Sustainable Fisheries Strategy 2017–2027

River and Inshore Beam Trawl Fishery
Level 1 ERA Whole of Fishery Assessment

Queensland Government

Level 1 Ecological Risk Assessment
River and Inshore Beam Trawl Fishery

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Executive Summary

The *Queensland Ecological Risk Assessment Guideline* (the Guideline) was released in March 2018 as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018e). This Guideline provides an overview of the strategy being employed to develop Ecological Risk Assessments (ERAs) for Queensland's fisheries. The Guideline describes a four-stage framework consisting of a Scoping Study; a Level 1, whole of fishery qualitative assessment; a Level 2, species-specific semi-quantitative or low-data quantitative assessment and; a Level 3 quantitative assessment (if applicable).

The aim of the Level 1 ERA is to produce a broad risk profile for each fishery using a qualitative ERA method described by Astles *et al.* (2006). The method considers a range of factors including the current fishing environment (*e.g.* current catch, effort and licensing trends), limitations of the current management arrangements (*e.g.* the potential for additional effort to be transferred into areas already experiencing higher levels of fishing mortality, changing target species) and life-history constraints of the species being assessed. In the *River and Inshore Beam Trawl Fishery* (RIBTF) the Level 1 ERA examined fishing related risks in 15 broader ecological components including target & byproduct species, bycatch, marine turtles, sea snakes, crocodiles, dugongs, cetaceans, protected teleosts, batoids, sharks, syngnathids, seabirds, terrestrial mammals, marine habitats and ecosystem processes.

To construct the risk profiles, seven fishing activities (*harvesting*, *discarding*, *contact without capture*, *loss of fishing gear*, *travel to/from fishing grounds, disturbance due to presence in the area, boat maintenance and emissions*) were assigned an indicative score (*e.g.* low, intermediate, high) representing the risk posed to each ecological component. Each ecological component was then assigned a preliminary risk rating based on the highest risk score within their profile. The preliminary risk ratings are precautionary and provided an initial evaluation of the low risk elements within each fishery. As this approach has the potential to overestimate the level of risk a secondary evaluation was conducted on ecological components with higher risk ratings. This evaluation examined the key drivers of risk, their relevance to the current fishing environment and the extent that a fishery contributes to this risk. The purpose of this secondary assessment was to examine the likelihood of the risk coming to fruition over the short to medium term and minimise the number of 'false positives'.

In the RIBTF, preliminary assessments indicated that fishing activates presented a negligible, low or intermediate risk to at least ten of the ecological components (seabirds, terrestrial mammals, crocodiles, dugongs, cetaceans, protected teleosts, syngnathids, marine turtles, sea snakes and sharks). Of the remaining ecological components, target & byproduct species, bycatch and batoids were all assigned a preliminary risk rating of intermediate/high with marine habitats and ecosystem processes assigned a high risk rating. While the key drivers of risk varied with each ecological component, a limited capacity to control catch and effort (target & byproduct species), limited information on fine-scale spatial movements, poor resolution in some of the catch data and a higher potential to interact with non-target species were influential in a number of the risk profiles.

After the likelihood of the risk coming to fruition was considered, the preliminary risk ratings of nine ecological components were reduced. The most significant amendment involved marine habitats which was downgraded from high to intermediate. This reduction recognised the comparatively small footprint of the fishery, key spatial closures and the extended history of trawl fishing in the prescribed

area. The risk rating assigned to target & byproduct species was also downgraded to intermediate due to the fishery having a limited capacity to expand over time, low levels of effort reported from areas outside the T5 management region and research showing that a number of the species are being fished sustainably. Similarly, the bycatch risk rating assigned was downgraded to intermediate as the RIBTF has shorter shot times, smaller catches and reduced sorting times; all of which will help to reduce the risk posed to this ecological component.

Final risk ratings indicate that the RIBTF presents a low to moderate risk to ecological components interacting with the fishery. While the primary apparatus used in the fishery (beam trawl) has less selectivity and a higher potential to interact with non-target species, these risks are partly mitigated by the size of the fishery, regional management arrangements and the concentration of effort in south-east Queensland. Based on the results of the whole of fishery (Level 1) ERA, none of the ecological components will be progressed to a Level 2 assessment. However, the Level 1 ERA did identify key knowledge gaps in the risk profiles of some ecological components. These information needs will be progressed to the *Monitoring and Research Plan* for further consideration and include:

- Improving the level of information on catch compositions for target and non-target species with particular emphasis on multi-species catch categories, bycatch compositions and release fates.
- Improving the level of information on fine-scale effort movements and the potential for it to impact on recruitment rates for key target species in the RIBTF and other trawl fisheries.
- Quantifying the level of overlap between sectors of the ECTF (*e.g.* the RIBTF, the *Moreton Bay Trawl Fishery* and the *East Coast Otter Trawl Fishery*) and the cumulative fishing pressures exerted on key species and habitats.
- Determining the extent of the overlap between fishing effort and key SOCI habitats and its potential to influence interaction rates for key species *e.g.* estuary stingrays, protected sawfish and marine turtles in areas outside of rivers, creeks and estuaries.

Summary of the outputs from the Level 1 (whole of fishery) Ecological Risk Assessment for the River and Inshore Beam Trawl Fishery (RIBTF)

Ecological Component	Level 1 Risk Rating	Progression
Target & Byproduct	Intermediate	*Monitoring & Research Plan*
Bycatch (non-SOCC)	Intermediate	*Monitoring & Research Plan*
Species of Conservation Concern (SOCC)		
Marine turtles	Low	Not progressed further.
Sea snakes	Low/Intermediate	*Monitoring & Research Plan*
Crocodiles	Negligible	Not progressed further.
Dugongs	Low	Not progressed further.
Cetaceans	Low	Not progressed further.
Protected teleosts (SOCI only)	Low	Not progressed further.
Batoids	Intermediate	*Monitoring & Research Plan*
Sharks	Low	Not progressed further.
Syngnathids	Low	Not progressed further.
Seabirds	Negligible	Not progressed further.
Terrestrial mammal	Negligible	Not progressed further.
Marine Habitats	Intermediate	*Monitoring & Research Plan*
Ecosystem Processes	Precautionary high	Not progressed, data limitations

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Definitions & Abbreviations

Active Licence	–	The definition of an active licence is the same as that used by the Department of Agriculture and Fisheries' data reporting system. An active licence represents a licence that has reported catch and effort in the RIBTF through the logbook reporting system irrespective of the amount of catch and effort.
BRD	–	Bycatch Reduction Device.
Bycatch	–	Bycatch is the proportion of catch that is discarded due to the species' low economic value, low marketability or where regulations prohibit its retention. For the purposes of this ERA, the definition of bycatch does not include discarded target or byproduct species.
Byproduct	–	The portion of catch retained for commercial sale that was not intentionally targeted.
DAF	–	Department of Agriculture and Fisheries, Queensland Government.
Ecological Component	–	Broader assessment categories that include *Target & Byproduct* (harvested) species, *Bycatch*, *Species of Conservation Concern*, *Marine Habitats* and *Ecosystem Processes.*
ECOTF	–	East Coast Otter Trawl Fishery.
ECTF	–	East Coast Trawl Fishery. Queensland's collective trawl fishery *e.g.* the Moreton Bay Trawl Fishery, East Coast Otter Trawl Fishery and the River and Inshore Beam Trawl Fishery.
EPBC Act	–	*Environment Protection and Biodiversity Conservation Act 1999*.
ERA	–	Ecological Risk Assessment.
False positive	–	The situation where a species at low risk is incorrectly assigned a higher risk rating due to the method being used, data limitation etc. In the context of an ERA, 'false positives' are preferred over 'false negatives'.
False negative		The situation where a species at high risk is assigned a lower risk rating. When compared, false negative results are considered to be of more concern as the impacts / consequences can be more significant.
Fishery Symbol	–	The endorsement that permits a fisher to access a fishery and defines what gear can be used *i.e.* N = Net, L = line, T = trawl. The number of fishing symbols represents the maximum number of

		operators that could (theoretically) access the fishery at a single point in time.
Fishing Licence	–	Effectively a fishing platform. A Fishing Licence can have multiple symbols attached including a net (N) and line (L) fishing symbol. However, operators in the RIBTF are not permitted to line and net fish simultaneously (one or the other).
FMP	–	Fisheries Monitoring Program.
MEY	–	Maximum Economic Yield.
Offshore waters	–	Tidal waters that are at least 2m deep at low water.
Permitted Species	–	Species outlined in the *Fisheries (Commercial Fisheries) Regulation 2019* that are harvested in smaller proportions than principle species. Otherwise referred to as byproduct.
Principle Species	–	Key harvested species outlined by the *Fisheries (Commercial Fisheries) Regulation 2019,* often referred to as target species.
QBFP	–	Queensland Boating and Fisheries Patrol.
RIBTF	–	River and Inshore Beam Trawl Fishery.
SAFS	–	Status of Australian Fish Stocks.
Species of Conservation Concern (SOCC)	–	Broader risk assessment category used in the Level 1 assessments that incorporates marine turtles, sea snakes, crocodiles, dugongs, cetaceans, teleosts, batoids, sharks, seabirds, syngnathids and terrestrial mammals. These species may or may not be subject to mandatory reporting requirements through the SOCI logbook.
Species of Conservation Interest (SOCI)	–	A limited number of species subject to mandatory reporting requirements as part of the Queensland logbook reporting system. Any reference to 'SOCI' refers specifically to the SOCI logbook or data compiled from the SOCI logbook.
TACC	–	Total Allowable Commercial Catch.
Target	–	The primary species or species groups that have been selectively fished for and retained for commercial, recreational or traditional purposes.
TED	–	Turtle Excluder Device.
WTO	–	Wildlife Trade Operation.

1 Overview

The *River and Inshore Beam Trawl Fishery* (RIBTF) is one of three prawn trawl fisheries operating on the Queensland east coast. This fishery along with the *Moreton Bay Trawl Fishery* (MBTF) and *East Coast Otter Trawl Fishery* (ECOTF), form the basis of the broader *East Coast Trawl Fishery* (ECTF). When compared, the operating environment for the RIBTF differs markedly from trawl operations in Moreton Bay and in the ECOTF. The RIBTF operates under a more complex regional management system with access to key areas restricted through the use of fishery symbols.[1] The fishery also has fewer licences, uses smaller vessels and smaller gear configurations; resulting in shorter shot times, smaller catches and smaller amounts of bycatch (by weight). Due to these factors, the RIBTF is widely viewed as having a lower overall impact on target species, non-target species, and the surrounding ecosystem (Zeller, 2008; Jacobsen *et al.,* 2018).

While the RIBTF has been subject to a number of sustainability and risk-based assessments, a fishery-specific Ecological Risk Assessment (ERA) has yet to be completed for this fishery. A broader ERA was completed for trawl fishing activities outside of the Great Barrier Reef Marine Park and included the RIBTF (Jacobsen *et al.,* 2018). The bulk of this assessment though focused on the otter trawl fishery and provided limited insight into the key sources of risk within the beam trawl fishery. However, research has shown that a number of the key species including banana prawns (*Fenneropenaeus merguiensis*), greentail prawns (*Metapenaeus bennettae*) and school prawns (*Metapenaeus macleayi*) are being fished sustainably (Tanimoto *et al.,* 2006; Larcombe *et al.,* 2018; Taylor *et al.,* 2018)

In March 2018, Queensland released the *Ecological Risk Assessment Guidelines* (the Guidelines) as part of the broader *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018e). This Guideline provides an overview of the ERA strategy being employed by Queensland and includes a four-stage framework consisting of 1) a Scoping Study, 2) a Level 1, whole of fishery qualitative assessment, 3) a Level 2, species-specific semi-quantitative or low-data quantitative assessment, and 4) a Level 3 quantitative assessment (if applicable).

The following represents a broader qualitative (Level 1) assessment of the risks posed by fishing activities in the RIBTF and their potential to influence key ecological components. The Level 1 assessment follows-on from the completion of a scoping study that provides information on the current fishing environment, licencing trends and broader catch and effort analyses (Department of Agriculture and Fisheries, 2019a).

2 Focus & Intent

The risk profiles for Queensland's commercial fisheries will vary and are highly dependent on the apparatus used. For example, the risk posed by line fishing activities will be lower when compared to a net or trawl fishery. Similarly, single-species fisheries like Spanish mackerel will present a lower risk when compared to multi-species or multi-apparatus fisheries. Every fishery will have elements that present a higher risk for one or more of the ecological components *i.e.* species groupings, marine habitats and ecosystem processes that interact with the fishery. These risk elements will still be present in smaller fisheries including those where there is greater capacity to target individual species.

[1] *On 1 September 2019, new management regions were established in the East Coast Trawl Fishery. These will form part of a broader harvest strategy for the ECTF that will include regional management initiatives.*

In recognition of the above point, the primary objectives of the Level 1 assessment were to identify a) the key sources of risk within a particular fishery and b) the ecosystem components that are most likely to be affected by this risk. Used in this context, Level 1 ERAs produce outputs or risk assessments that are very fishery-specific. The inherent trade off with this approach is that risk ratings cannot be compared between fisheries as the scale, extent and impact of the risk are unlikely to be equal. They will however provide insight into the areas or fishing activities within the RIBTF that may contribute to an undesirable event for one or more of the ecological components.

In focusing on the risk within the fishery, the Level 1 ERAs will provide further insight into the level of risk each ecological component may be exposed to. In doing so, the outputs of the Level 1 assessment will determine what ecological components will progress to a finer scale assessment. Otherwise referred to as a Level 2 ERA, these assessments will focus on species, species groupings, marine habitats or ecosystem processes (if applicable) within each of the ecological subcomponents.

3 Methods

The Level 1 assessment will be used to assess risk at the whole of fishery level with the primary objective being to establish a broad risk profile for each fishery. Level 1 assessments will focus on a wide range of ecological components and will include detailed assessments for *Target & Byproduct* (harvested) species, *Bycatch*, *Species of Conservation Concern*, *Marine Habitats* and *Ecosystem Processes*.

For the purposes of this ERA, the term 'Species of Conservation Concern' (SOCC) was used instead of 'Species of Conservation Interest' as the scope of the assessment will be broader. In Queensland, the term 'Species of Conservation Interest' or SOCI refers specifically to a limited number of non-targeted species that are subject to mandatory commercial reporting requirements. The expansion of this list allows for the inclusion of non-SOCI species including those that are afforded additional legislative protections *e.g.* the listing of hammerheads as 'Conservation Dependent' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In the case of the SOCC, this ecological subgroup has been further divided into: marine turtles, sea snakes, crocodiles, dugongs, cetaceans, batoids, sharks, syngnathids, seabirds, protected teleosts and terrestrial mammals. The division of the SOCC ecological component recognises the variable life-history traits of this subgroup and the need to develop risk profiles for each complex.

Of the five ecological components, ecosystem processes represent the biggest challenge for management response as the viability of these processes will be influenced by factors outside of the control of fisheries management *e.g.* climate change, pollution, extractive use of the marine resources, and urban, port and agricultural development. From an ERA perspective, this makes it difficult to quantify the level of impact an individual fishery is having on these processes and by extension the accurate assignment of risk ratings. This problem is compounded by the fact that it is often difficult to identify measurable indicators of marine ecosystem processes (Pears *et al.,* 2012; Evans *et al.,* 2016). For example, what parameters need to be measured to determine a) if an ecosystem process is in decline, stable or improving and b) how much of this change can be attributed to fishing activities or lack thereof?

In order to refine the Level 1 ERA for ecosystem processes, a preliminary assessment was undertaken. The preliminary assessment examined the potential for a fishery to impact on 16 categories outlined in the *Great Barrier Reef Outlook Report 2014* (Great Barrier Reef Marine Park

Authority, 2014). The specific processes examined in response to fisheries related impacts were *sedimentation*, *nutrient cycling / microbial processes*, *particle feeding*, *primary production*, *herbivory*, *predation*, *bioturbation*, *detritivory*, *scavenging*, *symbiosis*, *recruitment*, *reef building*, *competition*, *connectivity*, *outbreaks of disease* and *introduced species*. Not all processes are applicable to every fishery, but all processes were considered before being eliminated. A full definition of each ecosystem process has been provided in Appendix 1.

The Level 1 ERA was modelled off of an assessment method established by Astles *et al.* (2006) and incorporates five distinct steps: *Risk Context*, *Risk Identification*, *Risk Characterisation, Likelihood* and *Issues Arising*. A brief overview of each step is provided below.

1. *Risk Context* – defines the broad parameters of the assessment including the risk that is to be analysed (*i.e.* the management objectives trying to be achieved or the nature of the undesirable events), the spatial extent of the analysis, the management regimes and the timeframes of the assessment.

2. *Risk Identification* – identifies the aspects of each fishery or the sources of risk with the potential to contribute to the occurrence of an undesirable event.

3. *Risk Characterisation* – provides an estimate (low, intermediate or high) of the likelihood that one or more of the identified sources of risk will make a substantial contribution to the occurrence of an undesirable event. Used as part of a Level 1 assessment, this stage will assign each fishing activity with an indicative risk rating representing the risk posed to each ecological component. These scores will then be use to assign each ecological component with a preliminary risk rating based on the highest risk score within the profile. In the Level 1 ERA, these preliminary risk scores will be used to identify the low-risk elements in each fishery.

4. *Likelihood* – a secondary evaluation of the key factors underpinning the preliminary risk assessments, their relevance to the current fishing environment and the potential for the fishery to contribute to this risk in the short to medium term. This step was included in recognition of the fact that preliminary scores (see *Risk Characterisation*) may overestimate the level of risk for some ecological components.

5. *Issues Arising* – examines the assigned risk levels and the issues or characteristics that contributed to the overall classifications.

The above framework differs slightly from Astles *et al.* (2006) in that it includes an additional step titled *Likelihood.* The inclusion of this additional step recognises the precautionary nature of qualitative assessments and the potential for risk levels to be overestimated in whole of fishery ERAs. This step, in effect, assesses the likelihood of the risk occurring in the current fishing environment and takes into consideration a) the key factors of influence and b) their relevance to the current fishing environment. In doing so, the *Likelihood* step helps to differentiate between **actual** and **potential** high risks. This aligns with the objectives of *Ecological Risk Assessment Guideline* (Department of Agriculture and Fisheries, 2018e) and helps limit the extent of 'false positives' or the misclassification of low risk elements as high risk.

While viewed as a higher-level assessment, the Level 1 ERA provides important information on activities driving risk in a fishery, the ecological components at risk and areas within the fisheries

management system that contribute to the risk of an undesirable event occurring. Level 1 assessments will be undertaken for all ecological components including marine habitats and ecosystem processes which have the least amount of available data. These results will be used to inform the Level 2 assessments and refine the scope of subsequent ERAs. Level 2 assessments will focus specifically on the ecological subcomponents including key species and species groupings.

Additional information on the four-staged qualitative assessment is provided in Astles *et al.* (2006) and Pears *et al.* (2012). A broad overview of the ERA strategy used in Queensland has been provided in the Queensland *Ecological Risk Assessment Guideline* (Department of Agriculture and Fisheries, 2018e).

4 Level 1 Qualitative Assessment

4.1 Risk Context

The risk context for the whole of fishery assessments has been framed at a higher level and takes into consideration the main purpose of the *Fisheries Act 1994* which is to: "*…provide for the use, conservation and enhancement of the community's fisheries resources and fish habitats in a way that seeks to: apply and balance the principles of ecologically sustainable development; and promote ecologically sustainable development."*

Consistent with this objective, the risk context for the Level 1 assessment has been defined as:

> *The potential for significant changes in the structural elements of the fishery or the likelihood that fishing activities in the River and Inshore Beam Trawl Fishery will contribute to a change to the fishery resources, fish habitats, environment, biodiversity or heritage values that is inconsistent with the objectives of the Fisheries Act 1994.*

The inclusion of 'potential' in the risk definition recognises the need to take into consideration both current and historic trends and the likelihood that a fishery may deviate from these trends in the short to medium term. The reference to 'structural elements of a fishery' largely relates to the current fishing environment and the potential for it to change over the longer term *e.g.* the potential for effort to increase under the current management arrangements, effort displacements or the ability for effort to shift between regions.

In order to frame the scope of the assessment, a 20-year period was assigned to all Level 1 assessments. That is, the likelihood that the one or more of the ecological components will experience an undesirable and unacceptable change over the next 20 years due to fishing activities in the RIBTF. In order to do this, the Level 1 assessments assume that the management arrangements for the fishery will remain the same over this 20-year period. A 20-year timeframe has previously been used in ERAs involving the East Coast Trawl Fishery (ECTF) (Pears *et al.,* 2012; Jacobsen *et al.,* 2018) and is considered to be relatively precautionary.

When reviewing the context of the Level 1 assessment, it is important to take into consideration the operational constraints of the fishery being assessed. The RIBTF is one of the smaller trawl fisheries with 50–60 active licences logging between 2000–3000 fishing days each year (Department of Agriculture and Fisheries, 2019a). This contrasts with the ECOTF where there are >300 active licences and annual effort levels regularly exceed 25,000 fishing days (Department of Agriculture and Fisheries, 2018c). As the RIBTF uses smaller gear configurations and shorter shot times (Zeller, 2008;

Jacobsen *et al.,* 2018), the fishery also has smaller catches and a lower potential for *in-situ* (within net) mortalities. However, aspects of the RIBTF management regime are simpler as operators are not required to hold effort units or use a Turtle Excluder Device (TED) whilst operating in rivers and creeks (Department of Agriculture and Fisheries, 2019a).[2]

At a whole of fishery level, the risk of the RIBTF contributing to or causing an undesirable event has declined over the last 20 years. This has been achieved through a range of management reforms that have reduced both real and potential effort including licence restructures over the 2004/05 (DEWHA / GBRMPA), 2008/09 (Moreton Bay) and 2010/11 periods, the 2008/09 latent effort review process and licence buybacks related to the introduction of net-free zones (Department of Agriculture Fisheries and Forestry, 2012; Department of Agriculture and Fisheries, 2016a; b). These processes have resulted in a 46% decline in the number of fishing symbols (T5–T9) able to access the fishery (n = 154 in 2004 *vs.* n = 83 in 2017) (Department of Agriculture and Fisheries, 2019a). From an ERA perspective, these reductions help limit the extent of any increase in fishing effort / fishing mortality over the short to medium term. This risk continues to be managed through a limited entry licensing system which prevents new authorities being issued for the fishery.

The above factors are considered to be of notable importance when attempting to understand and quantify the '*Risk Context'* for this fishery.

4.2 Risk Identification

Fishing activities are frequently subdivided into categories that identify the sources of risk or potential hazards (Astles *et al.,* 2009; Hobday *et al.,* 2011; Pears *et al.,* 2012). What constitutes a hazard can vary between ERAs and is often dependent on the specificity and scale of the assessment. For larger scale assessments, some of the more commonly used fishing activities include: harvesting, discarding, contact without capture, loss of fishing gear, travel to and from fishing grounds, disturbance due to presence in the area and boat maintenance and emissions (Table 1). The fishing activities outlined in Table 1 will provide the foundation of the risk profiles and will be used to assign preliminary risk ratings to each ecological component (see *Risk Characterisation*).

In Queensland, 'cumulative fishing pressures' has also been identified as key source of risk (Table 1). Used as part of a Level 1 assessment, the term 'cumulative fishing pressures' will examine the risk posed by Queensland's other commercial fisheries and sectors outside of the commercial fishing industry. This parameter was included in the Level 1 assessment in recognition of the fact that a number of Queensland's fisheries have multiple fishing sectors (*e.g.* commercial, recreational, and charter). This means that the risk posed to some species may be higher than what is observed in the commercial fishing sector *e.g.* species that attract a high level of interest from the recreational fishing sector.

In addition to the cumulative fishing pressures, this section will include a secondary examination of the cumulative risks that exist outside the control of fisheries management. These factors often have a wide range of contributors, are generally more complex and at times unavoidable. As a consequence, it can be difficult to assign an accurate rating to these factors or to quantify how much of a contribution (if any) a fishery will make to this risk. The primary purpose of including these factors in the Level 1

[2] Vessel tracking or the use of a VMS was not previously required for operators in the RIBTF. Under the Queensland Sustainable Fisheries Strategy 2017–2027, vessel tracking will be required on all commercial fishing boats by 2020. In the RIBTF this requirement was due to occur by 1 January 2020 (https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy/vessel-tracking)

assessment is to provide the ERA with further context on how fisheries-specific risks relate to external factors, broader risk factors that a fishery will contribute to (*e.g.* boat strike) and factors that have the potential to negatively impact on a fishery (*e.g.* climate change, the potential for urban development to affect recruitment rates).

The inclusion of cumulative impacts in the Level 1 assessment provides further context on factors that may contribute to an undesirable event. In a fisheries-based ERA it can be difficult to account for these impacts in the final risk ratings. The main reason for this is that it can be difficult to define the extent of these impacts or quantify the level of contribution they make to an overall risk; particularly in a whole of fishery assessment (*e.g.* the impact of recreational fishing / boating activities on SOCC subgroups). Given this, final risk ratings will concentrate on commercial fishing activities with cumulative impacts (when and where appropriate) identified as an additional source of risk *e.g.* for species targeted and retained by commercial, charter and recreational fishers. In the event that one or more of the ecological components are progressed to a Level 2 assessment than the cumulative impacts will be given additional considerations.

Unlike the fishing activities, ratings assigned to 'cumulative risks' will not be used in the determination of preliminary risk scores (see *Risk Characterisation*). The main reason for this is that the preliminary risk scores relate specifically to commercial fishing activities.

The following provides an overview of the key fishing activities / sources of risk in the RIBTF and for each of the respective ecological components. When and where appropriate the contributor of risk (*i.e.* the fishing activity) is also identified in the text.

Table 1*. Summary of the key fishing activities and their relation to risk. Table 1 is based on an extract from Pears et al. (2012). * Cumulative risk scores are not considered when assigning preliminary risk ratings as these values relate specifically to the commercial fishing sector.*

Sources of Risk
Harvesting: capture and retaining of marine resources for sale.
Discarding*:* returning unwanted catch to the sea. This component of the catch is landed on the deck of the boat or brought to the side of the vessel before its release and the reference is applied to all sectors *e.g.* commercial, recreational, charter.
Contact without capture: contact of any part of the fishing gear with an ecological subcomponent (species, habitats *etc.*), but which do not result in the ecological components being captured and landed on deck.
Loss of fishing gear: partial or complete loss from the boat of gear including lines, nets, ropes, floats etc.
Travel to/from grounds: steaming of boat from port to fishing grounds and return.
Disturbance due to presence in the area: other influences of boat on organisms whilst fishing activities take place (*e.g.* underwater sound disturbances).
Boat maintenance and emissions: tasks that involve fuel, oil or other engine and boat-associated products that could be accidentally spilled or leaked into the sea or air.
Cumulative fishing pressure*:* Indirect external factors, including other fisheries or fishing sectors; and non-fisheries factors that apply across fishery sectors.

4.2.1 Whole of fishery

Harvesting and **discarding** are considered to be the greatest contributors of risk in the RIBTF, with **contact without capture**, and **disturbance due to presence in the area** viewed as secondary risk factors. Given the limited spatial extent of fishing activities, relative to the prescribed fishing boundary, **boat maintenance and emissions** and **travel to/from fishing grounds** will present a lower risk in this fishery. Similarly, **loss of fishing gear** is unlikely to be a major source of risk.

Most of the impacts from beam trawling will be regionalised as the distribution of effort is restricted through regional management arrangements, spatial/temporal closures and gear restrictions (Department of Agriculture and Fisheries, 2019a). While the extent of the risk will vary, areas with higher populations will be more susceptible to cumulative fishing and non-fishing pressures *e.g.* the targeting of prawn species in adjacent trawl fisheries and the collective impact of boat strikes (and the associated risk) on regional marine megafauna populations (Department of National Parks Sports and Racing, 2010). Based on the current structure of the fishery, these risks will be most relevant to the T5 fishery which operates in south east Queensland and accounts for the majority of the beam trawl catch and effort (Department of Agriculture and Fisheries, 2019a).

Of importance, a number of the initiatives being developed, considered and/or implemented as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* are targeted at the ECTF. While otter trawl fisheries remain the primary focus, the broader risk profile of the RIBTF (including cumulative risks) will be impacted on by these reforms. These measures will take time to develop and implement; therefore will take time to filter through to the ERA process. Further information on proposals and options being considered has been provided in the *Trawl Fisheries Working Group* communiques (available at: https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy/fishery-working-groups/trawl-working-group)

4.2.2 Ecological Subcomponents

Target & Byproduct (harvested)

As the RIBTF does not operate under output controls (*e.g.* effort controls or total allowable commercial catch limits, TACC), the overharvesting of regional stocks will be the main driver of risk for these species. While **discarding** of some target and byproduct species may occur, the fishery retains smaller cohorts and has an established market for smaller prawns. Accordingly, the discarding of retainable product is not expected to be a major risk in this fishery.

The majority (95%, 1995–2017 average) of the harvested RIBTF catch consists of three species: banana prawns (*Fenneropenaeus merguiensis*), greentail prawns (*Metapenaeus bennettae*) and school prawns (*Metapenaeus macleayi*) (Department of Agriculture and Fisheries, 2019a). Of the three, only banana prawns have been the subject of a detailed stock assessment (Tanimoto *et al.,* 2006). The prioritisation of this species largely relates to its significance in the ECOTF where it is **harvested** in greater quantities (Department of Agriculture and Fisheries, 2018c). The banana prawn stock assessment indicated that exploitable biomass for this species was comparatively high (50–70% natural biomass levels; Tanimoto *et al.,* 2006). However, this study also recognised that Queensland had a number of banana prawn sub-stocks and that biomass estimates varied regionally. This variability will increase the risk that one or more of the banana prawn sub-stocks will experience an undesirable event due to cumulative trawl fishing pressures (*i.e.* RIBTF, MBTF and the ECOTF). While noting this risk, stock status evaluations indicate that the risk is being managed with banana prawns

classified as sustainably fished across all state and commonwealth management units (Larcombe *et al.*, 2018; Department of Agriculture and Fisheries, 2019a).

Data on the stock structure and the biology of the two remaining species, greentail prawns (*Metapenaeus bennettae*) and school prawns (*Metapenaeus macleayi*), is less developed. This can be partly attributed to the fact that these species are targeted by a smaller section of the ECTF and contribute less to the total prawn (beam and otter) catch (Department of Agriculture and Fisheries, 2019a). As a consequence, they have been viewed historically as lower priorities for stock assessments. School prawns are targeted across multiple jurisdictions and the species has been included in the national *Status of Australian Fish Stocks* (SAFS) process. The most recent SAFS stock status evaluation classified the species as sustainable in both Queensland and New South Wales (Taylor *et al.,* 2018). This suggests that while **harvesting** represents a high potential risk for this species, this risk is being managed effectively across jurisdictions. While greentail prawns are one of the largest catch components of the RIBTF they have not been the subject of either a stock assessment or an indicative stock status evaluation.

A proportion of the RIBTF catch (7–45% of the annual catch) is reported as 'bay prawns' and refers to a commercial size class of prawn *vs.* a particular species (Courtney *et al.,* 2012). Bay prawns is used for smaller prawn cohorts that are captured and sold as a single entity due to the impracticality of sorting them into individual species. While the compositions are likely to vary, bay prawns will include greentail prawns (*M. bennettae*), school prawns (*M. macleayi*) and to a lesser extent brown tiger prawns (*Penaeus esculentus*) and eastern king prawns (*Melicertus plebejus*) (Department of Employment Economic Development and Innovation, 2009; Courtney *et al.,* 2012). While the use of more generic categories has reduced; the fishery continues to report (by necessity) a high proportion of the catch as part of broader complexes (*i.e.* bay prawns). This makes it difficult to assess the level of exploitation each species is exposed to and the risk that one or more of the species will experience an undesirable event.

The management regime for the RIBTF does not have an overarching control mechanism for catch or effort. This contrasts with the ECOTF where licence holders operate under a well-established effort unitisation system. From an ERA perspective, this presents as a high potential risk as catch and effort can increase substantially for one or more of the species. Evidently, this risk will be present in most fisheries that rely heavily on the use of input controls. For banana prawns, this risk will likely manifest as a cumulative fishing pressure with the RIBTF contributing to the occurrence of an undesirable event for one or more of the regional sub-stocks (Tanimoto *et al.,* 2006). For greentail and school prawns, this risk relates to an inability to manage catch and effort against key reference points or biomass indicators.

When compared to prawns. the remainder of the principal species (scallops, squid and bugs other than Balmain bugs) play less of a role in the RIBTF (Department of Agriculture and Fisheries, 2019a). This is reflected in the catch data which shows that all three groups are retained in low amounts; often less than 1t per year. Similar trends were observed for the permitted (byproduct) species where the annual catch levels tend to fluctuate below 0.5t (based on 2015–2017 data; Department of Agriculture and Fisheries, 2019a). These catch figures can be partly attributed to management arrangements that restrict the take of permitted species through possession limits, minimum size limits, and/or gender or

reproductive condition restrictions (Department of Agriculture and Fisheries, 2019a)**.**[3] These measures combined with low reported catches indicate that the **harvesting** of secondary target (principal) and byproduct (permitted) species is at the lower end of the risk spectrum.

The **discarding** of retainable species is difficult to quantify but is more likely to occur when they are caught in negligible amounts (common for octopus, threadfin bream, pipefish *etc.*) and when operators are fishing in areas other than rivers and estuaries. These areas will overlap with a broader range of permitted species and may result in higher discard rates for some species *e.g.* undersized and female blue swimmer crabs (Sumpton *et al.,* 2003). As a portion of this catch will be discarded in a dead or moribund state it will contribute to the fishing mortality rates for these species (Melville-Smith *et al.,* 2001). However, shorter shot times, smaller gear configurations and smaller catch weights would help to reduce the amount of *in-situ* (within net) and post-release mortalities (Department of Employment Economic Development and Innovation, 2009).

Of the remaining fishing activities, **contact without capture** and **disturbance due to presence in the area** are the most likely contributors of risk. Risks associated with **contact without capture** relate to undocumented mortalities and injuries (*i.e.* crushing from the beam, injuries incurred while escaping though the net). **Disturbance due to presence in the area** relates to local displacement of animals as the trawl gear progresses through the water column. In both instances, there is a low probability of these activities causing an undesirable event for the harvest species ecological component.

Bycatch (non-SOCC)

When compared to the ECOTF, the RIBTF uses smaller nets, has shorter shot times and has smaller overall catches (by weight). These factors help mitigate some of the key risks identified in the ECOTF including the extent of *in-situ* and post release mortalities for non-target species (Pears *et al.*, 2012; Jacobsen *et al.*, 2018). Bycatch species in the RIBTF will experience shorter fishing events, reduced catch sorting times and are less likely to be crushed under the weight of large catches (Department of Employment Economic Development and Innovation, 2009). The fishery will also interact with a lower diversity of bycatch species; particularly in riverine and creek systems. Despite this, the capture of non-target species remains an issue for the RIBTF and from an ERA perspective is considered to be one of the more notable risks associated with this fishery.

Beam trawling provides few avoidance strategies to reduce the incidental catch of non-harvested or unwanted species. Since the introduction of the Turtle Excluder Device (TED) and Bycatch Reduction Devices (BRD), bycatch volumes across trawl fisheries have reduced considerably; particularly for marine megafauna (Robins, 1995; Robins & Mayer, 1998; Brewer *et al.*, 2006; Pears *et al.*, 2012). In the beam trawl fishery, all operations must use a BRD when operating in rivers, creeks and inshore environments. When fishing in areas outside of rivers and creeks where marine megafauna interactions are more likely, operators must also use a TED (Department of Agriculture and Fisheries, 2019a).

Information on bycatch compositions from the RIBTF is limited as the majority of monitoring and research has focused on the ECOTF (*e.g.* Courtney *et al.,* 2007a; Courtney *et al.,* 2007b; Campbell *et al.,* 2017). Fishery observer reports from the T5 fishery recorded a 4:1 ratio of retained catch to bycatch (Department of Employment Economic Development and Innovation, 2009) and species

[3] *Threadfin bream and cuttlefish are the only permitted species complexes with no output controls in the ECTF (Department of Agriculture and Fisheries, 2019b).*

compositions consisted mostly of small fish, crabs and unmarketable penaeid prawns (Department of Employment Economic Development and Innovation, 2009). Similar catch to bycatch ratios and bycatch characterisation are expected throughout the fishery; albeit with regional variability in species compositions. For example, species compositions for beam trawlers operating in rivers and creeks will differ from those operating in inshore waters (Department of Employment Economic Development and Innovation, 2009; 2011).

Little current information exists on the composition of fin fish species caught as bycatch the RIBTF. However, some insight can be obtained from historical catch records and surveys of adjacent fisheries. Prior to the introduction of the *East Coast (Trawl) Management Plan 1999*, RIBTF operators were permitted to retain both regulated and non-regulated fin fish species (Department of Employment Economic Development and Innovation, 2009).[4] Catch data from this period shows that the fishery harvested a variety of fin fish including flathead, whiting, bream, mullet and several species targeted in other fisheries or by the recreational fishing sector (Robins & Courtney, 1998; Department of Agriculture and Fisheries, 2019a). As the dynamics of the fishery have not changed significantly, DAF anticipates that these species still account for a high proportion of the RIBTF bycatch. Surveys carried out for the Queensland Banana Prawn Fishery (inclusive of otter trawlers) found that teleost bycatch included (in descending percentage of bycatch) croaker, whiting, sole, perch, queenfish, threadfin, mackerel and cod (Stobutzki *et al.,* 1996).

Direct and post-release mortality of bycatch in beam trawlers will vary between species, trawl area, trawl method (shot time, gear size *etc.*) and catch size. Research on the fate of bycatch in beam trawl fisheries is limited and often pre-dates the introduction of BRDs (Lindeboom & de Groot, 1998; Reid, 1998; Robins & Courtney, 1998). This research indicated that mortality rates are higher in smaller species including fish (Lindeboom & de Groot, 1998). This finding is consistent with more recent research examining mortality rates in trawl bycatch (Broadhurst *et al.,* 2006; Courtney *et al.,* 2007b)**.**

The risk posed to non-SOCC bycatch will be dependent on a range of factors but is still considered a relatively high risk for this fishery. This assessment is largely based on the indiscriminate nature of trawl fishing and the potential for beam trawl operators to interact with a range of target and non-target species. While this assessment is counter-balanced by comparisons with the ECOTF, the capture of non-target species is considered to be one of the more notable risks within this fishery.

Species of Conservation Concern

Licence holders in the RIBTF have reported interactions with a small range of SOCI since the introduction of the compulsory logbook (Department of Agriculture and Fisheries, 2019a). While the reports are spread across a small number of species (*e.g.* sea snakes, marine turtles and a whale), the data is dominated by sea snake interactions (98%). Fate information submitted as part of the SOCI logbook indicate that the vast majority (>99%) of these animals were released alive (Department of Agriculture and Fisheries, 2019a).

As the fishery operates in estuarine, inshore and inter-tidal waters, the fishery will interact with more components of the expanded 'Species of Conservation Concern (SOCC) ecological component. As these species cannot be retained for sale in the ECTF, ***discarding*** is considered to be the largest risk

[4] *Until the introduction of the East Coast (Trawl) Management Plan 1999, T5–T9 licences were permitted to retain any regulated or non-regulated fish caught. Some teleost catch continued to be reported from the fishery after 1999 under transitional management arrangements which included the introduction of new logbook reporting requirements.*

factor for this ecological component. Secondary factors including ***contact without capture*** and ***disturbance due to presence in the area*** will make a smaller contribution to the overall level of risk. These risks mostly relate to the robustness of the gear, the active nature of the fishing activity and the potential for interactions to go unobserved. This includes animals that are excluded from the net due to the BRD or TED and animals that interact with the beam but are not landed.

Marine Turtles

Marine turtles (hawksbill, loggerhead, green and unspecified) made up less than 2% (*n* = 11) of the SOCI interactions recorded from the RIBTF from 2003 to 2017 (Department of Agriculture and Fisheries, 2019a). The low number of interactions can be attributed to the fishery operating in habitats not preferred by marine turtles (*i.e.* creeks and rivers) and the mandated use of TEDs when operating in waters outside rivers and creeks. This inference is supported by data collected as part of a previous Fisheries Observer Program which failed to record a single marine turtle interaction in the fishery (Zeller, 2008). However, TEDs have proven to be highly effective at excluding marine turtles from the trawl catch (Robins, 1995; Robins & Mayer, 1998; Brewer *et al.*, 2006; Pears *et al.*, 2012) and interaction rates may be higher in this fishery. The extent of these interactions will be difficult to quantify as most animals will enter and escape the net without detection (**contact without capture**). While noting this potential, DAF anticipates that interaction rates will remain low given the comparatively small overlap between the key fishing areas and preferred habitats of marine turtles.

Data supplied through SOCI logbooks indicate that all but one of the landed marine turtles were released alive. As the SOCI data only provides an evaluation of the animal's health at the time of its release (**discarding**), post-release mortalities are still possible. Quantifying post-release mortalities in a marine environment is difficult but they are more likely to occur when a turtle cannot access the surface for an extended period of time or if it receives injuries (internal and external) during the trawl event. For individuals that interact with the fishery, the risk of injury and mortalities will be higher for turtles that are retained in the codend and landed on board the vessel. In the RIBTF, this risk will be partly mitigated through shorter shot times and the use of TEDs in areas where the interaction potential is higher (Zeller, 2008; Courtney *et al.,* 2010). In the unlikely event that one or more of the turtles died after their release due to these injuries, the long-term implications would be offset by the low number of interactions.

At a whole of fishery level, the RIBTF was assessed as presenting low to intermediate risk of contributing to an undesirable event for marine turtles. This risk rating is considered to be precautionary in nature and takes into account a) the potential for the fishery to interact with the species complex in inshore waters and b) the potential for interactions to go unreported (**contact without capture**). Importantly, these risks continue to be managed through a combination of operational constraints (*e.g.* short shot times, low catch volumes) and the use of TEDs. There is potential for the risk rating to be reduced further with the introduction of *Vessel Tracking* and an improved understanding of the distribution of RIBTF effort in inshore waters (Department of Agriculture and Fisheries, 2018b).

Dugongs

There are no reports of dugongs interacting with the RIBTF in the SOCI logbook data or from the Fisheries Observer Program (Zeller, 2008). As the majority of RIBTF effort does not occur in environments preferred by this species (clearer water environments) including their feeding grounds (Department of the Environment, 2018), the fishery is not expected to interact with this subgroup.

The use of the trawl apparatus in the RIBTF will increase the level of marine disturbance within a fished area often experiencing increased sediment resuspension, increased turbidity and disruption of benthic communities (**disturbance due to presence in the area**). For dugongs, the main concern is that a trawl event will impact (directly or indirectly) on key habitats; namely seagrass beds. While noting this risk, there is little evidence that RIBTF operations actively operate in areas with large amounts of seagrass and/or in key dugong feeding grounds. Legislation governing the use of marine resources in the Morton Bay and Great Sandy Marine Parks further restricts trawl fishing in key dugong habitats.

Given the above considerations and the low likelihood of a RIBTF interacting with a dugong, the risk posed to this subgroup is anticipated to be low.

Cetaceans

There is a single record of a whale interacting with the RIBTF in the SOCI logbook data and no reports from the FOP data (Department of Agriculture and Fisheries, 2019a). The reported interaction was most likely a boat strike (as opposed to incidental capture in the trawl net) and was recorded as a live release. As the majority of RIBTF effort does not occur in environments preferred by cetaceans (offshore waters), it is highly unlikely that the fishery would cause an undesirable event for these species. Accordingly, this subgroup has been assigned a low risk rating for the purposes of this ERA.

Batoids

Elasmobranch interactions are higher in the ECOTF and there is greater potential for mortalities to occur in this fishery. As a consequence, the majority of research on elasmobranch bycatch centres on this aspect of the ECTF (Courtney *et al.,* 2007b; Kyne *et al.,* 2007; Campbell *et al.,* 2018). However, the RIBTF overlaps with a range of benthic batoids and this subgroup will be susceptible to capture in this fishery.

The majority of batoid interactions in the RIBTF will occur when fishers are operating in areas outside of rivers and creeks. These areas have a higher diversity of elasmobranch fauna and fishers may encounter a range of batoids including stingrays (*Family Dasyatidae*), shovelnose rays (*Family Rhinobatidae*) and guitarfish (*Family Rhynchobatidae*) (Last *et al.,* 2016). The extent of batoid interactions and by extension the risk of undesirable event occurring will reduce as the fishery progresses further into riverine and creek systems. With that said, there is limited information in the literature to support either inference or to verify the extent of batoid interactions (low, medium or high). Similarly, the distribution of some species may extend into brackish waters where there are higher levels of effort.

More broadly, the introduction of BRDs and TEDs has had a notable effect on the amount of bycatch that is caught in trawl fisheries along the Queensland coastline. While not mandated for use across the RIBTF, operators must use a TED when operating in waters outside of rivers and creeks where marine megafauna interactions are more likely. For batoids, research has shown that TEDs are effective at preventing larger rays from entering the cod-end (Stobutzki *et al.,* 2001; Stobutzki *et al.,* 2002; Brewer *et al.,* 2006). Due to their size, smaller individuals can still slip through a TED and will experience higher mortality rates once captured in the cod-end (Stobutzki *et al.,* 2001; Brewer *et al.,* 2006; Kyne *et al.,* 2007). It is noted though that the RIBTF has shorter shot times and smaller catches; both of which will help reduce the number of *in-situ* (within net) mortalities.

While batoid mortalities will be lower in the RIBTF, some animals will incur injuries during the trawl event. These injuries will most likely occur during their initial capture, during the net retrieval / catch sorting process (**discarding**) or due to interactions with the TED or the beam trawl (**contact without capture**). In other instances, this complex may experience more direct injuries or mortalities *e.g.* during the net setting process or being struck with the trawl shoe (Lindeboom & de Groot, 1998). The risk of batoid sustaining an injury during the trawl event will be higher and, depending on the size of the animal and the origin of the injury, may contribute to number of post-release mortalities.

At a finer scale, sawfish (*Family Pristidae*) are one of the few elasmobranch families afforded full protection in Queensland waters. Sawfish distributions have contracted through time and populations on the Queensland east coast (for some species) may now be extirpated; particularly in central and southern Queensland (Carlson & Smith, 2013; D'Anastasi *et al.*, 2013). Given this contraction and the distribution of beam trawl effort, this complex is not expected to interact with a high proportion of the RIBTF. If a sawfish were to interact with the RIBTF it would mostly likely occur in the T8 and T9 fisheries where there is less effort and fewer licences (Department of Agriculture and Fisheries, 2019a). If a sawfish were to interact with a beam trawl, the risk of injury would be higher due to the morphology of the rostrum and an increased potential for entanglements. As these species have already experienced notable population declines, there is some potential for the RIBTF to contribute to the overall level of risk. The extent of this risk would be highly dependent on the species, the level of interaction and the release fate of the animal.

Manta rays[5] are the only other batoid group afforded full protection under fisheries legislation and a number of devil rays (*Family Mobulidae*) are classified as 'no-take' in the Great Barrier Reef Marine Park. While the geographical distribution of these species overlap with parts of the RIBTF, it is unlikely that this fishery will interact with this complex with great frequency.

Of note, the estuary stingray (*Hemitrygon fluviorum*) is not classified as a SOCI but is listed as 'Near Threatened' under the *Nature Conservation Act 2006*. This listing is linked with declining habitats; although their capture as bycatch in New South Wales and Queensland has been identified as key source of risk (Kyne *et al.,* 2016). The estuary stingray is commonly associated with shallow-inshore waters and frequently occurs in mangrove fringed rivers and estuaries. As these habits overlap with the preferred fishing grounds, there is a higher potential for this species to be caught in the RIBTF. This species though is not subject to any additional reporting requirements and there is limited data of its catch in Queensland waters.

At a whole of fishery level the batoid subgroup were considered to be at intermediate risk within the RIBTF. This risk rating was influenced by an absence of catch data, higher potential for the fishery to interact with these species in inshore waters and an increased potential for interactions to occur around key habitats and feeding grounds *e.g.* mangrove lined rivers and estuaries. At a species-specific level, the level of risk will vary and may decline with additional information on catch and effort trends. One species, the estuary stingray, may present as a higher risk as fishing activities in the RIBTF would contribute to the cumulative pressures exerted on this species.

[5] *A recent review of the Family Mobulidae (devil rays) reclassified the genus 'manta' as a synonym of the genus 'Mobula' (Last et al., 2016).*

Sharks

Historical data for the RIBTF includes a small component of shark catch (Department of Agriculture and Fisheries, 2019a). While the data has poor species resolution, this portion of the catch is likely to consist of smaller benthic species and juvenile whalers that are more common in intertidal waters.

Of the species with additional protections, few have geographical ranges or habitat preferences that overlap with the RIBTF. The speartooth shark (*Glyphis glyphis*) lives in riverine/estuarine environments and the species has a fragmented distribution in north Queensland. Information on the abundance and distribution of the speartooth shark is limited and the species has not been reported from commercial fisheries operating on the Queensland east coast. The rarity of *G. glyphis* would contribute to an absence of catch data with research suggesting that population numbers for the species are low (Pogonoski & Pollard, 2003; Stevens *et al.*, 2005). Based on known distributions, interactions with the RIBTF are considered to be unlikely and (if applicable) would be restricted to the low-effort T9 fishing area (Department of Agriculture and Fisheries, 2019a).

Distributional data indicates that the RIBTF will not interact with the remaining shark species afforded full protection in Queensland waters including the great white shark (*Carcharodon carcharias*), the grey nuse shark (*Carcharias taurus*) and the sand tiger shark (*Odontaspis ferox*) (Last & Stevens, 2009). Similarly, the RIBTF is not expected to interact with shark species afforded additional protections in the Great Barrier Reef Marine Park (GBRMP) *e.g.* the short fin mako (*Isurus oxyrinchus*).

The benefits of using TEDs in inshore waters will be similar to that observed for batoids (Stobutzki *et al.,* 2001; Stobutzki *et al.,* 2002; Brewer *et al.,* 2006). While the majority of larger sharks will be excluded from the catch, smaller individuals or benthic species may pass through the TED and into the cod-end (**discarding**). In these instances, DAF anticipates that the majority of the animals will be released alive. As operators in rivers and creeks do not utilise a TED, there is an increased risk that larger sharks will be caught in the net including the bull shark (*Carcharhinus leucas*) or the pigeye (*C. amboinensis*) shark. In these instances the short shot times would assist in minimising *in-situ* and post release mortalities. The risk of injuries through **contact without capture** would still be present. These impacts though are unlikely to have a long-term or detrimental impact on the regional shark populations.

Sharks as a complex are considered to be at a low to intermediate risk of experiencing an undesirable event as a result of fishing activities in the RIBTF. As with batoids, this assessment is precautionary and based on the need to improve catch data for the fishery including on species composition and interaction rates. For some species and areas of the fishery, this risk rating will represent an overestimate and it is likely that the (overall) risk rating for this subgroup will decline with increasing data. This includes information on interaction rates which are expected to be comparatively low but cannot be confirmed through direct validation/observation.

Protected teleosts

There are four species of teleost with SOCI reporting requirements: the humphead Maori wrasse (*Cheilinus undulatus*), the potato rockcod (*Epinephelus tukula*), the Queensland groper (*E. lanceolatus*) and barramundi cod (*Chromileptes altivelis*). No interactions with these species have been reported through the SOCI logbooks or through historical catch data for the RIBTF (Department of Agriculture and Fisheries, 2019a). However, a small number of Queensland groper have been

reported from the mud and blue swimmer fishery. As sectors of this fishery operate in similar environments, this suggests that there is some potential for this species to interact with the RIBTF. Despite this potential, interactions with protected (SOCI) teleosts will be low and it is unlikely to represent a significant long-term sustainability risk to these species.

Sea snakes

Of the subgroups included in the SOCC ecological component, sea snakes have the highest interaction rates in the RIBTF. Catch data obtained through the SOCI logbooks shows considerable within year variability with the fishery reporting between 0–294 interactions each year between 2003 and 2017 (average 58 interactions per year) (Department of Agriculture and Fisheries, 2019a). Separate research on the incidental capture of sea snakes in trawl fisheries provides a more accurate assessment for the RIBTF; quantifying interaction rates at around 1.2 animals per boat day fished (Courtney *et al.,* 2010).

The SOCI data revealed that more than 99% of the sea snake interactions in the RIBTF ended with the animal being released alive. This data is supported by research on sea snake – trawl interactions which identified beam trawls as having the lowest rates of within-trawl mortality (Courtney *et al.,* 2010). These results indicate that sea snakes caught in a beam trawl nets have a high probability of surviving the fishing event. As with most bycatch species, this factor can be largely attributed to the fishery having shorter shot times (Courtney *et al.,* 2010), smaller catches and reduced catch sorting times.

While based on a separate sector of the ECTF, the use of a fisheye and square mesh codend BRD in the ECOTF reduced sea snake catch rates by 60–63% in the red-spot king prawn fishery (Courtney *et al.,* 2010). These results were the catalyst for regulatory changes which limited the type of BRDs permitted for use in certain areas of the ECTF (Business Queensland, 2016). Both the fisheye and square mesh codend BRD are permitted for use in the RIBTF and their use may help to minimise the number of snakes being landed (**contact without capture**). Regulating their use in this sector though may not be warranted given the short shot times and the low levels of mortality. The use of a square mesh codend in the RIBTF may also result in an unacceptable loss of retainable product (*i.e.* smaller prawns).

At recent effort levels, the RIBTF is likely to pose a lower risk to this subgroup despite the fishery having higher interaction rates. This risk is currently management through the operational constraints of the fishery and bycatch mitigation measures. Going forward, the ability of the fishery to monitor and manage this risk will continue to improve as aspects of the *Queensland Sustainable Fisheries Strategy 2017–2027* come into effect *e.g.* the expansion of the *Vessel Tracking* or electronic monitoring. Should direct or indirect mortality rates increase (*e.g.* change in gear or fishing methods), the risk to sea snakes within this fishery may require further assessment.

Syngnathids

Catch data indicates that operators in the RIBTF are unlikely to have significant interactions with syngnathids (seahorses, pipefish and seadragons). No interactions have been reported in the SOCI logbook and there are no reports of the species in the FOP data (Zeller, 2008). While operators are able to retain some pipefish, harvest records disclose that just over a one kilogram has been retained in the fishery since 1988—Duncker's (<1 kg in 2016) and pallid pipehorses (<1 kg in 2016) (Department of Agriculture and Fisheries, 2019a).

Syngnathids tend to aggregate in lower densities and in environments with vertical heterogeneity (Connolly *et al.*, 2001; Caldwell & Vincent, 2013). This means that they tend to inhabit areas less conducive to beam trawl fishing. In a previous Fisheries Monitoring Program (FMP) for syngnathids, it was discovered that the majority of specimens were caught by trawlers at depths of 60–64 metres (Dodt, 2005). The key target species in the RIBTF, banana, greentail, and school prawns, are caught by beam trawl nets at depths much shallower than this (Department of Employment Economic Development and Innovation, 2011).

Due to the lack of habitat overlap with the fishing area and the low levels of interactions, fishing activities in the RIBTF will present as a lower risk for this subgroup.

Crocodiles

Only one interaction with a crocodile has been reported from the RIBTF and the habitat range for both species (*Crocodylus porosus* and *C. johnsoni*) has limited overlap with high effort areas. In the unlikely event that a crocodile is caught in a beam trawl it will most likely occur in the low effort T8 and T9 fishing areas (Read *et al.*, 2004; Australian Museum, 2018; Department of Agriculture and Fisheries, 2019a). Based on the distribution of the two species, the key fishing grounds and the number of interactions, the RIBTF is not expected to have a significant or long-term impact on crocodile populations in north-eastern Australia.

Seabirds

When compared to other subgroups in the SOCC ecological component, seabirds will be at the lower end of the risk spectrum. A single interaction with a tern has been recorded from the fishery since 2003 (Department of Agriculture and Fisheries, 2019a) and total interactions are not expected to increase significantly in the near future.

Terrestrial mammals

The false water rat, *Xeromys myoides*, is a small mammal that inhabits and feeds in intertidal environments. This native rodent is not truly aquatic and lacks the ability to swim (Department of the Environment and Energy, 2003; 2018); therefore it will not interact with a beam trawl while in operation.

Marine Habitats

Demersal trawling activities have a significant amount of contact with the substrate and the benthic communities which inhabit them (**disturbance due to presence in the area**) (Sciberras *et al.,* 2018). Beam trawling activities flatten sediment, remove ripples, expose shell fragments (Lindeboom & de Groot, 1998; Kaiser *et al.*, 2002) and have the ability to penetrate up to 30mm into the benthos depending on the type of substrate (de Groot, 1984). These factors increase the risk that biogenic structures and shallow benthic infauna will be removed, dislodged, or damaged (**disturbance due to presence in the area, contact without capture**). Physical modifications (tracks) from beam trawl gear can last up to 52 hours depending on the sediment and gear type, but impacts on benthic organisms can be more significant and more long lasting (de Groot, 1984; Lindeboom & de Groot, 1998). Sediment resuspension caused by trawl fishing can locally increase turbidity, release nutrients and contaminants form the sediments into the water column, and smother feeding/respiratory organs of fauna (Duplisea *et al.,* 2001; Kaiser *et al.,* 2002).

Infaunal organisms are highly influential elements in marine habitats, playing important roles in bioturbation, building burrows, creating feeding voids and irrigating sediments (François *et al.,* 2001). This not only creates physical complexity, but alters chemical conditions and transports solutes between water and sediment (Aller & Aller, 1998). Removal of fish which contribute to biogenic processes such as creating burrows or pits in the sand can be important for epifaunal communities to colonise (Coleman & Williams, 2002). Topographic complexity has significant relationships with fish biomass (Luckhurst & Luckhurst, 1978; Roberts & Ormond, 1987).

The nature of trawl fishing and its potential to directly impact marine habitats will present as a higher risk in this fishery (Robins & Courtney, 1998). When compared to the ECOTF, these impacts will be on a smaller scale and more relevant to regional habitats (Sciberras *et al.,* 2018). The extent of these impacts will be constrained by the size of the fishery and regional management arrangements (*e.g.* spatial closures) that restrict beam trawl effort to flat, sandy or muddy substrate with a long history of trawl fishing. Within these regions, species assemblages will experience a higher degree of natural disturbance and in some areas reduced water quality. To this extent, these assemblages are expected to more resilient to the effects of trawl fishing.

While noting the above, the nature of the fishery and its potential to directly impact marine habitats will present as a higher risk for this fishery. This risk however is not limited to the RIBTF, with disturbance to marine habitats regularly identified as a high risk in a range of trawl fisheries including the ECOTF (Pears *et al.,* 2012).

Ecosystem Processes

Of the ecosystem processes considered as part of the Level 1 assessment (Appendix 1), the most significant risks will be associated with the removal of product from the system, the discarding of non-target species and the impact of the fishery on shallow water habitats.

Penaeids are important elements for marine food webs and their removal from natural systems may impact a range of ecosystem processes including in detritivory, scavenging, herbivory and predation (Department of Primary Industries and Regional Development, 2013). As penaeids feed on decaying organic matter, they play an important role for nutrient recycling, in addition to being a part of the ecosystem's nutrient biomass. Prawns also serve as an important food source for a diverse range of predators including fish, cephalopods, crustaceans, jellyfish, batoids and seabirds (Dall *et al.,* 1991). These ecosystem processes will be impacted on by fishing activities in the RIBTF due to type and size of the species being harvested. Bioturbation, recruitment, connectivity, and outbreaks of disease on the other hand are likely to be at a lower risk range (Appendix 1).

Key fishing areas of the RIBTF (*e.g.* inshore areas and mangrove-lined estuaries) are frequently classified as important nursery areas for penaeids along with an abundance of other species (Vance *et al.,* 1990; Primavera, 1998; Manson *et al.,* 2005). The targeting of smaller prawns combined with the potential impacts on marine habitats in these areas may have an effect on recruitment rates. In the broader context of Queensland's fisheries, these risks will be more relevant to species targeted in multiple trawl sectors.

While the majority of non-targeted species are returned to the water, there is a higher probability of animals sustaining injuries, experiencing significant levels of stress, or dying as a result of their interaction with the RIBTF (Lindeboom & de Groot, 1998; Broadhurst *et al.*, 2006). Determining the level of impact on regional ecosystems is difficult to quantify; although scavenging is likely to be the

ecosystem process most effected. Other ecosystem processes that may be impacted on by the RIBTF includes predation, competition, outbreaks in disease, and bioturbation based on the demersal and epibenthic species.

On account of the active nature of the fishing activity and the degree of contact with benthos, it is unsurprising that **disturbance due to presence in the area** poses the greatest risk to elements of the marine ecosystem. Higher range risks pertain to processes associated with benthos, including sedimentation, bioturbation, and primary production[6], as direct contact from beam trawl gear is very likely to impact on these environments. Intermediate risks pertain to trophic-related components such as nutrient cycling, particle feeding, herbivory, and detritivory, linking to the mortality of benthic invertebrates that specialise in these roles (Hutchings, 1990; Poiner *et al.,* 1998; Kaiser *et al.,* 2002; Broadhurst *et al.,* 2006) (Appendix 1).

4.3 Cumulative Impacts

A significant portion of fisheries-based ERAs are dedicated to understanding the potential impacts and risks posed by commercial fishing activities. There will however be a range of factors that contribute to an ecological component experiencing an undesirable event including the presence and size of other fishing sectors, broader environmental trends and operations that are not managed within the fisheries framework.

For the purpose of this assessment, the cumulative impacts section has been subdivided into '*Fisheries Related Impacts*' and *'External Risks'*. The inclusion of *Fisheries Related Impacts* as a cumulative fishing pressure reflects the fact that most of Queensland's fisheries have multiple sectors *e.g.* commercial, recreational, charter. These sectors, for the most part, are managed alongside the commercial fishery and are subject to management regimes managed by the Department of Agriculture and Fisheries (DAF). The inclusion of *Fisheries Related Impacts* in the *Risk Characterisation* process reflects DAF's ability to mitigate potential risks through the broader management structure.

The establishment of a secondary cumulative risks category, *External Risks*, recognises that there are factors outside the control of DAF that have the potential to contribute to an undesirable event occurring for one or more of the ecological components. These risks represent an accumulation of issues or activities that span across stakeholders, fisheries and often state and federal management bodies. Of those that are identified, fishing activities are considered to be a contributing factor but are unlikely to be the primary source of risk and/or cannot simply be resolved through a fisheries context *e.g.* climate change.

External Risks are addressed in Queensland through a wide variety of forums and by various departments. Given the wide-ranging nature of these risks, these risks will not be addressed directly within Queensland's ERA framework. They have however been included in the Level 1 assessment as they have the potential to either impact on fishery (*i.e.* pose a risk to the fishery) or are a factor that the fishery contributes to (*i.e.* risks posed by the fishery). When and where appropriate, the Queensland Government will contribute to these discussions including (among others) participating in the *Reef Plan 2050* process, broader management reform initiatives, national plans of action and recovery

[6] Although beam trawling generally does not spatially overlap with areas of primary production (e.g. seagrass beds), this risk refers to the disturbance of the benthos which prevents the establishment and growth of primary producers including sea grass, cyanobacteria, macroalgae, and semi-aquatic flora.

strategies. In these instances, DAF will continue to participate and represent the fishing interests of the State.

4.3.1 Fisheries Related Impacts

For shared ecosystem subcomponents, fishing pressures originating from the ECOTF contribute more to the cumulative risk ratings. For example, over 70% of the total banana, greentail and school prawn catch (2015–2017) was retained for sale in the ECOTF[7] (**harvesting**) (Department of Agriculture and Fisheries, 2019b). This difference has been recognised in previous assessments and highlights a potential for RIBTF-specific risks to be overshadowed by other fisheries (Jacobsen *et al.,* 2018). From a risk management perspective, it also shows that the RIBTF is more likely to be a contributor of risk *verse* the main driver of risk.

The RIBTF and ECOTF have a degree of commonality in respect to their general bycatch compositions *e.g.* smaller teleost species, non-targeted invertebrates and key SOCC subgroups (**discarding**). As the two ECTF sectors target the same species contiguously, it is likely that a number of the non-target species are caught as bycatch in both. The ECOTF will again be the major source of risk for a number of these species; although the RIBTF will still contribute to the overall risk levels. The potential for this risk to translate to an undesirable event due to trawl fishing activates will be dependent on a range of factors including post-interaction survival rates, the resilience of the species and other risk factors like harvest levels in non-commercial fisheries.

The cumulative impacts of trawl fishing (otter and beam) on marine habitats will be most relevant to inshore areas where the two sectors target the same species (**disturbance due to presence in the area**). These habitats often experience higher disturbance and (in most instances) have a notable history of trawl fishing. Given this, it is highly likely that these areas have already experienced a depletion in abundance and species richness (Sciberras *et al.,* 2018) due to several decades of repetitive trawling. The risk going forward is that species diversity at the margins of the fished areas will decline over time due to the cumulative fishing pressures of both the RIBTF and ECOTF. At this point in time, it is difficult to quantify the extent of this risk as there is limited information on the level of overlap (none, low, medium, high) between beam and otter trawl effort. This issue is being rectified through the *Queensland Sustainable Fisheries Strategy 2017–2027* and the use of an expanded *Vessel Tracking* system (Department of Agriculture and Fisheries, 2017; 2018b).

Recreational fishers targeting prawns are legally required to use different gear (cast nets and small mesh seine nets only) and have possession limits of 10L (Department of Agriculture and Fisheries, 2018d). Although these limits apply, recreational prawn catch is not routinely reported and the majority of information is obtained through voluntary recreational fisher surveys. The *2013–14 Statewide Recreational Fishing Survey* revealed that Queenslanders retained over 2 million prawns (**harvesting**), discarding less than 3% of the total recreational catch (Webley *et al.,* 2015). The high proportion of retained catch in the recreational sector means that some of the harvesting related impacts (refer to *Ecological Subcomponents; Target & Byproduct (harvested)* above) will apply to this sector. Given that statewide annual recreational catch of prawns is likely to be around 6t (2005 data; Department of Employment Economic Development and Innovation, 2011), the impact of this sector on targeted prawn species will be lower than the commercial sectors.

[7] *Largest by harvest weight and GVP (Department of Agriculture and Fisheries, 2018d)*

Risks relating to the harvest of RIBTF species by Aboriginal peoples and Torres Strait Islander peoples is more difficult to assess as there is less information on catch and effort rates. Gear restrictions for this sector may be less stringent and take into account the importance of traditional fishing rights. Traditional fishing catch and effort rates have yet to be quantified and the level of overlap with key species is relatively unknown. At a whole of fishery level, catch and effort from Aboriginal peoples and Torres Strait Islander peoples will (most likely) present as a lower risk for a number of the ecological components including harvested species, bycatch and marine habitats because of lower numbers. This risk though will be highly dependent on the species and their significance to this sector.

4.3.2 External Risks

Urban Development & Changes in Land Use

Penaeids, among a multitude of other species, are reliant on inshore estuary and mangrove habitats during their early life stage/s (Vance *et al.,* 1990; Primavera, 1998; Manson *et al.,* 2005). Some habitat locations are highly susceptible to urban development but both the source and extent of the associated risk may vary. In some instances, the impact of urban development will have a direct and immediate impact on the RIBTF & the natural resources that support it. For example, a 2014 buyback of licences in the T5 fishing area was directly related to the repatriation of fished grounds to accommodate new infrastructure; namely the expansion of the Port of Brisbane. In other instances, the impacts may not be as evident or immediate and will be more difficult to measure and demonstrate *e.g.* long-term impacts on prawn recruitment rates.

Clearing natural habitats (*i.e.* vegetation and bar removal, dredging *etc.*) to build marine infrastructure (*i.e.* navigable channels, marinas, seawalls, and ports) has the potential modify local and regional biodiversity, cause habitat fragmentation, and modify natural patterns for dispersal species such as penaeids, (Bulleri & Chapman, 2010). Alteration of natural hydrology can be the result of the construction of artificial systems, and can impact on marine life by changing flow rates, salinity, and sedimentation levels in tidal waters (Ball *et al.,* 2006; Queensland Government, 2016). Examples of this type of development include the construction of dams, flood mitigation gates, concrete drains and gutters, and infilling of wetlands for urban development (Queensland Government, 2016). All of the above examples can pose a risk to the RIBTF through the loss of fishing grounds, the degradation of key habitats and the disruptions of recruitment events.

Excavation of land is a problem for catchments and marine habitats because of the extensive presence of acid sulphate soils along the Queensland coastline. Sulphuric acid and heavy metal run-off from disturbed soils are known to have detrimental impacts on plants such as mangrove forest die-off, and mass fish and invertebrate kills (Queensland Government, 2016). Anthropogenic pollution such as herbicides, pesticides, and oil, are known to have adverse effects on the physiology of marine organisms and biodiversity of species assemblages, (Reylea, 2005; Rhind, 2009; National Oceanic and Atmospheric Administration, 2018).

Other sources of urban development within the state include sand mining, aquaculture infrastructure, energy infrastructure (gas, electricity, water pipelines/dams), increased recreational activities (Department of Environment Water Heritage and the Arts, 2009). It is difficult to quantify the impact urban infrastructure development has on the RIBTF as the source and severity vary between regions. Nonetheless, alienation of supporting coastal habitats and adjacent stream catchments due to urban

and infrastructure development is a factor that will continue to exert influence on this fishery and depending on location, may (in parts) present a larger risk to key ecological components than the fishery itself.

Marine Debris & Pollutants

While loss of gear is less of an issue in the RIBTF, discarded, abandoned and lost fishing gear from commercial and recreational fishing is an ongoing issue within the marine environment. Nylon fishing mesh and line is resistant to biological decomposition making it a persistent entanglement hazard for marine life. Plastic particulate debris is a significant problem for marine ecosystem health. In addition to fishing activities, plastic debris originates from tourism, both land and sea based, land based runoff and shipping (Bergmann *et al.,* 2015). Discarded fishing line, and other plastic debris eventually degrade into microplastics, which are easily ingested by many species, including species harvested for human consumption. Microplastics are highly mobile and able to interact with species from all trophic levels (Bergmann *et al.,* 2015).

Discharge of garbage from a marine vessel is illegal in all Australian waters. However, boating causes the discharge of a number of pollutants. The major pollution sources associated with recreational and small to medium fishing vessels is fuel and oil. Although, antifouling paints, exhaust fumes including greenhouse gases and Polycyclic Aromatic Hydrocarbons (PAHs), and heavy metals are also released into the marine environment through boating activities (Burgin & Hardiman, 2011). Many of these pollutants are bioaccumulative, *i.e.* they build up in the environment due to their persistence. Discarding and loss of fishing related debris also occur in this fishery. This includes both deliberate and incidental release. Aside from lost fishing gear, the most significant sources of fishing related marine debris are bait bags and cigarette butts, and food packaging (Byrnes *et al.,* 2016).

Farming, particularly sugarcane and grazing, and urban development are the largest contributors to land based runoff. Excess nutrients, fine sediments and pesticides have substantially increased in the pre-development levels, and significantly reduce the overall water quality (Waterhouse *et al.,* 2017). Reduced water quality leads to loss of mangroves, corals and seagrass cover, population declines in mega fauna and the overall degradation of the marine environment (Brodie *et al.,* 2017). These factors, as with urban development, may (in parts) present a larger risk to key ecological components than the fishery itself.

The RIBTF is likely a comparatively minor contributor to marine pollution from all sources. However, risk from individual sources of marine pollution is difficult to determine and almost impossible to assign to a particular sector or activity with confidence, due to the uncertainty as to which source from multiple possible sources is the most likely to generate a given impact. For example, marine pollutants can be sourced from land based runoff and boat emissions, not only from fishing operations, but also from recreational boat users and commercial shipping. Given these factors, the relatively small spatial scale of the fishery in creeks, riverine and nearshore habitats, marine pollutants arguably poses a greater risk to the long-term viability of the fishery and its supporting ecosystem.

Boat Strike

The effects of vessel use are similar regardless of whether they are used for commercial or recreational fishing, or some other form of recreational use. Therefore, despite the direct impacts being relatively low for RIBTF, these impacts, when analysed in context of the all vessel activity, may be a higher risk than initially perceived.

For most air-breathing species, the general probability of boats strikes is low, but become more likely depending on habitat use and vessel traffic. Turtle interactions are more likely in internesting habitats and whilst travelling through shallow coastal foraging areas *i.e.* traveling to or from the fishing grounds (United Nations Environment Program, 2014). Dugongs are also vulnerable in shallow coastal foraging areas. Boat strikes are considered a major risk to turtles; particularly in areas like Moreton Bay. In the Queensland stranding database, stranded turtles with mortalities attributed to vessel strikes greatly outnumber fishing related mortalities. The greatest risk for humpback whales occurs in offshore areas around major ports and the offshore area between the Whitsundays and Shoalwater Bay (Department of the Environment and Energy, 2017).

The risk associated with boat strike mortalities is significant as it will be much larger than fisheries as it will involve a wide range of recreational and commercial services. It is for this reason that boat strike mortalities will present a higher risk than commercial fishing in some areas. For example, the *Marine Wildlife Stranding and Mortality Database* attributed between 60 and 116 turtle mortalities per year to boat strike or fractures (2000–2011 data) (Meager & Limpus, 2012). This is compared to the estimated 19 turtle deaths per year to netting activities / on deck damage and one to 53 mortalities attributed to ghost nets (2000–2011 data) (Meager & Limpus, 2012).

Climate Change

Anthropogenic climate change is expected to have significant and lasting effects on the marine environment. These will likely impact fisheries operations, with some effects already perceptible in recent years. In Queensland, the severity of storms, tropical cyclones and extreme rainfall events are predicted to increase by the end of the century (Steffen *et al.,* 2017). In the past, these events have led to population reductions in affected areas and reduced fish catchability for extended periods after these events (Holbrook & Johnson, 2014). Further to this, increased warming of the atmosphere also leads to increased sea surface temperatures. Temperatures have been steadily increasing around Australia, and globally. This increase in temperature has been responsible for several largescale mass die-offs of coral, mangroves and seagrass (Hoegh-Guldberg *et al.,* 2007; Duke *et al.,* 2017; Arias-Ortiz *et al.,* 2018), which are critical spawning and nursery grounds for many species.

Changes in temperature and oceanic chemistry have been reported to affect physiology, growth and reproduction of fisheries species as well as the primary production that many of these species depend on (Sumaila *et al.,* 2011). This can lead to widespread shifts in fish and ecosystem productivity and stock distributions. There is also evidence of increased ocean acidity. Increased carbon dioxide in the atmosphere decreases the pH of seawater (*i.e.* increased acidity), leading to ocean acidification and dissolution of calcium based reef-building corals, molluscs and crustaceans (Hoegh-Guldberg *et al.,* 2007). Within this context, sustainably managed fisheries will be in a better position to respond to the effects of climate change. Fisheries already under significant stress due to, for example, overfishing, pollutants, and habitat degradation, may not have the resilience to deal with such a largescale threat (Sumaila *et al.,* 2011).

While DAF is currently unable to manage for the effects of climate change, due to the largely unquantifiable nature of largescale climatic effects on the RIBTF, these issues are important to consider when identifying risks and future management decisions for the fishery. The Queensland Government will continue to address these issues through a range of forums.

4.4 Risk Characterisation

Used as part of the Level 1 assessment, the primary purpose of the *Risk Characterisation* stage is to assign a qualitative value to each fishing activity that represents the potential (low, Intermediate or high) for it to contribute to an undesirable event for each of the ecological components and SOCC subcomponents (Table 2). In doing so, the *Risk Characterisation* stage aims to identify the key sources of risk from each fishery in order to inform finer scale assessments. If, for example, an ecological subcomponent is identified as 'high risk' in the Level 2 *Productivity and Susceptibility Analysis* (PSA) or a *Sustainability Assessment for Fishing Effects* (SAFE), the results of the Level 1 assessment will identify the activities within the fishery that are contributing to this risk.

The scores assigned to each ecological component (excluding Ecosystem Processes) and SOCC subcomponent are based on the issues raised during the *Risk Identification* process (refer section 4.2). To this extent, they take into consideration the current fishing trends (*e.g.* current catch, effort and licensing), limitations of the current management regime (*e.g.* the potential for additional effort to be transferred into areas already experiencing higher levels of fishing mortality, substantial increases in fishing mortality for key species, changing target species) and the consequences of the interaction. While the majority of SOCC are classified as bycatch they have been assessed as separate entities in recognition of their complex life histories. Risk scores assigned to ecosystem processes are based on the preliminary assessment (Appendix 1) and represent the maximum score assigned to that particular fishing activity.

Outputs of the *Risk Categorisation* stage, excluding *cumulative impacts*, were used to assign each ecological component with a preliminary risk rating based on the highest risk score in the profile (Table 2). If for example an ecological component received a 'high risk' for one or more of the fishing activities, it would be reflected in the preliminary risk ratings (Table 2; Appendix 2). These preliminary risk ratings are conservative in nature and provide the first opportunity to remove low risk elements from the assessment process. Scores assigned to the cumulative risks were not considered as the preliminary risk scores are only applicable to the commercial fishery. The cumulative impacts scores though provide insight into the potential for ancillary risks to impact each of the respective ecological components.

In line with above approach, preliminary assessments for the RIBTF indicated that fishing activates presented a negligible, low or intermediate risk to at least ten of the ecological components (seabirds, terrestrial mammals, crocodiles, dugongs, cetaceans, protected teleosts, syngnathids, marine turtles, sea snakes and sharks) (Table 2, Appendix 2). Of the remaining ecological components, target & byproduct species, bycatch and batoids were all assigned a preliminary risk rating of intermediate/high with marine habitats and ecosystem processes assigned a high risk rating (Table 2).

While not universal, data limitations and an inability to validate catch rates and discards (*e.g.* target & byproduct species, bycatch, SOCC) were factors of influence in a number of the higher risk ratings (Appendix 2). A full account of the preliminary risk ratings, the key considerations and risk factors have been provided in Appendix 2. However, the following provides a general overview of the key findings of the risk characterisation stage:

- Target & byproduct species received higher risk ratings due to the absence of an overarching control on catch or effort and an absence of biological reference points or indicative

sustainability assessments for key species. This ecological component will also experience significant cumulative fishing pressures.

- Bycatch species were assigned a higher risk rating due to the fishery having a greater potential to interact with non-target teleost and invertebrate species. This portion of the catch was also at higher risk of being returned in a dead or moribund state.

- Disturbance due to presence in the area was considered to be a significant risk for a number of the ecological components including target & byproduct, bycatch, marine habitats and ecosystem processes.

- Sea snakes and batoids were assigned higher risk ratings due to the fishery having a higher potential to interact with these SOCC subgroups (particularly in inshore waters) and the reduced TED effectiveness for smaller species.

- The lack of species resolution in the catch data influenced the risk rating of a number of the ecological components including harvest species (*e.g.* bay prawns) and bycatch.

***Table 2**. Summary of preliminary risk scores for the River and Inshore Beam Trawl Fishery (RIBTF), including the impact of the main fishing activities on key ecological components.*

Ecological Component	Beam trawl fishing—Risk Profiles							Preliminary Risk Rating	Cumulative fishing impacts
	Harvesting	Discarding	Contact without capture	Loss of fishing gear	Travel to/from grounds	Disturbance due to presence in area	Boat maintenance & emissions		
Target & Byproduct	I/H	L	L	L	L	I/H	L	I/H	H
By-catch (non-SOCC)	-	I/H	I/H	L	-	I/H	L	I/H	H
SOCC									
Marine turtles	-	L	L/I	L	-	L/I	L	L/I	H
Sea snakes	-	I	L/I	L	-	L/I	L	I	H
Crocodiles	-	L	L	L	-	L	L	L	-
Dugongs	-	L	L	L	-	L	L	L	-
Cetaceans	-	L	L	L	-	L	L	L	-
Batoids	-	I/H	I	L	-	I/H	L	I/H	H
Protected teleosts	-	L	L	L	-	L	L	L	L
Sharks	-	L/I	L/I	L	-	L	L	L/I	L/I
Syngnathids	-	L	L	-	-	L	L	L	I
Sea birds	-	-	-	-	-	-	-	-	-
Terrestrial mammals	-	-	-	-	-	-	-	-	-
Marine Habitats	-	-	-	L	-	H	L	H	H
Ecosystem Processes	H	H	I	L	L	H	L	H	H

4.5 Likelihood

The *Risk Characterisation* stage takes into consideration what is occurring in the fishery and what can occur under the current management regime. This provides a more holistic account of the risks posed by the fishery and provides the Level 1 ERA with greater capacity to address the (potential) long-term consequences of a risk. The inherent trade off with this approach is that some of the ecological components may be assigned more conservative risk ratings. Otherwise known as 'false positives', these values effectively overestimate the level of risk posed to an ecological component or subcomponent. In other words, preliminary risk ratings compiled in the *Risk Characterisation* stage may represent a potential risk—something that is discussed at length in the *Ecological Risk Assessment Guideline* (Department of Agriculture and Fisheries, 2018e).

False positives should not be discounted as they point towards areas where further monitoring and assessment may be required. However, triggering management changes or progressing an ecological component to a Level 2 (species-specific) ERA based on a conservative whole of fishery (Level 1) assessment may be unwarranted. This places added importance on examining the preliminary risk ratings and determine if they represent a **real** or **potential** high risk (Department of Agriculture and Fisheries, 2018e).

In order to address the potential overestimation of risk for some ecological components, a secondary qualitative review of the preliminary risk ratings were undertaken. This review examined factors underpinning each assessment, their relevance to the current fishing environment and areas where this risk may be overestimated. The purpose of the secondary review is not to dismiss the preliminary findings of the *Risk Characterisation* stage. Rather, this secondary assessment aims to assess the likelihood of the risk coming to fruition over the short to medium term. This in itself will aid in the identification of priority risk areas and help to inform broader discussions surrounding the development of risk management strategies for key species. Given the extent of fisheries reforms outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017) and the available resources, this was considered to be an important and necessary step.

When mitigation measures and risk likelihood are given further consideration, the risk ratings of nine ecological components were amended. The preliminary risk ratings for target & byproduct species, bycatch and batoids were downgraded from intermediate/high to intermediate and sea snakes from intermediate to low/intermediate (Table 3, Appendix 2). The downgrading of these ratings further recognised the operational constraints of the fishery (*e.g.* smaller vessels, shorter shot times, smaller catches), improved post interaction survival rates and the use of bycatch reduction devices (BRDs and TEDs). To this extent, they provide a better representation of what is occurring in the fishery under the current management regime.

Outside of the above ecological components, the most significant amendment to the preliminary risk ratings involved the marine habitat ecological component which was downgraded from high to intermediate (Appendix 2). Amendments to the risk rating assigned to this ecological component better reflects the spatial constraints of the fishery, the extent of spatial closures contained in fisheries and non-fisheries legislation and the low capacity of the fishery to expand into areas without a significant history of trawl fishing. The remainder of the amendments involved low risk species and ecological components that were unlikely to interact with the fishery (Appendix 2).

A summary of the key findings of the Level 1 ERA have been provided in Table 3. Additional information on the Level 1 risk ratings including key considerations of both the preliminary risks and mitigation measures has been provided in Appendix 2.

***Table 3**. Level 1 risk ratings for the ecological components and subcomponents interacting with the River and Inshore Beam Trawl Fishery (RIBTF) taking into consideration the likelihood of the risk coming to fruition in the short to medium term.*

Ecological Component	Level 1 Risk Rating	Considerations / Justifications	Level 2 Required?
Target & Byproduct	Intermediate	• Absence of an effective control of catch and effort at a whole of fishery, regional and species level; although operational constraints (*e.g.* gear size, shot times, use of spatial closures) limit the extent of fishing. • Stock status assessments indicates that a number of the species including banana prawns and eastern school prawns are sustainably fished. However, species like banana prawns may be exposed to a higher risk due to regional biomass variability and cumulative fishing pressures. • Uncertainty remains regarding the composition of multi-species catch categories and addressing this risk will be difficult without further research or measures to validate catch in the RIBTF. • Risks in this fishery are likely to be more relevant in south-east Queensland where there is a higher concentration of effort. • The fishery is already managed under a limited licensing policy and buybacks have seen the total number of licences decline by almost half. • Licence reductions reduced real effort and minimised risk of effort increasing over the short to medium term. • Risk rating may be precautionary and could be reduced with improved information on fine-scale effort movements and catch validation techniques. • Risk associated with fine-scale movement of effort is being actively addressed through the *Queensland*	No. Progressed through the Monitoring & Research Plan.

Ecological Component	Level 1 Risk Rating	Considerations / Justifications	Level 2 Required?
		Sustainable Fisheries Strategy 2017–2027 and the expansion of the *Vessel Tracking* system. • The overall risk from this fishery to target and byproduct species will be smaller than other trawl sectors (*e.g. Moreton Bay Trawl Fishery* and *East Coast Otter Trawl Fishery*) *i.e.* RIBTF will be a contributor of risk *verse* the main driver of risk.	
Bycatch (non-SOCC)	Intermediate	• Beam trawls, as with otter trawls, have a high potential to interact with a range of non-target species. • There is limited information on catch compositions and discard fates for this ecological component including the extent of regional variability. • Quantifying bycatch levels in the RIBTF is difficult as there are (currently) limited options to validate catch rates and compositions. • Operational constraints will reduce the impact of the RIBTF on this ecological component *e.g.* shorter shot times, smaller catches and reduced sorting times. • BRDs are required for all RIBTF vessels and TEDs required for all fishers operating in waters outside rivers and creeks. Licence reductions have also helped to reduce effort in this fishery and by extension the amount of bycatch (overall). • While mortality rates for some species / species complexes are expected to be higher (*e.g.* small teleosts), these species are typically fecund, fast growing and have a strong capacity to rebound after potential declines. • The need to progress this ecological component beyond a Level 1 ERA will be dependent on the available data, the quality of the effort data and the extent of the overlap between the areas fished and the distribution of key species / species groupings. • The expansion of the *Vessel Tracking* systems will help refine risk rating by monitoring of fine-scale	No. Progressed through the Monitoring & Research Plan.

Ecological Component	Level 1 Risk Rating	Considerations / Justifications	Level 2 Required?
		effort patterns. Introducing catch validation techniques will further refine ratings. • Improved catch reporting processes, including the introduction of electronic logbooks to improve catch composition data and electronic observation are being investigated as part of the *Sustainable Fisheries Strategy 2017–2027*. • For most bycatch species, the RIBTF will be a contributor of risk *verses* the main driver of risk.	
Species of Conservation Concern (SOCC)			
Marine turtles	Low	• The risk of a turtle interacting with the RIBTF will be higher when operating in waters outside of rivers and creeks (habitats preferred by these species). When operating in these areas, operators are required to use both a TED and a BRD. • While the risk to this subgroup is anticipated to the low, there are limitations on the amount of available data and the ability to validate SOCI interactions. • The expansion of the *Vessel Tracking* systems will assist in the monitoring of fine scale effort patterns and provide further insight into the potential for this fishery to interact with marine turtles. • Improved catch reporting processes, including the introduction of electronic logbooks to improve catch composition data and electronic observation are also being investigated as part of the *Sustainable Fisheries Strategy 2017–2027*.	No
Sea snakes	Low / Intermediate	• Subgroup with the highest number of SOCI interactions reported from the RIBTF (*n* = 624). • Evidence indicates that sea snakes caught in this fishery have high post-release survival rates (Courtney *et al.*, 2010). Best management and handling practice in place and mandatory reporting required for this subgroup.	No

Ecological Component	Level 1 Risk Rating	Considerations / Justifications	Level 2 Required?
		• Risk rating may be precautionary and could be reduced with improved information on fine-scale effort movements and catch validation techniques. The introduction of *Vessel Tracking* will help provide some of this information. • There are inherent limitations on the ability of management to validate SOCI data and obtain an accurate account on the total number of interactions / fishing mortalities. • Improved catch reporting processes, including the introduction of electronic logbooks to improve catch composition data and electronic observation are also being investigated as part of the *Sustainable Fisheries Strategy 2017–2027*.	
Crocodiles	Negligible	• Limited potential for interactions to occur and majority of effort occurs outside habitats preferred by this subgroup.	No
Dugongs	Low	• Low potential for interactions / direct mortalities due to the area being fished, the type of fishing and gear configuration. • Bycatch mitigation measures in place for this fishery including the use of TEDs in waters outside rivers and creek systems. • Depending on the location, disturbance due to presence in the area may be a risk factor for this subgroup. • Cumulative risks including the impact of boat strike, habitat degradation and customary fishing practices arguably present a bigger risk to this subgroup.	No
Cetaceans	Low	• Low potential for interactions due to the area being fished, the type of fishing method and gear configuration. • Most interactions with this subgroup will be indirect *e.g.* dolphins feeding off of bycatch or fish that have escaped through the BRD/TED.	No

Ecological Component	Level 1 Risk Rating	Considerations / Justifications	Level 2 Required?
		• Bycatch mitigation measures in place for this fishery including the use of TEDs in waters outside rivers and creek systems.	
Protected Teleosts	Low	• Limited capacity for the fishery to interact with protected species due to their preferred habitats. • Fishery may interact infrequently with juvenile Queensland Groper. Post-interaction survival rates will be better for this species when compared to smaller teleosts. • Interactions with this subgroup not expected to have long-term consequences for regional populations.	No
Batoids	Intermediate	• RIBTF operations will interact with a range of batoids and there is an increased potential for injuries and mortalities. However, post-interaction survival rates are expected to be higher when compared to the ECOTF. • There is limited information on catch compositions, discard rates and discard fates as batoids are not permitted to be retained for sale and the majority are not classified as SOCI. • Catch compositions will vary between management regions symbols and may include protected species *e.g.* the estuary stingray and sawfish. • Quantifying catch rates for batoids will be difficult as there are (currently) limited options to validate RIBTF catch rates and compositions. • Operational constraints would help to reduce the impact of this fishery on this ecological component *e.g.* shorter shot times, smaller catches and reduced sorting times. • While bycatch mitigation measures are used in the RIBTF (including TEDs in waters outside of rivers and creeks), they are less effective at excluding smaller batoids and sawfish.	No. Progressed through the Monitoring & Research Plan.

Ecological Component	Level 1 Risk Rating	Considerations / Justifications	Level 2 Required?
		• Risk rating may be precautionary and could be reduced with improved information on fine-scale effort movements and catch validation techniques. • The expansion of the *Vessel Tracking* systems will assist in the monitoring of fine scale effort patterns and provide further insight into the potential for this fishery to interact with batoids. • Improved catch reporting processes, including the introduction of electronic logbooks to improve catch composition data and electronic observation are also being investigated as part of the *Sustainable Fisheries Strategy 2017–2027*. • Impacts on these species likely to be higher in the ECOTF and the RIBTF will be a contributor of risk *verse* the main driver of risk.	
Sharks	Low	• Smaller potential for the fishery to interact with this subgroup with interactions more likely to occur in inshore waters and/or with species that utilise a variety of marine habitats *e.g.* juvenile bull sharks. • Information on catch compositions and discard rates is limited. • Operational constraints would help to reduce the impact of this fishery on this ecological component *e.g.* shorter shot times, smaller catches and reduced sorting times. • Some mitigation measures in place to minimise the catch of shark including the use of a TED in waters outside of rivers and creeks. TEDs have proven to be highly effective at excluding larger sharks from the trawl catch. • The expansion of the *Vessel Tracking* systems will assist in the monitoring of fine scale effort patterns; therefore helping to refine the Level 1 assessment for this subgroup. • Improved catch reporting processes, including the introduction of electronic logbooks to improve catch	No

Ecological Component	Level 1 Risk Rating	Considerations / Justifications	Level 2 Required?
		composition data and electronic observation are also being investigated as part of the *Sustainable Fisheries Strategy 2017–2027*.	
Syngnathids	Low	• Lower potential for interactions to occur in this fishery, particularly in rivers and creeks where there is limited overlap with habitats preferred by syngnathids. • Catch records indicate that some species will interact with the fishery—pipefish are classified as a 'permitted species' under the *(Commercial Fisheries) Regulation 2019*. These interactions are more likely to occur in nearshore waters. • Low numbers are retained for sale in this fishery and may increase through time due to market demands. • Quantifying catch rates for this subgroup will be difficult as there are (currently) limited options to validate RIBTF catch rates and compositions. • Interactions with this subgroup may be underestimated due to their cryptic nature.	No
Seabirds	Negligible	• Only one interaction reported in the fishery and their capture in a beam trawl is considered to be highly unlikely.	No
Terrestrial mammal	Negligible	• No interactions reported with this fishery and their capture in a beam trawl or otter trawl highly unlikely.	No
Marine Habitats	Intermediate	• Trawl events will have a direct impact on the immediate environment with increased sedimentation, increased turbidity and disturbance to biotic communities all identified as likely consequences. • Areas fished in the RIBTF have already experienced permanent changes due to fishing activities that have occurred over an extended period (decades). • Greatest potential risk would be to marine habitats on the periphery of already trawled areas *i.e.* the gradual expansion of the trawl area through time.	No. Progressed through the Monitoring & Research Plan.

Ecological Component	Level 1 Risk Rating	Considerations / Justifications	Level 2 Required?
		• Extent of the risk posed by RIBTF largely managed through spatial closures and the restriction of fishing effort to already trawled areas. • There is limited information on the fine-scale distribution of effort and the level of overlap between trawl sectors; particularly in inshore and nearshore waters. • The expansion of the *Vessel Tracking* systems will assist in the monitoring of fine scale effort patterns; therefore helping to refine the Level 1 assessment for this ecological component.	
Ecosystem Processes	Precautionary high; data deficient	• Interacts with diverse range of species and trophic levels, however, the broader impacts of trawling on ecosystem processes are complex. • Ecosystem processes most likely to be affected includes scavenging, sedimentation, primary production and predation. • Assessment of the key risks and potential consequences is difficult due to data deficiencies. • While recognising that ecosystem processes has been assigned a higher risk rating, the ecological component will not be progressed to a Level 2 assessment without a significant increase in the amount of available information. • The expansion of the Vessel Tracking systems will assist in the monitoring of fine scale effort patterns; therefore helping to refine the Level 1 assessment for this ecological component.	Not progressed due to data deficiencies

4.6 Issues Arising

Catch composition data

In multi-species fisheries like the RIBTF the acquisition of better catch data will continue to be of high priority. While the use of generic categories has reduced; the fishery continues to report (by necessity) a high proportion of the catch in broader complexes (*i.e.* bay prawns). This will make it difficult to assess the level of exploitation each species is exposed to and the risk that one or more of the species will experience an undesirable event.

Refinements to the logbook reporting system has improved the level of data on RIBTF catch compositions. This is most notable in the amount of catch being reported in generic categories like *Prawn—mixed bait, Prawn—unspecified* and *Fish—unspecified* (Department of Agriculture and Fisheries, 2019a). Although these refinements have improved the transparency of the data, it still contains some broader catch categories, including *Squid—unspecified* and *Cuttlefish—unspecified*. In the RIBTF, the most notable of the generic categories is *bay prawns* which make up a high proportion of the RIBTF catch (Department of Agriculture and Fisheries, 2019a). While reporting of bay prawns to species level is impractical, additional information on the broader composition of this catch will greatly assist future ERAs. Accurate catch composition data is not only important for monitoring the RIBTF, but will assist in predicting spatial/temporal catch patterns for species that recruit to the ECOTF. This again will assist in making a more informed assessment of the cumulative risks posed by trawl fishing activities on the Queensland east coast.

In the past this catch has been partly validated through a Fisheries Observer Program. This program ceased in 2013 due to operational constraints and the focus of data validation is now based on data analysis, limited range checks at the data entry point and outlier reports generated once the data has been entered. Unlike other trawl fisheries, catch data in the RIBTF is not validated using catch disposal records. Management are continuing to explore options to improve data validation in this fishery by collecting more information to cross check logbooks. '*Improved Monitoring & Research'* was also included in the *Queensland Sustainable Fisheries Strategy 2017–2027* as one of four foundation reforms and is being actively addressed through a *Fisheries Data Validation Plan* and a *Monitoring and Research Plan* (Department of Agriculture and Fisheries, 2018g). These reforms along with the expansion of *Vessel Tracking* will improve the accuracy of Queensland's catch and effort data. These measures though will take time to develop and implement; therefore will take time to filter through to the ERA process.

Capture of non-target species

Given the nature of trawl fishing, it is unlikely that the capture of non-target species will be eliminated completely from the RIBTF or the broader ECTF. There has however been significant advancements in trawl gear technology and the introduction of BRDs and TEDs has reduced the amount of bycatch (Brewer *et al.,* 2006; Courtney *et al.,* 2007b). The introduction of mandatory TEDs and BRDs arguably represents the most significant advancement in trawl bycatch minimisation to date. To this extent, the ability of gear modifications to deliver an analogous (large scale) reduction in trawl bycatch is considered to be unlikely in short term. This has been reflected in the rise of research projects examining the most efficient TED–BRD combinations and their ability to exclude key species or species groupings (Courtney *et al.,* 2010; Campbell *et al.,* 2017). In Queensland, this research has led to a rationalisation of the number of BRDs permitted for use in the RIBTF to the five most efficient: the square mesh codend, square mesh panel, the fisheye, bigeye and the V-cut and bell codend.

The benefits of using a TED in the RIBTF will be limited as the majority of the bycatch will pass through bar spacings and into the codend. In terms of BRD efficiency, this places added importance on understanding bycatch compositions in the RIBTF and the design/s that will maximise the harvest to discard ratio. Similarly, these data limitations make it difficult for management bodies like the Fisheries Working Groups (FWG) to evaluate the suitability, applicability and viability of alternatives (*e.g.* chain and net modification, electrical or water jet stimulation, alternate mesh panel designs) including their ability to reduce bycatch whilst retaining target product (Linnane *et al.,* 2000; McHugh *et al.,* 2015; Soetaert *et al.,* 2015; Soetaert *et al.,* 2016; Rijnsdorp *et al.,* 2017; Kopp *et al.,* 2018).

Limited understanding of SOCC interactions

Species of Conservation Interest or SOCI is a group of species that are afforded additional protections in Queensland waters. Often no-take species, this group formed the basis of the broader *Species of Conservation Concern* (SOCC) ecological component that was assessed as part of this Level 1 ERA. In Queensland, all commercial operators are required to report interactions with these species in a dedicated SOCI logbook.

Both the diversity and number of SOCI interactions will be lower in the RIBTF and the fishery will present a lower overall risk to these subgroups when compared to other trawl fisheries. In terms of the Level 1 ERA, one of the drivers of risk was a limited understanding of how this fishery interacts with this subgroup; particularly in inshore waters. This risk, in part, stems from the fact that operators have only recently been required to use a *Vessel Tracking* system and it will be unclear how the distribution of effort overlaps with key habitats until the system is well-established. *Vessel Tracking* data will help gain a better understanding of the risk posed by this fishery (low, medium, high) to SOCC subgroups in inshore waters and help to refine ERAs.

Obtaining accurate information on SOCC interactions will be of significant importance future ERAs involving the RIBTF. The provision of more accurate data, either through the SOCI logbooks or broader bycatch analyses, will help to refine these assessments and provide mangers with greater capacity to differentiate between real and potential risks (refer to the ERA Guidelines; Department of Agriculture and Fisheries, 2018e).

Non-commercial fishing data

When compared to socially important teleost species, the harvesting of RIBTF species by recreational fishers and by Aboriginal peoples and Torres Strait Islander peoples will present a lower risk. Despite this, there is limited information on the take of key species from non-commercial fishers. For the three species that make up the majority of the catch in the RIBTF (banana prawns, greentail prawns and school prawns), this information will be of some benefit when attempting to determine total mortality *e.g.* in stock assessments.

5 Summary & Recommendations

The Level 1 ERA indicates that the RIBTF is a contributor of risk for most ecological components *verse* the main driver of risk. While comparisons can be made to the ECOTF, the operational constraints of the RIBTF reduce some of the more notable trawl-related risks. For example, mortality risks associated with the weight of the catch and the ‘crushing’ of non-target species would be lower in the RIBTF. Similarly, smaller gear configurations, reduced trawl speeds and trawl times (approx. 30–60 mins) help to reduce the risk of injury during the trawl event. As the fishery (mostly) operates in creeks, rivers and estuarine waters, it also presents as a lower risk for species with larger conservation concerns *e.g.* turtles, dugongs and cetaceans. The risk profile for this fishery though is complicated by the fact that effort is not evenly distributed along the Queensland east coast. This is significant as assessments based at the whole of fishery level will mask regional differences in the risk posed by this fishery. For example, fishing activities in south-east Queensland will present a higher risk for a number of the ecological components when compared to the T8 and T9 fishing areas (Department of Agriculture and Fisheries, 2019a).

When the outcomes of the preliminary risk assessment and the secondary evaluation (Table 3; Appendix 2) are taken into consideration, only one of the ecological components were assigned a risk rating above intermediate; ecosystem processes (Table 3). The ability to undertake a finer scale assessment for this ecological component is restricted by significant data deficiencies. Similar deficiencies were observed throughout the risk profiles for the target & byproduct, bycatch and marine habitat ecological components. Most of these risks relate to an absence of catch composition data and an inability of management to track regional catch trends including discards. For ecological components like bycatch and batoids, there may also be need to investigate the regional impacts of the fishery on these species.

Given the above considerations, none of the ecological will be progressed to a Level 2 ERA. While the RIBTF will not be the subject of a Level 2 (species-specific) ERA, a number of information gaps will be progressed through the *Fisheries Queensland Monitoring and Research Plan* (Department of Agriculture and Fisheries, 2018c), the *Fisheries Data Validation Plan* (Department of Agriculture and Fisheries, 2018f) and/or through the harvest strategy framework (Department of Agriculture and Fisheries, 2018a). Specifically:

- Improving the level of information on catch compositions for target and non-target species with particular emphasis on multi-species catch categories, bycatch compositions and release fates.
- Improving the level of information on fine-scale effort movements and the potential for it to impact on recruitment rates for key target species in the RIBTF and other trawl fisheries.
- Quantifying the level of overlap between sectors of the ECTF (*e.g.* the RIBTF, the *Moreton Bay Trawl Fishery* and the *East Coast Otter Trawl Fishery*) and the cumulative fishing pressures exerted on key species and habitats.
- Determining the extent of the overlap between fishing effort and key SOCI habitats and its potential to influence interaction rates for key species *e.g.* estuary stingrays, protected sawfish and marine turtles in areas outside of rivers, creeks and estuaries.

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Appendix 1—Ecological Processes Preliminary Assessment

A1—Ecological Processes Categories

Categories taken into consideration as part of the Level 1 preliminary assessment for the Ecological Processes ecological component. Definitions adopted from the Great Barrier Reef Outlook Report (Great Barrier Reef Marine Park Authority, 2014) and (Pears *et al.,* 2012).

CATIGORY	DESCRIPTION
SEDIMENTATION	The inflow, dispersion, resuspension and consolidation of sediments
NUTRIENT CYCLING / MICROBIAL PROCESSES	The input, export and recycling of nutrients within the ecosystem. Removal of animals through harvesting is a direct loss of nutrients to the ecosystem
PARTICLE FEEDING	Feeding process targeted at particles suspended in the water column, or deposited on submerged surfaces
PRIMARY PRODUCTION	The conversion of the sun's energy into carbon compounds that are then available to other organisms
HERBIVORY	The consumption of plants
PREDATION	The removal of mid and top order predators from the marine environment and the potential for animals to be subject to increase predation
BIOTURBATION	The biological reworking of sediments during burrow construction and feeding and bioirrigation (mixing of solutes) leading to the mixing of oxygen-bearing waters into sediments
DETRITIVORY	Feeding on detritus (decomposing organic matter)
SCAVENGING	Predators eating already dead animals
SYMBIOSIS[8]	The interdependence of different organisms for the benefit of one or both participants
RECRUITMENT	The impact of the fishery on the ability of a species replenishment populations
REEF BUILDING	The process of creating habitats composed of coral and algae and includes the creation of all biogenic (*i.e.* of living origin) habitats
COMPETITION	Interactions between species that favour or inhibit mutual growth and functioning of populations
CONNECTIVITY	Migration, movement and dispersal of propagules between habitats at a range of scales; and functional connectivity which represents ontogenetic cycles of habitat use
OUTBREAKS OF DISEASE	The spread or introduction of disease to organisms or ecosystems
INTRODUCED SPECIES	The introduction of exotic species and their spread once established

[8] *According to the practical application of symbiosis outlined in Pears et al. (2012), trawl fishing is unlikely to impact symbiotic relationships based on the premise that both or neither organisms are caught during the fishing event.*

A2—Ecosystem Processes Preliminary Assessment

Due to the difficulty of assessing the impacts of a fishery on ecosystem processes, a precautionary approach was adopted for the Level 1 assessment. In line with this approach, an initial or preliminary assessment was undertaken for 16 ecosystem processes that may be influenced by fishing activities. As with risk scores for the whole of fishery assessment (Table 2) each category was assigned a risk rating of Low (L), Intermediate (I), High (H), or negligible (-). This risk score describes the potential for each the fishing activity to impact negatively on the ecosystem process category.

For the Level 1 ERA, each fishing activity was assigned a final risk score that corresponded with the maximum risk rating assigned in the preliminary assessment. If for example 'Predation' received an 'H', than the final risk score for harvesting will be a H. To this extent, the final risk scores assigned to each fishing activity present the highest potential risk and therefore may not be applicable to all of the ecosystem processes categories. Used in this context, the Level 1 assessment for ecosystem processes should be considered as both precautionary and preliminary in nature. The following presents a summary of the preliminary risk scores assigned to the main fishing activities in the RIBTF.

	Trawl fishing – Main activities of the Fishery							**Cumulative impacts Other fisheries**
Category	**Harvesting**	**Discarding**	**Contact without capture**	**Loss of fishing gear***	**Travel to/from grounds****	**Disturbance due to presence in area**	**Boat maintenance & emissions**	
Sedimentation	-	-	-	L	L	H	-	H
Nutrient cycling	I	-	-	-	-	I	-	-
Particle feeding	-	-	L/I	-	-	I	-	H
Primary production	-	-	-	L	-	H	-	-
Herbivory	I	L/I	L/I	-	-	I	-	I
Predation	I	L/I	L/I	-	L	H	-	H
Bioturbation	L	L	L	L	-	H	-	H
Detritivory	I	L	L	-	-	I	-	I
Scavenging	I	H	L	-	-	H	-	H
Symbiosis	-	-	-	-	-	-	-	-
Recruitment	L	-	-	-	-	-	-	H
Reef Building	-	-	-	-	-	L	-	L
Competition	I	L	L	-	-	L	-	I
Connectivity	L	-	-	-	-	L	-	L
Outbreaks of disease	L	L	L	-	L	L	L	L
Introduced species	-	-	-	-	-	-	-	-
ECOSYSTEM PROCESSES (overall)	I	H	I	L	L	H	L	H

Appendix 2—Risk Ratings and Outputs.

The primary objective of the Level 1 assessments were to a) identify the key sources of risk within a particular fishery and b) the ecosystem components that are most likely to be effected by this risk. Preliminary risk ratings developed as part of the *Risk Characterisation* stage take into consideration the current fishing environment (*e.g.* current catch, effort and licensing trends) and risk factors associated with the current management regime (*e.g.* the potential for additional effort to be transferred into areas already experiencing higher levels of fishing mortality, substantial increases in fishing mortality for key species, changing target species). Depending on the fishery, broader risk factors may also contribute to an ecological component receiving a more conservative risk rating. These preliminary rates are precautionary or more conservative in nature and provide a more holistic account of a) risks posed by the fishery and b) provide the Level 1 ERA with greater capacity to address the (potential) long-term consequences of a risk. The trade-off with this approach is that the preliminary risk may overestimate the level of risk posed to an ecological component or be a reflection of the 'potential risk'. Otherwise known as a 'false positive', these values effectively overestimate the risk posed to an ecological component or subcomponent.

The potential for large-scale qualitative ERAs to produce 'false positives' places added importance on examining the likelihood of the risk coming to fruition in the short to medium term. The following provides an overview of the preliminary risk ratings and an assessment of the likelihood of it occurring in the RIBTF. Depending on the species and the current fishing pressures, preliminary risk ratings may be amended to reflect the current fishing environment.

Ecological Component	Key Issues / Sources of Risk	Risk Characterisation (Preliminary rating)	Considerations of Likelihood and Mitigation Measures	Level 1 Risk Rating
Target & Byproduct	• Absence of an effective control of catch and effort at a whole of fishery, regional and species level. • Poor species resolution in some of the catch composition data and limited ability to report at species level (*e.g.* bay prawns).	Intermediate / High	*Likelihood* • Low to moderate depending on the species and the type of fishing involved (river *vs.* inshore). *Mitigation Measures & Considerations* • Risk rating conservative in nature and likely to reduce with additional	Intermediate

	• Limited information on the biomass / stock status of species outside of banana prawns.		information on stock structure and fishing mortality of target species. • Operational constraints would help to reduce the impact of this fishery on this ecological component *e.g.* shorter shot times, smaller catches and reduced sorting times. • Stock status assessments indicates that a number of the species including banana prawns and eastern school prawns are sustainably fished. • Uncertainty remains regarding the composition of multi-species catch categories and addressing this risk will be difficult without further research. • Risks associated with fine-scale movement of effort will be refined as *Vessel Tracking* becomes more established. • The risk posed by this fishery will vary regionally and be more relevant to south east Queensland. • The overall risk from this fishery to target and byproduct species will be smaller than other trawl sectors (*e.g. Moreton*	

			Bay Trawl Fishery and *East Coast Otter Trawl Fishery*). • RIBTF will be a contributor of risk *versus* the main driver of risk.	
Bycatch (non-SOCC)	• Beam trawls, as with otter trawls, have higher potential to interact with a range of non-target species. • There is also a higher potential for this subgroup to incur *in-situ* and post-release mortalities—particularly for smaller teleosts. • Limited information on bycatch compositions for this sector as the majority of the attention has focused on the *East Coast Otter Trawl Fishery* (ECOTF). • Limited reporting requirements for bycatch species and limited capacity to assess bycatch levels / species compositions in working conditions.	Intermediate / High	*Likelihood* • Risk considered to be high for this fishery as interactions with non-targeted bycatch would occur with considerable regularity. *Mitigation Measures & Considerations* • Information on bycatch rates and compositions unlikely to improve without improved catch validation. • Operational constraints would help to reduce the impact of this fishery on this ecological component *e.g.* shorter shot times, smaller catches and reduced sorting times. • Bycatch mitigation measures in place including the use of a BRD in all operations and a TED when operating in areas outside of rivers and creeks. • Mesh size controls and the use of a BRD helps to reduce the amount of bycatch caught in estuarine / riverine systems.	Intermediate

			• Licence reductions have helped to reduce effort in this fishery. Reduced effort, while not universal or equal across fisheries, will aid in reducing bycatch levels. • The implementation of *Vessel Tracking* will assist in the monitoring of fine-scale effort patterns and provide insight into the species each sector may encounter. • While mortality rates for some species / species complexes are expected to be high (*e.g.* small teleosts), these species are typically fecund, fast growing and have a strong capacity to rebound after potential declines. • The need to progress this ecological component beyond a Level 1 ERA will be dependent on the available data, the quality of the effort data and the extent of the overlap between the areas fished and the distribution of key species / species groupings.	
Species of Conservation Concern (SOCC)				

Marine turtles	• Reported turtle interactions in the RIBTF are low in number and infrequent in nature. •	Low / Intermediate	<u>*Likelihood*</u> • Low for this fishery due to limited overlap with key habitat areas and the use of TEDs in areas outside or rivers and creeks. <u>*Mitigation Measures & Considerations*</u> • Mitigation measures already in place including the use of TEDs. • While beam trawls are not required to use a TED when operating in riverine and estuarine systems where there is limited overlap with the habitats preferred by marine turtles. • The risk of a turtle interacting with the fishery would be higher when operating outside of rivers and creeks. In these instances, operators are required to use a TED. • The implementation of *Vessel Tracking* will assist in the monitoring of fine-scale effort patterns and provide further insight into the potential for this fishery to interact with marine turtles.	Low

Sea snakes	• Subgroup with the highest number of SOCI interactions (*n* = 624). • Post-interaction mortality rates expected to be low if proper handling procedures are followed. • Finer-scale review may be required to determine what, if any, species are progressed to Level 2 assessment.	Intermediate	<u>*Likelihood*</u> • Low to moderate risk depending on the location. <u>*Mitigation Measures & Considerations*</u> • Interactions and therefore risk is expected to be lower in more turbid waters *i.e.* riverine and creek systems. • Best management and handling practice in place and mandatory reporting required for this subgroup. • Good grounding of research on capture rates, mortality rates and BRD effectiveness. • Subgroup expected to survive trawl event in good condition and post-release mortality rates anticipated to be low. • The implementation of *Vessel Tracking* will assist in the monitoring of fine-scale effort patterns and provide further insight into the composition of the sea snake data. • Subsequent ERAs (if applicable) would benefit from further information on	Low / Intermediate

			species compositions, their distribution and how they overlap with fishing effort.	
Crocodiles	• Only one interaction with a crocodile reported in the RIBTF. • Limited spatial overlap between key fishing grounds (SEQ) and preferred habitats (possibly in FNQ). • Interactions (if applicable) more likely in the T8 and T9 fisheries where there is less effort. • Interactions with the RIBTF are unlikely to have a long-term or significant impact on crocodile populations.	Low	*Likelihood* • Low to negligible. *Mitigation Measures & Considerations* • Limited potential for interactions to occur and majority of effort occurs outside preferred habitats.	Negligible
Dugongs	• Low potential for interactions / direct mortalities due to the area being fished, the type of fishing method (active trawling) and gear configuration. • Limited spatial overlap between key fishing grounds / preferred habitats and the use of TEDs are mandatory when fishing in areas outside river and creek systems.	Low	*Likelihood* • Low to negligible. *Mitigation Measures & Considerations* • Bycatch mitigation measures in place for this fishery including the use of TEDs in waters outside rivers and creek systems. • Need for further mitigation measures reduced as there is limited spatial overlap between key fishing grounds / preferred habitats.	Low

			• Most likely risks are associated with disturbance due to presence in the area. This risk is most applicable when operating in areas outside of rivers, creeks and estuaries.	
Cetaceans	• Low potential for interactions / direct mortalities due to the area being fished, the type of fishing method (active trawling) and gear configuration. • Limited spatial overlap between key fishing grounds and habitats preferred by cetaceans.	Low	*Likelihood* • Low to negligible. *Mitigation Measures & Considerations* • Risk profile will be similar to dugongs. • Bycatch mitigation measures in place for this fishery including the use of TEDs in waters outside rivers and creek systems. • Most interactions expected to be indirect *e.g.* dolphins feeding off of bycatch or fish that have escaped through the BRD/TED. • Need for further mitigation measures reduced as there is limited spatial overlap between key fishing grounds / preferred habitats.	Negligible
Protected teleosts (SOCI only)	• Interactions and mortality rates will be low for this fishery. • A small number of interactions with the Queensland Groper have been reported	Low	*Likelihood* • Low to negligible.	Low

	in the mud and blue swimmer crab fishery which operates in similar areas. • .		*Mitigation Measures & Considerations* • Limited potential for this fishery to interact with this subgroup due to their preferred habitats. • Some potential to interact with juvenile Queensland Groper. • Bycatch mitigation measures will be less effective for this subgroup. • Interactions not expected to have long-term consequences for regional populations.	
Batoids	• Beam trawls, as with otter trawls, have higher potential to interact with a range of batoid species. • Greater overlap between key fishing grounds and preferred habitats and increased potential for batoids to incur injuries or mortalities. • Post-release survival rates improved due to use of TEDs in areas outside of rivers and creeks, shorter shot times and smaller catches. • Limited information on catch rates and compositions.	Intermediate / High	*Likelihood* • Moderate risk posed to this subgroup due to the extent of the interactions and the potential for it to occur across sectors of the RIBTF. *Mitigation Measures & Considerations* • Operational constraints would help to reduce the impact of this fishery on this ecological component *e.g.* shorter shot times, smaller catches and reduced sorting times.	Intermediate

			• Post-interaction survival rates expected to be good for this subgroup. • While operators are required to use a TED when fishing in waters outside of creeks and rivers, they are less effective at excluding smaller batoids. • The majority of batoids not classified as SOCI; therefore are not subject to mandatory reporting requirements. • As batoids are not permitted to be retained for sale in trawl fisheries there is limited information on catch compositions or discard rates. • Catch compositions / discard rates are difficult to validate at this point in time. • Catch compositions will vary between beam trawl symbols but may include protected species *e.g.* the estuary stingray and sawfish. • Impacts on these species likely to be higher in the *East Coast Otter Trawl Fishery*. Accordingly, the RIBTF will be a contributor of risk for this subgroup *versus* the main driver of risk.	

Sharks	• Low–moderate interaction rates with smaller shark species more susceptible to capture. • Moderate overlap between key fishing grounds and preferred habitats; although subgroup will derive benefit from the use of TEDs. • Limited information on catch rates and compositions.	Low / Intermediate	*Likelihood* • Low. *Mitigation Measures & Considerations* • Levels of interactions and mortalities not expected to have a long-term or significant impact on regional shark populations. • Operational constraints would help to reduce the impact of this fishery on this ecological component *e.g.* shorter shot times, smaller catches and reduced sorting times. • Fishery unlikely to interact with shark species afforded additional protections. • Some mitigation measures in place to minimise the catch of shark including the use of a TED in waters outside of rivers and creeks. • The implementation of *Vessel Tracking* will assist in the monitoring of fine scale effort patterns; therefore helping to refine the Level 1 assessment for sharks.	Low
Syngnathids	• Low potential for interactions / direct mortalities due to the area being fished	Low	*Likelihood*	Low

	and the habitats preferred by syngnathids. • Dunker's and Pallid pipehorses are permitted species in this fishery (not SOCC) but negligible amounts are harvested. • Overall number of interactions may be masked due to the cryptic nature of the species. • Post-interaction rates will be lower for this subgroup.		• Low. <u>*Mitigation Measures & Considerations*</u> • While interactions are low, some species can be retained for sale. To this extent, catch rates may be influenced by market demand. • Operational constraints would help to reduce the impact of this fishery on this ecological component *e.g.* shorter shot times, smaller catches and reduced sorting times. • Risk is largely driven by a) the comparatively low levels of reported catch and b) the concentration of effort in rivers, creeks and estuarine environments where syngnathids are less likely to occur.	
Seabirds	• No interactions reported with this fishery and capture or entanglement in a beam trawl is highly unlikely.	Negligible	<u>*Likelihood*</u> • Low. <u>*Mitigation Measures & Considerations*</u>	Negligible

			• N/A as interaction rates (if applicable) are unlikely to have long term implications for regional populations.	
Terrestrial mammal	• No interactions reported with this fishery and capture or entanglement in a beam trawl is highly unlikely.	Negligible	*Likelihood* • Low. *Mitigation Measures & Considerations* • N/A as interaction rates (if applicable) are unlikely to have long term implications for regional populations.	Negligible
Marine Habitats	• High degree of contact with marine habitats over a sustained period. • Higher potential for direct and indirect disturbance. • Impacts will be environment specific and will depend on the extent of trawl history.	High	*Likelihood* • Moderate to high. *Mitigation Measures & Considerations* • Beam trawls will have a direct impact on the immediate environment. • Trawling has the potential to cause regional disturbances or alter the long-term structure of the fished areas. This will mostly relate to marine habitats located on the periphery of already trawled areas. • Areas fished in the RIBTF have already experienced permanent changes due to	Intermediate

			fishing activities that have occurred over an extended period (decades). • Greatest potential risk would be to marine habitats on the periphery of already trawled areas *i.e.* the gradual expansion of the trawl area through time. • Extent of this risk is largely managed through spatial closures and the restriction of fishing effort to already trawled areas. • Despite the above, the risk posed to marine habitats is considered to be one of the more significant risks in this fishery.	
Ecosystem Processes	• Interacts with diverse range of species and trophic levels. • Has the potential to influence a range of ecosystem processes. • Longevity of the impact will vary as will the extent of the impact.	Precautionary high; data deficient	*Likelihood* • Uncertain. *Mitigation Measures & Considerations* • The broader impacts of trawling on ecosystem processes are complex. • Will depend on a range of factors including the area of operation and the composition of the trawl catch. • Ecosystem processes most likely to be affected includes scavenging,	Precautionary high; data deficient

			sedimentation, primary production and predation. • Assessment of the key risks and potential consequences is difficult due to data deficiencies. • While recognising that ecosystem processes has been assigned a higher risk rating, the ecological component will not be progressed to a Level 2 assessment without a significant increase in the amount of available information.	