer. The factors which influence the timing and duration of the breeding season are largely unknown, although the strength of recruitment appears to be influenced by the magnitude of wet-season freshwater flows and the associated productivity of the near-shore environment.

Depending on location, king threadfin usually grow to 60 to 80 cm total length (TL) and are 2 to 4 years old before attaining sexual maturity as males. Blue threadfin attain sexual maturity (as males) at approximately 30 cm TL or two years of age. King threadfin can live for 22 years[1] and reach 170 cm fork length (FL).[6] Blue threadfin, in contrast, can live for approximately eight years and reach 100 cm TL.[5] A protandrous reproductive mode is a characteristic of threadfins: juvenile fish mature as males and later change sex into females.[7] Blue threadfin sampled along the east coast of Queensland change sex at between 40 cm and 50 cm FL, whereas sex-change of king threadfin occurs across a broad range, with 50 per cent of females from the Fitzroy River attaining maturity at 136 cm FL, when individuals are 8.8 years old.[1] However, on the east coast king threadfin generally begin to change sex at around 100 cm when they are 6 years old.[1]

Threadfin salmon age/length at maturity (sourced from Welch *et.al.* 2010[1])

	East Coast: length at maturity - males	East coast: length/age at sex change - females
King threadfin – 60 cm TL (minimum legal size)	60 - 80 cm FL	~100 cm FL, 6 years old
Blue threadfin – 40 cm TL (minimum legal size)	30 cm FL	40 – 50 cm FL, 2.5 - 3.5 years old

Geographical distribution

The distribution of king threadfin extends throughout tropical coastal waters of Australia and New Guinea.[5] The blue threadfin is known from the same regions and throughout South-East Asia[6] and the Persian Gulf.[1]. Within Australia, king threadfin are found from Asgburton River in Western Australia to the Brisbane River on the east coast,[1] while blue threadfin extend from the Exmouth Gulf in the west to the Mary River in Queensland.[1] Threadfins are found predominantly in sandy foreshore areas and also in coastal rivers and estuaries.[5,6]

Population status in the Great Barrier Reef Marine Park

In 2009 –10, total harvest of threadfin salmon was approximately 248 tonne; comprised of 193 tonne (135 tonne of king threadfin, 152 tonne of blue threadfin and 6 tonne unspecified threadfin) from the commercial sector and 55 tonne from the recreational sector (2005 estimate).

Based on records of catch, effort and Catch Per Unit Effort (CPUE), Fisheries Queensland described the status of threadfin salmon in 2010 as follows:

> Blue threadfin: "Commercial catches and catch rates are stable since 2002. Life history characteristics are resilient to fishing pressure. There are no indications of stock declines." The overall status of blue threadfin was concluded to be 'sustainably fished.'[3]
>
> King threadfin: "No trends in commercial catches and catch rates … recent research suggests king threadfin may have highly localised populations and may be under increased fishing pressure in some areas. Sustainability reference points are not monitored at a regional level so it is not possible to determine overall catch trends or stock status at this time." The overall status of king threadfin was concluded to be 'uncertain'[3].

Recent research using multiple methods for stock discrimination (genetics, otolith chemistry, parasite abundance, life history and mark-recapture data) show that threadfins exist as discrete local populations, such that fishing pressure may have the potential to cause local stock depletions and/or removal of females.[1]

Ecosystem role/function

Threadfin salmon are mid-size, roving predators in tropical, coastal habitats. In some locations they are relatively abundant. However, data relating to their ecological role and their influence on other components of coastal ecosystems is completely lacking.

Ecosystem goods and services

Ecosystem goods and services category	Services provided by the species, taxa or habitat
Provisioning services (e.g. food, fibre, genetic resources, bio-chemicals, fresh water)	Threadfin salmon are an important component of the Queensland East Coast Inshore Fin Fish Fishery. They are highly sought-after by both recreational and commercial fishers. Capture methods are predominantly hook and line (recreational sector) and gill net (commercial sector).[5] The reported total commercial harvest of threadfins in Queensland waters has averaged 282 tonnes during the period 2002-2006[8]. The relative proportions of blue and king threadfin are approximately 57 per cent and 43 per cent respectively. Much of the commercial threadfin harvest is sold as frozen fillets or gutted whole fish and is marketed in towns and cities in Queensland. In recent years, a premium market has developed in southern states for iki-jimi iced whole fish (a quick method of killing and bleeding fish to maintain quality). The GVP (gross value of product) in the year 2009 was estimated to be $640,000. In 2005, the total recreational catch of threadfins was estimated to be 55 tonnes. Threadfins are regarded as an excellent sportfish with esteemed table qualities. Hence, threadfins are specifically targeted by some recreational fishers.[51] Threadfin salmon are caught by Indigenous fishers, but the total catch is unknown.
Cultural services (e.g. spiritual values, knowledge system, education and inspiration, recreation and aesthetic values, sense of place)	Threadfin salmon have significant cultural value to some Indigenous peoples that reside in coastal areas of Queensland. Firstly, they provide a source of food for some communities and form part of cultural obligations in the carriage of traditional knowledge, a significant part of the role between Elders and younger clan. Secondly, they exist traditionally as spiritual beings in Dreamtime stories of certain saltwater tribes.
Supporting services (e.g. primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling)	The supporting services of threadfin salmon within marine ecosystems are unknown though they are considered to contribute to nutrient cycling services as secondary and tertiary level predators.
Regulating services (e.g. invasion resistance, herbivory, seed dispersal, climate regulation, pest regulation, disease regulation, natural hazard protection, erosion regulation, water purification)	The regulating services of threadfin salmon within marine ecosystems are unknown though they are considered to contribute to the regulation of prey populations as secondary and tertiary level predators.

Pressures influencing threadfin salmon in the Great Barrier Reef Marine Park

Pressures

Threadfins in the Marine Park are exposed to a range of pressures including coastal development and declining water quality, climate change and fishing.[1,9,10,11] These pressures affect a range of different life history stages. A more detailed description of the range of pressures that impact on threadfins in the Marine Park is provided in the vulnerability assessment matrix at Appendix 1.

Vulnerability assessment matrix

The *Great Barrier Reef Outlook Report 2009*[12] identified a number of commercial and non-commercial uses of the Marine Park, along with habitat loss and degradation as a result of climate change, coastal development and declining water quality due to catchment run-off as the key pressures reducing the resilience of the ecosystem.

From the *Great Barrier Reef Outlook Report 2009*[12] 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,[13] 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 considering the level of natural adaptive capacity that threadfin salmon 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 threadfin salmon to that particular pressure. This allows for the formulation of suggested actions to minimise the impact of the pressures which threadfin salmon 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 threadfin salmon

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

Key concerns

- The Welch and colleagues' Fisheries Research and Development Corporation project highlights that "both blue and king threadfin form many discrete stocks throughout their fished range at spatial scales of less than 100 km. This spatial complexity can present challenges to management however, if ignored, can lead to overfishing and the likely collapse of less resilient stocks."[1] Welch and colleagues[1] state that the "(l)ife history traits estimated for both species among the different regions demonstrate not only that each species are capable of phenotypic plasticity, but also the variation shows that different stocks are likely to exhibit different responses to exploitation, with some more resilient than others. This alone should alert fisheries managers as to the importance of considering the stock complexity shown."
- The greater genetic diversity of east coast stocks of blue threadfins may provide them with some resilience to fishing pressure.[1]
- Given that minimum legal sizes (MLS) for king threadfin is 60 cm TL,[14] it is likely that a major proportion of the landed fish are male (50 per cent change sex to female by 100 cm FL). This size at maturity data suggests that many king threadfin will be exposed to fishing pressure before they have a chance to breed.[5] Thus, fishing may significantly reduce egg production of king threadfin. However, the effectiveness of any increase in MLS will depend strongly on the selectivity of the mesh sizes currently used in the commercial net fishery and post-release survival in both the net and line fisheries, as post-release mortality of undersize fish is likely to be very high.[5]
- Given the highly localised population structure and the very large size when they change sex, king threadfin are vulnerable to overfishing through localised depletions and/or selective removal of males before they can change sex to females.[7,1]
- For king threadfin salmon in the Gulf of Carpentaria, the Welch and colleagues study[1] shows "truncated size and age structures as well as the presence of very small females. They also show that mean size at

age has decreased over time. These are classic indicators of overharvesting having occurred whereby large mature females have been removed from stocks and in response fish are changing sex at smaller sizes and younger ages to compensate, and in doing so less energy is being used for growth." Welch and colleagues cite a number of studies that have demonstrated this for size and age at maturity and other life history traits in exploited populations and highlight the concern that these indicators may be irreversible and should be seen as early warning signals for management intervention.[1] Further research of east coast stock at appropriate spatial scales is required to determine stock structures and appropriate management interventions.

- Blue threadfin are not currently considered to be under the same level of pressure from fishing as king threadfin. On the east coast, blue threadfin change sex to females between 400 and 500 mm FL. Therefore, a proportion of the blue threadfin population in Queensland may have matured and changed sex to females before being exposed to fishing pressure at the current legal size of 400mm TL.[1] This proportion of fish would have had the opportunity to spawn before being exposed to fishing pressure.[5] The remaining proportion will not have. With spatial scales of less than 100 km likely to be defining stock structure, greater understanding of age at sex change for blue threadfins is required for east coast stocks.
- Aspects of threadin biology such as phenotypic plasticity are broadly acknowledged as being highly variable with regard to geographic location (such as size at which they change sex from male to female)[1]. For example, Welch and colleagues[1] state that for most of their Australian range the "parameters of sex change suggest that all stocks of blue threadfin not only have matured well before the current minimum legal size limit of 400 mm TL, but also have changed sex and had the opportunity to spawn as females. The exception is for the east coast stocks which change sex at significantly larger sizes than any other location. This may be a concern for managers of east coast stocks given the disproportionate contribution of large females to recruitment through more, larger and better quality eggs" (citing Berkeley *et. al.* 2004;[15] Carr and Kaufman, 2009[16]).
- Given that critical juvenile and adult habitats occur near shore, threadfin populations are likely to be influenced by local land use practices, stream flow regulation in river catchments and by estuary modifications associated with port developments and canal estates.
- Except for a few population parameters (e.g. size at maturity), little is known about the biology of threadfin salmon. In particular, there is considerable uncertainty regarding the population status of threadfins in the Marine Park. Thus, a precautionary approach to management is warranted for threadfin species in the Marine Park. In the meantime, additional research on the biology, ecological importance and habitat requirements of threadfins is required.
- Threadfin salmon die very quickly when caught in gill nets.[5] However, there is limited information on discard rates of juvenile fish and on post-release mortality. This information is required to better understand the overall impact of fishing on threadfin species.
- There is a need to manage the cumulative impacts affecting threadfins in inshore habitats. This should be incorporated into a broader risk assessment for inshore biodiversity, as the factors impacting threadfins in inshore habitats are also impacting species like marine turtles, dugong and inshore dolphins, which also rely on these habitats.

Management of threadfin salmon 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	• 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 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.	• Provides State Parties to the Convention with definitions of natural and cultural heritage, measures for the protection of natural and cultural heritage; the means of administration and obligations of the Convention; funding arrangements, educational programs and reporting obligations.	United Nations Educational, Scientific and Cultural Organization (UNESCO)

Convention on Biological Diversity (CBD)	• The three main objectives of the CBD are:
	  • 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.
		• 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 (UNEP) – CBD Secretariat

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and *Environment Protection and Biodiversity Conservation Regulations 2000*	• Legislative framework for environmental protection in Australia • The Great Barrier Reef Marine Park is one of eight matters of national environmental significance in Australia • Provides means of assessment of 'actions' (often called a proposal or project) within Australian marine and terrestrial environments that are likely to impact on a matter of national environmental significance protected under the EPBC Act • 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	• An action will require approval if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance protected under the EPBC Act. The action must be referred to the Minister and undergo an assessment and approval process • The Significant Impact Guidelines have been developed as a resource for the support of assessment and approvals process for actions • An action likely to have a significant impact on the Marine Park (including threadfin and their habitat) could be deemed to be a 'controlled action' under the EPBC Act and require a greater level of scrutiny through an environmental impact	Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)

	appropriate, the development of threat abatement plans and recovery plans.	assessment before consideration of approval • Strategic assessment is an alternative to a case-by-case approach and is considered a better way to address cumulative impacts over a landscape scale which may stem from a policy, plan or program or multiple projects providing combined impact • Assessment and export approval processes for all fisheries with an export component (or Wildlife Trade Operation). The East Coast Inshore Fin Fish Fishery managed by Fisheries Queensland has a current WTO under the EPBC Act • Penalties for non-compliance • Act is regularly reviewed.	
Guidelines for the ecologically sustainable management of fisheries -2007	• Provides guidance to the assessment of Australian fisheries that seek to operate with a Wildlife Trade Operation (WTO) accreditation under the EPBC Act • Threadfin salmon are caught within the East Coast Inshore Fin Fish Fishery (ECIFFF), which is a fishery managed under the Queensland *Fisheries Act 1994* with a current WTO accreditation.	• Fisheries under EPBC Act WTO assessment must demonstrate that they operate under a management regime that meets two principles. 1. A fishery must be conducted in a manner that does not lead to over-fishing, or for those stocks that are over-fished, the fishery must be conducted such that there is a high degree of probability the stock(s) will recover; and 2. Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.	DSEWPaC
Fisheries Act 1994 (Qld) and *Fisheries Regulation 2008*	• 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.	• Size limits (40 cm for blue threadfin; 60 cm for king threadfin) • Recreational possession limits (10 for blue salmon; five for king salmon) • Prescribed fishing gears and regulation on the way in which they may be used • 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. Theses areas provide nursery grounds and habitat for fish species which are likely to be prey for threadfin salmon and provide refugia for threadfin juveniles. • Compulsory logbook reporting for commercial fishers	Queensland Government

		• Penalties for non-compliance.	
East Coast Inshore Fin Fish Fishery (ECIFFF) management arrangements	• Management arrangements are established under the *Fisheries Act 1994* (Qld) and *Fisheries Regulation 2008* • Accredited WTO under *Environment Protection and Biodiversity Conservation Act 1999* managed by the Queensland Government • Commonwealth regulation requires reporting on management arrangements and conditions of the WTO through an annual status report • Reports on interactions with Species of Conservation Interest (SOCI). SOCI data is gathered through logbooks and the Queensland Shark Observer Program.	• Published *Guidelines for commercial operators in the East Coast Inshore Fin Fish Fishery* to provide commercial fishers with a summary of management arrangements • Review of the Fishery under *Environment Protection and Biodiversity Conservation Act 1999*. Review completed February 2012. New WTO with conditions issued; valid to 2015.	Queensland Government
Great Barrier Reef Marine Park Act 1975 and *Great Barrier Reef Marine Park Regulations 1983*	• 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.	• 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.	GBRMPA
Great Barrier Reef Marine Park Zoning Plan 2003	• A multiple-use marine protected area management tool that protects biodiversity by the regulation of activities within the Great Barrier Reef Marine Park • The Representative Area Program that provided the basis for the Zoning Plan spatial planning decisions, described 70 broad-scale habitats, or bioregions, and as such provides the basis for ecosystem-based management in the Marine Park.	• Spatial management of activities within the Great Barrier Reef based on protection of habitat type representative areas • Thirty-four per cent of the Marine Park is dedicated as Marine National Park (green) or Preservation (pink) zones in which no extractive activities are permitted • Penalties for non-compliance • Processes of review.	GBRMPA
Great Barrier Reef Biodiversity Conservation Strategy 2012	• Identifies threadfin salmon as a species 'at risk' in the Marine Park • Grades the level of risk experienced by threadfin salmon through a vulnerability assessment process.	• The Biodiversity Conservation Strategy outlines a Framework for Action with three strategic objectives aimed at building or maintaining ecosystem resilience and protecting biodiversity: 1. Engage communities and foster stewardship 2. Building ecosystem resilience in a changing climate 3. Improved knowledge • Objectives are comprised of program-level outcomes with key actions and contain targets for measuring success	GBRMPA

		• Implementing the Strategy will be undertaken through a multi-agency, multi-stakeholder collaborative approach.	
Great Barrier Reef Climate Change Action Plan 2007-2012	• Identifies specific measures to enhance resilience of the Great Barrier Reef ecosystem and support adaptation by regional communities and industries that depend on it.	• Allocation of dedicated funding to implement actions to improve the resilience of the Great Barrier Reef ecosystem.	GBRMPA
Marine Parks Act 2004 (Qld) *and Marine Parks Regulation 2006*	• The object of this Act is to provide for the conservation of the marine environment by: • declaring State marine parks • establishing zones, designated areas and highly protected areas within marine parks • developing zoning and management plans • recognising the cultural, economic, environmental and social relationships between marine parks and other areas • applying the precautionary principle.	• Aims to involve all stakeholders cooperatively • Coordination and integration with other conservation legislation • Penalties for non-compliance • Processes of review.	Queensland Government
Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld)	• A multiple-use marine protected area management tool that protects biodiversity by the regulation of activities within the Great Barrier Reef Coast Marine Park • The Representative Area Program that provided the basis for Great Barrier Reef spatial planning decisions, described 70 broad-scale habitats, or bioregions and as such provides the basis for ecosystem-based management in the Great Barrier Reef Coast Marine Park.	• Spatial management of activities within State waters of the Great Barrier Reef based on protection of representative bioregions • Penalties for non-compliance • Complements spatial management zones and certain regulatory provisions established under the *Great Barrier Reef Marine Park Zoning Plan 2003.*	Queensland Government
Reef Water Quality Protection Plan 2009	• 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.	• Improve water quality that flows into the Reef by targeting priority outcomes, integrating industry and community initiatives and incorporating new policy and regulatory frameworks.	Joint Australian Government and State of Queensland initiative
Great Barrier Reef Protection Amendment Act 2009 (Qld)	• 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.	• Mix of strict controls on farm chemicals and regulations to improve farming practices.	Queensland Government
Coastal Protection and Management Act 1995 (Qld) and *Coastal Protection and Management Regulation 2003*	• 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.	• Queensland Coastal Plan outlines directions for effective protection and management of the coastal zone.	Queensland Government
Queensland Coastal	• The Queensland Coastal Plan has two parts: State Policy for	• The State Policy for Coastal Management provides policy	Queensland

Plan (prepared under the *Coastal Protection and Management Act 1995* and includes a state planning policy under the *Sustainable Planning Act 2009*)	Coastal Management and the State Planning Policy 3/11: Coastal Protection (SPP).	direction for natural resource management decision-makers about land on the coast, such as coastal reserves, beaches, esplanades and tidal areas • The SPP provides policy direction and assessment criteria to direct land-use planning and development assessment decision making under the *Sustainable Planning Act 2009*.	Government

Sustainable Planning Act 2009 (Qld) and *Sustainable Planning Regulation 2009*	• 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.
		• Regional plans operate in conjunction with other state planning instruments, usually taking precedence over them
		• Regional plans must conform to policies established within the Queensland Coastal Plan
		• Regional plans identify:
		  • 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

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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	Yes; locally	Yes; regionally	Yes; developing coast predominantly south of Cooktown	Yes; locally	Yes; developing coast predominantly south of Cooktown	Yes; locally	Yes; state-wide	Yes; developing coast predominantly south of Cooktown	Yes; urban coast predominantly south of Cooktown
Degree of exposure to source of pressure **(low, medium, high, very high)**	Low. No commercial marine tourism activities around threadfin salmon.	Low. There is potential for exposure at Shoalwater Bay, but exposure is considered to be low.	High. High exposure of threadfin species to both existing and potential impacts of commercial fishing in the ECIFFF.	High. High risk of exposure for threadfin species 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. Impacts combine cumulatively with other pressures.	Low. Recreational activities within the Marine Park have a low, indirect impact on threadfin populations.	Low. Exposure exists but is yet to be quantified.	High. High degree of exposure to climate change, particularly through the effects of ocean warming and acidification on pelagic larval stages.	High. Threadfins depend 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 threadfins.
Sensitivity to source of pressure **(low, medium, high, very high)**	Low. There is currently no known commercial marine tourism activities focussed around threadfin salmon. Any use would be non-extractive and therefore sensitivity is assumed to be low.	Low. Defence activities are well-managed and limited in extent, duration and geographic distribution.	High. Impacts of commercial fishing may be higher than reported due to the potential for post-release mortality of discarded, undersize fish. Current methods of net fishing have poor selectivity in terms of both size and species. For both species of threadfin, particularly king threadfin, many fish are	High. Threadfin are actively targeted and captured as a valuable sport and table fish by recreational fishers. The majority of legal-sized fish captured would be retained. There is limited information on post-release mortality of under-sized fish. For both species of threadfin, particularly king threadfin, many fish are harvested from	Medium. Threadfin 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. Oil spills from a shipping incident has the potential to cause impact of very high sensitivity at stock-level scales. Ports and shipping development may also impact on the	Low. Any use would be non-extractive and therefore sensitivity is assumed to be low.	Medium. Indigenous take of threadfins 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 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.[17,18]	High. Threadfin salmon 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 threadfin salmon 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**
			harvested from the stock before they can change sex to females and reproduce.	the stock before they can change sex to females and reproduce.	productivity/ abundance of prey species for threadfins. However, ports and shipping activities are focussed around geographically-discrete locations meaning impacts associated with this pressure are considered to effectively apply at the local scale.					
Adaptive capacity – natural **(poor, moderate, good)**	Moderate. Limited information exists on whether threadfin would move to avoid chronic disturbance caused by commercial marine tourism activities. But based on stock structure, any localised impact could threaten local stocks. However, this is not expected to occur.	Moderate. Limited information exists on whether threadfin would move to avoid chronic disturbance caused by Defence activities. But based on stock structure, any localised impact could threaten local stocks.	Poor. Threadfins are unlikely to be able to modify their behaviour to avoid commercial fishing operations. This is especially true for a species that has been shown to maintain such localised stocks with limited to no inter-mixing.	Poor. Threadfins are actively targeted and captured as valuable sport and table species by recreational fishers. If baits are set to catch fish in habitats frequented by threadfin salmon it is unlikely they will avoid them. This is especially true for a species that has been shown to maintain such localised stocks with limited to no inter-mixing.	Poor. Limited information exists on whether threadfins would move to avoid chronic disturbance. If ports and shipping activity were to create chronic disturbance in habitats frequented by threadfin salmon, their adaptive capacity to respond to such pressure is likely to be poor. This is especially true for these species that have been shown to maintain localised stocks with limited to no genetic dispersal.	Moderate. Limited information exists on whether threadfin would move to avoid chronic disturbance caused by recreation activities. However, this is not expected to occur.	Poor. Threadfins are captured by Indigenous fishers. If baits are set to catch fish in habitats frequented by threadfin salmon it is unlikely they will avoid them. This is especially true for a species that has been shown to maintain such localised stocks with limited to no inter-mixing.	Moderate. Although it is possible that the distribution and structure of threadfin salmon stocks will change under predicted climate change scenarios, the species may have the capacity (for example due to phenotypic plasticity) to adapt to some impacts. Threadfin salmon's 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 threadfin salmon and their prey species. It is unknown whether threadfin 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 threadfin salmon and their prey species in near-shore waters. It is unknown whether threadfin 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**
Adaptive capacity – management **(poor, moderate, good)**	Good. GBRMPA has developed best practice guidelines for tourism operators to interact with fish species in the Marine Park. However, given that threadfin salmon are most frequently encountered in turbid, nearshore waters, it is unlikely there will be any need to manage tourism activities associated with this species.	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. A range of management controls and other input and output controls have been implemented for commercial fishers under the ECIFFF. The capacity for GBRMPA management 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 Marine Park and coastal waters.	Moderate. A range of management controls and other input and output controls have been implemented for recreational fishers under the ECIFFF. The capacity for GBRMPA management 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 Marine Park and coastal waters.	Moderate. The location of ports is difficult to change because of specific requirements. Environmental impact assessments made under the *EPBC Act 1999* 'controlled action' provisions provide a process to assess the impacts of proposed port developments. 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, not mitigate the impacts of climate change directly.	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.	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 Reef Water Quality Protection Plan and Reef Rescue Program.
Residual vulnerability **(low, medium, high)**	Low	Low	High	High	Medium	Low	Low	High (potential)	High	High

	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**
Level of confidence in supporting evidence **(poor, moderate, good)**	Good. Knowledge of current marine tourism operations. Poor. Knowledge of threadfin salmon ecology in relation to pressure.	Good. Knowledge of current Defence operations in the Marine Park. Poor. Knowledge of threadfin salmon ecology in relation to pressure.	Good. DEEDI, 2010;[3] Welch *et al.* 2002,[5] 2010[1]	Good. DEEDI, 2010;[3] Welch *et al.* 2002,[5] 2010[1]	Good. Knowledge of current ports and shipping operations in the Marine Park. Poor. Knowledge of threadfin salmon ecology in relation to pressure.	Poor.	Poor. Welch *et al.*, 2010.[1]	Moderate. Munday *et al.* 2007,[18] Richardson *et al.* 2009,[17] Munday *et al.* 2009.[2]	Poor.	Moderate. Hutchings *et al.* 2005;[9] Brodie & Fabricius 2008[11]

The pressures addressed in this Vulnerability Assessment were identified in the *Great Barrier Reef Outlook Report 2009*.[12]

* Coastal habitats (rivers, estuaries, seagrasses, mangroves and wetlands) are under increasing pressure from human activities. More than 85 per cent of Queensland's population live on the coastal fringe. Predicted strong population growth means that the intensity of activity and development in coastal zones is likely to persist.[19]

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

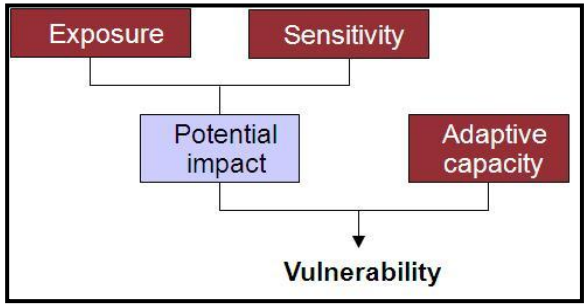

Figure 1. The key components of vulnerability assessments (Adapted from Wachenfeld *et al.*, 2007)

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

The methods used to determine the degree of exposure or sensitivity of threadfin salmons 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 threadfin salmons to adapt to pressures in the Great Barrier Reef, and the capacity of management to intervene (which in turn may assist threadfin salmons 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 threadfin salmons may be expected to experience for the given pressure. An explanation of the procedure by which this process has been applied and qualifying statements for the assessment of adaptive capacity (natural and management) scores are provided within the vulnerability assessments page of the GBRMPA website.

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