Sustainable Fisheries Strategy 2017–2027

Gulf of Carpentaria Line Fishery
Level 1 ERA – Whole of Fishery Assessment

Queensland Government

Level 1 Ecological Risk Assessment
Gulf of Carpentaria Line Fishery (GOCLF)

Lisa Walton, Ian Jacobsen & Brad Zeller

Fisheries Queensland, Department of Agriculture & Fisheries

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; 2018a). 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 Gulf of Carpentaria Line Fishery (GOCLF) 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. 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 within each profile, 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 GOCLF, preliminary assessments indicated that at least nine of the ecological components were at negligible to low risk of experiencing an undesirable event. Of the remaining ecological components only target & byproduct species, sharks and ecosystem processes were assigned a preliminary risk rating of intermediate or higher. For target and byproduct species, a limited capacity to control catch and effort and a restricted understanding of the Gulf of Carpentaria Spanish mackerel stock (*e.g.* biomass indicators and reference points) were the key drivers of risk. While not universal, data limitations and a limited understanding of discards were factors of influence in a number of the other risk profiles.

After the likelihood of the risk coming to fruition was considered, the preliminary risk ratings of seven ecological components were reduced. Most of these reductions involved low risk ecological components, species that are unlikely to interact with the fishery and/or have high post-interaction survival rates. Of the ecological components that were amended, the most notable reduction was for target & byproduct species which was downgraded from high to intermediate/high. This amendment recognises that the GOCLF has become more one dimensional with operators primarily targeting Spanish mackerel (97.2–99.9% of the retained catch). However, the extent of the rating reduction was

limited by an absence of biomass estimates for the key species (*e.g.* Spanish mackerel), uncertainty surrounding the structure of regional stocks (Langstreth *et al.*, 2018b) and an absence of an effective control on catch and effort at a whole of fishery, regional or species level.

The final risk ratings for the GOCLF indicate that the fishery presents as a low risk to most ecological components. For most of these, the targeting of Spanish mackerel has helped reduce the number of interactions (*e.g.* with bycatch) and the potential for an interaction to occur (*e.g.* batoids, marine turtles, dugongs, sea snakes, syngnathids and seabirds). From an ERA perspective, this has reduced the need to progress these ecological components to a finer-scale Level 2 (species-specific) ERA. For target and byproduct species, the ecological component with the highest risk rating, risks largely relate to Spanish mackerel and will be addressed through the *Queensland Monitoring & Research Plan* and *Harvest Strategy Policy*.

Of note, the above considerations are based on the understanding that a) the GOCLF will continue to target Spanish mackerel and b) demersal line fishing makes a minor contribution to annual catch and effort levels. In the event that the fishing dynamics change and demersal line fishing becomes more prevalent (*e.g.* due to changing market demands), a review of the Level 1 ERA will be required. In the interim, the Level 1 ERA identified key knowledge gaps in the risk profiles of some ecological components. These information needs will be progressed to the Fisheries Queensland *Monitoring and Research Plan* for further consideration. Key information needs required to refine risk profiles in the GOCLF include:

- Improving the level of information on Spanish mackerel stocks in the Gulf of Carpentaria including on the stock structure, biomass reference points and spawning aggregation sites.
- Obtaining more information on cryptic mortalities including post-release mortalities for key species and depredation rates.
- Improving the level of understanding on species compositions, discard rates and fates for low-priority target species and non-target species.
- Further assessment of regional catch and effort levels in the recreational fishing sector for key species where cumulative fishing impacts present as a higher risk.
- Monitoring of key economic drivers, emerging market trends (*e.g.* line fisheries on the Queensland east coast) and their potential to influence regional fishing behaviours such as an increased focus on demersal fin fish species.

Summary of the outputs from the Level 1 (whole of fishery) Ecological Risk Assessment for the Gulf of Carpentaria Line Fishery (GOCLF).

Ecological Component	Level 1 Risk Rating	Progression
Target & Byproduct	Intermediate / High	*Monitoring & Research Plan / Harvest Strategy*.
Bycatch (non-SOCC)	Low	No
Species of Conservation Concern (SOCC)		
Marine turtles	Low	No
Sea snakes	Negligible	No
Crocodiles	Negligible	No

Ecological Component	Level 1 Risk Rating	Progression
Dugongs	Low	No
Cetaceans	Low	No
Protected teleosts	Low	No
Batoids	Low	No
Sharks	Low / Intermediate	No
Syngnathids	Negligible	No
Seabirds	Low	No
Terrestrial mammal	Negligible	No
Marine Habitats	Low	No
Ecosystem Processes	Intermediate	No

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Definitions & Abbreviations

Active Licence	–	The definition of an active licence is the same as that used by DAF's data reporting system. Used in this context, an active licence represents a licence that has reported catch and effort in the GOCLF through the logbook reporting system irrespective of the amount of catch and effort.
Bycatch	–	The portion of the catch that is discarded/returned to sea. For the purpose of this ERA, the definition of bycatch does not include unwanted target and byproduct species.
Byproduct	–	The portion of catch retained for commercial sale that was not intentionally targeted.
CRFFF	–	Coral Reef Fin Fish Fishery.
DAF	–	Queensland Department of Agriculture and Fisheries.
ECIFFF	–	East Coast Inshore Fin Fish Fishery.
Ecological Component	–	Broader assessment categories that include *Target & Byproduct* (harvested) species, *Bycatch*, *Species of Conservation Concern*, *Marine Habitats* and *Ecosystem Processes.*
Ecological Subcomponent	–	Species, species groupings, marine habitats and categories included within each Ecological Component.
ECSMF	–	East Coast Spanish Mackerel 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 GOCLF are not permitted to line and net fish simultaneously (one or the other).
GOCDFFTF	–	Gulf of Carpentaria Developmental Fin Fish Trawl Fishery.
GOCIFFF	–	Gulf of Carpentaria Inshore Fin Fish Fishery.
GOCLF	–	Gulf of Carpentaria Line Fishery.
ITQ	–	Individual Transferrable Quota.
Offshore waters	–	Tidal waters that are at least 2m deep at low water.
QBFP	–	Queensland Boating & Fisheries Patrol.
RRFFF	–	Rocky Reef Fin Fish 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, protected teleosts, batoids, sharks, seabirds, syngnathids and terrestrial mammals. These species may or may not be subject to mandatory reporting requirements.
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.
Target Species	–	The primary species or species groups that have been selectively fished for and retained for commercial, recreational or Aboriginal peoples and Torres Strait Islander peoples purposes.

1 Overview

The Gulf of Carpentaria Line Fishery (GOCLF) extends from Slade Point near the tip of the Cape York Peninsula westward to the Queensland – Northern Territory border and operates in all tidal waterways south of latitude S10°48'. A line only fishery, GOCLF operators predominantly target Spanish mackerel but retain a variety of other fin fish species in smaller quantities *e.g.* grey mackerel, trevally, kingfish and nannygai (Department of Agriculture and Fisheries, 2019b). The fishery interacts with few non-target species including those classified as *Species of Conservation Interest* (SOCI).

The GOCLF was included in a comprehensive ecological risk assessment (ERA) examining risk in all Queensland-managed fisheries operating in the Gulf of Carpentaria (Zeller & Snape, 2006). This report was based on the Fisheries-Ecological Sustainable Development Reporting Framework (Fletcher *et al.*, 2005) and provided relative risk levels for 47 retained species, 45 non-retained species and 44 general ecosystem components (Zeller & Snape, 2006). The results of this risk assessment have been built upon in the proceeding years through programs like the national *Status of Australian Fish Stocks* (SAFS) and Queensland stock status process. However, a secondary risk assessment for the GOCLF has not been undertaken since the original review (Zeller & Snape, 2006).

The fishing environment for the GOCLF has undergone considerable change since he completion of the previous ERA. The fishery was originally managed through the *Fisheries* (*Gulf of Carpentaria Inshore Fin Fish) Management Plan 2009*. However, this Management Plan was repealed in November 2011 and the management arrangements placed under the *Fisheries Regulation 2008*. As part of review processes, the GOCLF underwent a number of management reforms which included symbol amalgamations, fishing area expansions and the introduction of a prohibition on the use of multi-hook apparatus (*e.g.* demersal trotlines or droplines). Strategies used to monitor catch and effort in the fishery have also evolved and the level of information has continued to improve through time. Today, the GOCLF is managed under the *Fisheries Act 1994* and its subordinate legislation.

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; 2018a). 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 GOCLF 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, 2019e).

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.

In recognition of the above point, the primary objective of the Level 1 assessments 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 GOCLF 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 *species introductions*. 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, 2018a) 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, 2018a).

4 Whole of Fishery Qualitative Assessments

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 Gulf of Carpentaria Line 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 GOCLF. 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 both the level of complexity of the GOCLF and the management regime history. Due to the similarities in fishing methods and target species, the GOCLF is frequently compared to line fisheries located on the Queensland east coast including the East Coast Spanish Mackerel Fishery (ECSMF). However, the operating framework for the GOCLF is simpler; comprising just the one fishing symbol (L4) and no quota allocations. This contrasts with the ECSMF, the Coral Reef Fin Fish Fishery (CRFFF), Rocky Reef Fin Fish Fishery (RRFFF) and East Coast Inshore Fin Fish Fishery (ECIFFF) which are managed using

multiple symbols that provide access to different areas of the Queensland east coast. (*e.g.* L1, L2, L3 and L8 fishery symbols). In the ECSM and CRFFF, these are used in conjunction with quota symbols used to manage the take of key species.

When compared to line fisheries situated on the Queensland east coast, the operating potential for the GOCLF is relatively small (n = 46 L4 fishing symbols; Department of Agriculture and Fisheries, 2019h). The ECIFFF and RRFFF have the largest operating potential with up to 1358 line fishing symbols (*n* = 1358 L1, L2, L3 and L8 fishery symbols) able to access and operate in these fisheries[1]. While these symbols can also be used in the ECSM and the CRFFF, target species are managed under Individual Transferrable Quotas (ITQs). As a consequence, access to these fisheries will be limited by quota availability. This differential is reflected in participation rates with 20 licence holders operating in the GOCLF in 2017 compared to 251 in the CRFFF, 274 in the RRFFF, 168 in the ECSMF and 320 in the ECIFFF. Similar trends were observed in the effort data with the GOCLF registering 1101 primary effort days compared to the ECSMF (*n* = 3704 days), the RRFFF (*n* = 4121 days), the ECIFFF (*n* = 7209 days) and the CRFFF (*n* = 23110) (based on 2017 data; Department of Agriculture and Fisheries, 2019a; c; d; h)[2].

More broadly, there has been a notable decline in the number GOCLF fishing symbols (*n* = 105 in 1999, *n* = 46 in 2017) and the number of licences accessing the fishery over a 12 month period (*n* = 37 in 2002; *n* = 15–20 from 2012 to 2017) (Department of Agriculture and Fisheries, 2019h). Reductions in the number of fishing symbols and the number of active licences (Department of Agriculture and Fisheries, 2019h) would help to reduce the risk of an undesirable event occurring for one or more of the ecological components. While not universal, one of the benefits of reducing the number of fishing symbols and active licences is that there is a direct correlation with the amount of effort utilised in the fishery. The premise being that a decrease in the number of active licences would be accompanied by a reduction in effort and a corresponding but not necessarily equal reduction in total fishing mortality. The extent of this benefit would be dependent on a range of factors including the species being targeted, improvements in fishing efficiency, fishing power increases and effort creep.

4.2 Risk Identification

Fishing activities are frequently subdivided into categories that identify the sources of risk or potential hazards (Astles *et al.*, 2006; 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

[1] *Figure represents the theoretical number of licences that could access the fishery at one point in time. In reality, the number is much less as licences may have multiple ‘L’ symbols attached and/or have them attached to a platform that does not operate in a line fishery e.g. around 40% of the L3 fishery symbols are attached to a licence that is used in the trawl fishery.*

[2] *Based on the effort days of the primary vessel.*

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 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 (*e.g.* from other fisheries) 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 GOCLF 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.

Sources of Risk
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 GOCLF, with **contact without capture** and **loss of fishing gear** viewed as secondary factors of influence. Given the fishing methods, there is a smaller possibility that **disturbance due to presence in the area** and **boat maintenance & emissions** will contribute to the risk posed to one or more of the ecological components. These impacts are likely to be localised, shorter in duration and primarily associated with dory vessels and trolling.

4.2.2 Ecological Components

Target & Byproduct Species (harvested)

A heavy reliance on input controls means that the management regime has limited capacity to deal with increasing effort at a whole of fishery, regional or species level. At a whole of fishery level, licence restrictions and a 56% reduction in the number of fishing symbols indicates that effort in the GOCLF is unlikely to reach that of the ECSMF (Department of Agriculture and Fisheries, 2019h)[3]. Despite this, effort can increase rapidly between seasons; something that was evident in 2017 data where the number of active licences and total effort increased by 20% (2016 = 16 active licences; 2017 = 20 active licences) and 76% (2016 = 625 days fished, 2017 = 1101 days fished) respectively (Department of Agriculture and Fisheries, 2019h). While effort levels and participation rates are still within the historical average, catch in the GOCLF has become more one-dimensional with effort now concentrated on a small group of pelagic fin fish species.

Licence holders in the GOCLF primarily target Spanish mackerel (**harvesting**), with the species making up 97–99% of the reported catch (2015–2017 inclusive) (Department of Agriculture and Fisheries, 2019h). As Spanish mackerel have the highest level of fishing mortality, there is an increased risk that the species will experience an undesirable event due to fishing activities in the GOCLF. This risk is elevated by the lack of information on northern Australian stocks, with a quantitative stock assessment yet to be carried out for Spanish mackerel in the Gulf of Carpentaria. Evidence also suggests that the structure of Spanish mackerel stocks in northern Australia is more complicated with the species forming

[3] *Given the dominance of Spanish mackerel in the GOCLF catch, the ECSMF is considered to be the best direct comparison on the Queensland east coast.*

smaller biological stocks with limited interactions (Lester *et al.*, 2001; Moore *et al.*, 2003; Buckworth *et al.*, 2007; Langstreth *et al.*, 2018b). This combined with an absence of information on stock biomass makes it difficult to establish a baseline of sustainability reference points for this species. Indicative sustainability assessments for the species though indicate that the Gulf of Carpentaria Spanish mackerel stock is being fished sustainably (Langstreth *et al.*, 2018b). This suggests that the risk to this species is being managed under the current fishing environment.

While fishers on the Queensland east coast are known to target Spanish mackerel spawning aggregations, there is limited information on seasonal migration patterns and locations of spawning aggregations in the Gulf of Carpentaria (Moore *et al.*, 2003; Roelofs, 2004; Sumpton & O'Neill, 2004; Buckworth *et al.*, 2007). If fishers were found to be targeting spawning aggregations, high catch rates could be maintained while the metapopulation experiences declines (Buckworth *et al.*, 2007). This again presents as a potential risk as the targeting of spawning aggregations can affect both the standing biomass and long-term recruitment rates. The extent of this risk (low, intermediate or high) will be difficult to quantify without additional information on fishing patterns and Spanish mackerel reproductive behaviours.

Provisions governing the use of the L4 fishery symbol allow operators to retain all fin fish species excluding barramundi, black jewfish, scaly jewfish, blue threadfin, king threadfin, silver javelin and giant Queenfish (Department of Agriculture and Fisheries, 2019h). In the GOCLF, the use of multi-hook apparatus (*e.g.* demersal trotlines or droplines) was prohibited in 2008 and trolling for Spanish mackerel became the dominant fishing method. This transition had a direct impact on the amount and number of fish being retained for sale in the fishery. In 2017, licence holders retained 6t of byproduct consisting of just 18 species or species complexes (excluding Spanish mackerel). Of the byproduct species retained for sale in the GOCLF, only grey mackerel recorded annual retention rates >1t. The remaining species including grass emperor, nannygai, kingfish and trevally were retained in smaller quantities and often at <0.5t per year (based on 2015–2017 data; Department of Agriculture and Fisheries, 2019h). Given these factors, increasing effort will present as a lower risk for the byproduct species. This situation may change if market demand for secondary species increases (**harvesting**)[4] or demersal line fishing becomes more prominent in the GOCLF.

For target and byproduct species, **discarding** of fish will be due to regulations that prohibit their retention or poor marketability/quality (*e.g.* injured or damaged fish). While evidence suggests that commercial operators can improve size selectivity through the use of alternate gear/bait types and the targeting of larger fish in key locations (Roelofs, 2004), a portion of the fish will be **discarded** due to minimum legal size limits. As pelagic schooling fin fish tend to have lower post-release survival rates (Davis, 2002; Broadhurst *et al.*, 2005; Campbell *et al.*, 2010), a proportion of the **discarded** Spanish mackerel will die as a result of this interaction. These mortalities are not included in the catch data and are difficult to quantify or account for in regional stock assessments. Other factors that may contribute to the level of discards in the GOCLF include health concerns surrounding the presence of ciguatera in older/larger fish (Food and Agriculture Organization, 2004; Kohli *et al.*, 2017) and as a result of injuries sustained during the fishing event (*e.g.* from shark depredation).

Contact without capture in the GOCLF applies to fish that have been able to free themselves before landing (*e.g.* foul-hooks, line breaks, and hook dislodgement) and those that are lost due to depredation.

[4] *While black jewfish cannot be retained in the GOCLF it is a good example of how market demand can lead to substantial increases in fishing mortality. Previously viewed as byproduct, interest in black jewfish has increased substantially due to market demand for their swimbladders which can sell for up to $700 a kilogram.*

While difficult to quantify, it is anticipated that post-interaction survival rates will be higher for fish that have escaped the hook before landing. This in part is due to the fish (theoretically) experiencing a shorter fishing event. There may however be longer-term implications for the health of the animal such as an increased risk of predation due to injury, the impacts of biofouling and infections (Borucinska *et al.*, 2002; McLeay *et al.*, 2002). On the other end of the spectrum, depredation occurs when injured and panicked fish attract the attention of larger predators (*e.g.* sharks and dolphins) who take advantage of the tethered prey (Zollett & Read, 2006; Mitchell *et al.*, 2018). Depredation compounds fishing mortality rates and presents a risk to both the fishery and to the predators that interact with the apparatus (from becoming hooked themselves) (Department of Primary Industries and Fisheries, 2005; Raby *et al.*, 2014; Mitchell *et al.*, 2018). As with post-release mortalities, fish lost to depredation are not included in the catch data and are not accounted for in stock assessments. This phenomena may also lead to lost fishing gear and can impact on profitability of fishing operations.

Illegal fishing activities present an additional risk for most fisheries and the GOCLF is no exception. In terms of illegal fishing operations, there is little evidence to suggest that the Gulf of Carpentaria differs markedly from the Queensland east coast. However, the remoteness of the Gulf of Carpentaria combined with a lack of infrastructure means that the region is more sensitive to operational constraints. In the GOCLF, risks associated with illegal fishing will include non-reporting of product (black markets), inaccurate reporting and/or non-compliance with input or output controls such as minimum legal size and in-possession limits. These risks are managed through the Queensland Boating and Fisheries Patrol (QBFP) who continue to enforce the current regulations. These risks are not considered to be exclusive to a particular sector and the overwhelming majority of people adhere to the regulations. However, illegal fishing activities have the potential to impact all ecological components including harvest species and are therefore relevant to this ERA. The ability of QBFP to manage some of these risks (*e.g.* fishing in regulated waters) will improve overtime with the continued implementation of the data validation plan (Department of Agriculture and Fisheries, 2018d) and the introduction of *Vessel Tracking* (Department of Agriculture and Fisheries, 2018e).

Outside of **harvesting** and **discarding**, few of the fishing activities will have a significant impact on the target & byproduct species ecological component. As the GOCLF targets pelagic fin fish via trolling, there is a low risk of gear being lost due to snags on structural features or the substrate (**loss of fishing gear**). Accordingly, the most likely origin for gear loss will be line breakages (**contact without capture**) or poor disposal practices. **Disturbance due to presence in the area** can also be applied to trolling and the risk will be applicable to both the primary vessel and any associated tenders. While these fishing activities will create sound and surface disturbance, the extent of these risks are likely to be low, short term and localised.

Further information on key target and byproduct species including the impact of the fishery on sharks and rays is provided in the *Species of Conservation Concern* overview. Additional information on the impacts of the recreational fishing sector is contained within the 'cumulative impacts' section of this report.

Bycatch (non-SOCC)

In the GOCLF, the majority of bycatch (**discarding**) would consist of target and byproduct species that are not retained due to regulations, health issues (Kohli *et al.*, 2017) and poor product quality. Outside of unwanted target and byproduct species, the remainder of the bycatch component would consist of no-take species (*i.e.* barramundi, black jewfish, scaly jewfish, blue threadfin, king threadfin, silver javelin

and giant queenfish) and low-value/non-marketable fin fish (Department of the Environment Water Heritage and the Arts, 2010; Department of Agriculture and Fisheries, 2019h). The risk to these species will include hook-related injuries, angling stress, and an increased susceptibility to predation (Wells *et al.*, 1986; Taylor *et al.*, 2001; Broadhurst *et al.*, 2005; Danylchuk *et al.*, 2007).

There is little information on the broader composition of GOCLF bycatch, although inferences can be drawn from studies or observational data from neighbouring or closely aligned fisheries such as the Northern Territory Spanish Mackerel Fishery, the ECSMF, and the CRFFF. In fisheries that solely target Spanish mackerel, like the Northern Territory Spanish Mackerel Fishery, bycatch is considered to be negligible (Sly, 2003; Roelofs, 2004). A study in 2005 identified a number of bycatch and byproduct species caught incidentally in the ECSMF, including low-value pelagic fin fish and sharks (Department of Primary Industries and Fisheries, 2005).

Based on the available data, the bycatch ecological component will be at the lower end of the risk spectrum. This inference is based on the assumption that licence holders will continue to target pelagic fin fish via trolling. If demersal line fishing were to become more prevalent in the GOCLF, this assessment will need to be reviewed as the number of species interacting with the fishery will most likely increase.

Species of Conservation Concern

Being a largely pelagic line fishery, the GOCLF has little potential to interact with many of the subgroups included in the *Species of Conservation Concern* (SOCC) ecological component. Of the species subject to additional reporting requirements (SOCI)[5], sea snakes were the only group represented in the logbook data. As a high proportion of these subgroups cannot be retained for sale, **discarding** is considered to be the fishing activity posing most risk to SOCC species.

Marine turtles

While some marine turtle species take baited hooks (*e.g.* loggerhead turtles), their direct capture in the GOCLF is considered unlikely. Trolling offers few opportunities for marine turtles to take baited lines as lures/hooks are towed behind the vessel and near the surface of the water. In the unlikely event that a marine turtle was caught or foul-hooked, the operator will be on hand to release the animal and minimise the interaction period. The risk posed by hook ingestion may be higher for demersal line fishing operations. However, the prominence of Spanish mackerel in the catch data suggests that this type of line apparatus is used infrequently in the GOCLF (Department of Agriculture and Fisheries, 2019h).

Indirect impacts including those associated with entanglements arguably presents as a higher risk for this subgroup. Entanglements can occur in line not associated with a fishing event (*e.g.* line that has been lost, cut off, or discarded during a previous fishing event) or resulting from capture (*e.g.* line that is still attached to a hook embedded or swallowed by the animal) (**contact without capture, loss of fishing gear**). The negative consequences of line entanglement is often long-term and can include death due to asphyxiation or increased predation risk due to impairment or loss of an appendage (Meager & Limpus, 2012). In some instances, the impacts may be more immediate and prevent the animal from reaching the surface *e.g.* if opposite end is attached caught in the substrate.

[5] *Species of Conservation Concern or SOCI refers specifically to species that are subject to mandatory reporting requirements. The SOCI list was used as the foundation of the Species of Conservation Concern (SOCC) ecological component and includes batoids and sharks that can be retained for sale in the GOCLF.*

The expansion of trolling and the banning of multi-hook apparatus (*e.g.* demersal trotlines or droplines) helps mitigate some of the risks posed by gear loss. As lures and baited hooks are towed behind the vessel and nearer the surface of the water, there is a low risk that the line will become entangled to the point that it is not retrievable and/or becomes lost. In the GOCLF, the most likely source of gear loss will be due to line breakages that occur during the fish retrieval process. This is considered to be less of a risk in pelagic line fisheries as operators tend to use gear configurations with higher breaking strains. Accordingly, the GOCLF is expected to make a smaller contribution to the amount of fishing line that is lost or discarded in the Gulf of Carpentaria.

As air-breathing marine animals with habitat range overlaps with key fishing areas (Department of Agriculture and Fisheries, 2019h), turtles are at risk of colliding with vessels engaged in troll fishing activities (**disturbance due to presence in the area, contact without capture**). Trolling is carried out at low speeds, however even low speeds (7km/h) can induce fatal injuries in sea turtles (Work *et al.*, 2010). Vessel strike is one of the leading anthropogenic causes of turtle strandings according to the *Marine Wildlife Standing and Mortality Database* with as many as 126 dead or injured turtles recorded per year on Queensland's coastlines (based on 2000–2011 data; Department of Environment and Science, 2017). As the majority of fishing effort in the GOCLF is via trolling, vessel strike will present as a more moderate risk to marine turtles. The extent of this risk will be tempered by the size of the fishery (n = 46 L4 fishery symbols) and the number of active licences (n = 20) (Department of Agriculture and Fisheries, 2019h).

Given the extent of hooking rates in comparable line fisheries, the interaction potential and the contribution of the fishery to broader risk factors (*e.g.* loss of fishing gear, boat strike), the subgroup is expected to be at the lower end of the risk spectrum.

Sea snakes

Only one sea snake interaction has been reported from the GOCLF through the SOCI logbooks (Department of Agriculture and Fisheries, 2019h). As the majority of effort in this fishery is targeted towards faster moving predatory fish, there is a low to negligible risk that a sea snake will successfully reach the bait/lure.

If a sea snake were to interact with fishing gear (including foul hooks), fishers will be on hand to address the situation. While the animal will incur some injuries, post-release survival rates for this group will be high providing proper handling procedures are followed. Given these factors, the risk of fishing activities causing an undesirable event for sea snakes is considered to be low.

Crocodiles

The GOCLF operates in proximity to areas with higher crocodile densities (Fukuda *et al.*, 2008). However, being a line fishery that mostly target pelagic fin fish, interactions with the gear of the fishery are highly unlikely.

Dugongs

The risk profile for dugongs will be similar to that observed for marine turtles, with vessel activity being the primary driver of risk in this fishery. Trolling is likely to create a **disturbance due to presence in the area**, and increase the likelihood of boat strike (**contact without capture**). These risks will be most relevant in areas where dugong hotspots have been reported including around Mornington Island, Wellesley and South Wellesley Islands, Pellow Islands, and the north-western coast of the

Cape York Peninsula (Department of Environment and Heritage Protection, 2018). To account for these risks, a number of regional closures have been employed to protect dugongs in key areas and/or habitats where dugongs are likely to congregate in higher densities *e.g.* seagrass beds (Zeller & Snape, 2006). Outside of these areas, it can be difficult to assess the level of overlap (small, medium, large) between GOCLF trolling effort and dugong distributions.

While noting the risk of boat strike, interactions between dugongs and the GOCLF are expected to be low. This risk has been reduced through the use of spatial closures and the targeting of pelagic fin fish in deeper waters. It is recognised that information on the extent of the overlap between dugong populations and GOCLF effort is limited. This issue is being actively addressed through the *Queensland Sustainable Fisheries Strategy 2017–2027* and the introduction of *Vessel Tracking* on all commercial fishing boats (Department of Agriculture and Fisheries, 2018e). Going forward, information obtained from *Vessel Tracking* will provide insight on fine-scale effort movements in the Gulf of Carpentaria and will help determine whether further monitoring and assessment for this subgroup is required.

Cetaceans

Cetacean interactions in the GOCLF will be rare and, if applicable, are more likely to be the result of boat strike (**contact without capture**). Data obtained through the SOCI logbooks show that no cetacean interactions have been recorded in the fishery since 2003 (Department of Agriculture and Fisheries, 2019h). Data from the ECSMF though shows that this subgroup will interact infrequently with the line apparatus and the vessel (Department of Primary Industries and Fisheries, 2005). In these instances, the animals were released alive without significant injury or evidence that the interaction had a long-term or detrimental impact of the health of the individual.

As the GOCLF has fewer operators and less effort, the risk posed by this subgroup is expected to be equal to or lower than the ECSMF. In the unlikely event that operators in the GOCLF interact with a cetacean it is more likely to be with the vessel *versus* entanglement in the gear.

Protected teleosts

There are four species of teleost with SOCI reporting requirements: the humphead Maori wrasse (*Cheilinus undulates*), the potato rockcod (*Epinephelus tukula*), the Queensland groper (*Epinephelus lanceolatus*) and barramundi cod (*Chromiletes altivelis*). The distribution of all four species largely centre on the Queensland east coast with only limited accounts of the Queensland groper and Barramundi cod occurring in Gulf of Carpentaria waters (Australian Museum, 2013; 2016c; a; b). As a line fishery that primarily targets fast moving pelagic fin fish, the GOCLF will have limited opportunities to interact with these larger, reef dwelling species under the current fishing environment.

Batoids

The distribution of fishing effort in the GOCLF overlaps with a wide range of batoid species inhabiting both inshore (<2m depth) and offshore (>2m depth) waters. The potential for the fishery to interact with this subgroup has reduced substantially with the increased use of trolling to target Spanish mackerel. As lures/hooks are towed behind the vessel and near the surface, the majority of benthic batoids are unlikely to target the bait. Similarly, pelagic batoids including manta rays and devil rays are unlikely to interact intentionally with the apparatus as it would not resemble their preferred prey (Last & Stevens, 2009; Last *et al.*, 2016).

Batoids, unlike other subgroups included in the SOCC ecological component, can be retained for sale in the GOCLF. Catch data for the fishery show that stingrays contribute negligible amounts to the total catch; <4t since 1993 (**harvesting**). In instances where batoids were retained for sale, they were more likely to be caught using multi-hook apparatus (*e.g.* demersal trotlines or droplines). As these are now prohibited in the GOCLF, it is unlikely that the fishing pressure exerted on regional populations will increase dramatically as a result of the GOCLF.

Given the current fishing environment, this SOCC subgroup is unlikely to experience an undesirable event due to fishing activities in the GOCLF. If demersal line fishing were to become more prevalent in the GOCLF, this assessment will need to be reviewed as the number of species interacting with the fishery will most likely increase.

Sharks

Assessing the risk to this SOCC subgroup is more complicated as it includes both protected species and species that can be retained for sale. Sharks have historically formed part of the total GOCLF catch with maximum catch levels peaking in 2007 at 141t (Department of Agriculture and Fisheries, 2019h). Catch of this subgroup has reduced dramatically since the banning of multi-hook apparatus with operators reporting less than 1t since 2010 (Department of Agriculture and Fisheries, 2019h).

The GOCLF has the potential to interact with a range of shark species, with **contact without capture** considered to be the primary source of risk followed by **discarding**. Anecdotal evidence suggests sharks will target Spanish mackerel operations and prey on hooked fish being angled to the surface. If handled correctly, post-release survival rates for **discarded** line-caught sharks will be high. However, mortalities may still occur in this fishery due to injuries incurred during the fishing event and/or due to poor handling techniques *e.g.* use of a gaff, injuring the shark during the gear retrieval process. The extent of these mortalities or injuries will be difficult to quantify without additional catch validation measures and further information on the fate of line caught sharks (*e.g.* number of sharks retained for harvest in the GOCLF, discarded: line cut, discarded: injured). With the expansion of the shark reporting requirements, some of this information is already being collected from the GOCLF [6].

Unless there is a significant change in the fishing environment and/or a large scale movement of effort towards sharks, the primary risk to this subgroup will be **contact without capture**. However, there is limited information on the extent of these types of interactions in the GOCLF. This subgroup may also require further assessment if circumstances change and demersal line fishing becomes more prominent in this fishery.

Syngnathids

Interactions between GOCLF and syngnathids is highly unlikely and the fishery poses a negligible risk to this subgroup.

Seabirds

There is little information about seabirds interacting with the GOCLF, but a report on bycatch in the ECSMF identified low interaction rates with this subgroup (Department of Primary Industries and Fisheries, 2005). These interactions mostly involved entanglements rather than hooking and the

[6] *As on 1 January 2018, all net and line operations must report shark discards as part of the logbook reporting system.*

presence of the fisher helped minimise the duration of the interaction and the risk of injury. As the GOCLF targets similar species with the same apparatus, the risk profile for this subgroup will be similar.

Within the fishery, trolling operations will have the greatest potential to interact with this subgroup as the bait/lure is towed closer to the water surface. This increases the interaction potential as seabirds can access the bait during the fishing event. While noting these risks, data from the ECSMF suggests that seabird interactions in the smaller GOCLF will still be low and infrequent. However, it will be difficult to quantify the extent of these interactions (*i.e.* none, very rare, infrequent or frequent) and the level of risk (*i.e.* negligible, low, intermediate, high) without further validation of the SOCI data.

When compared to direct capture, entanglement in lost or discarded fishing line (**loss of fishing gear**) presents as a higher risk for this subgroup. This risk transcends the GOCLF and will be applicable to both the commercial and recreational fishing sectors. As the recreational fishery uses lighter gear and has varying levels of experience, this sector will make a significant contribution to the amount of lost and discarded fishing line. To this extent, the risks posed by **loss of fishing gear** are anticipated to be lower in the commercial GOCLF.

Terrestrial mammals

The false water rat *Xeromys myoides* is a small native mammal that has a semi-aquatic lifestyle. Interactions between GOCLF operators and this species are highly unlikely and the fishery presents a negligible risk to this subgroup.

Marine Habitats

While the GOCLF operates mostly in offshore waters (>2m deep) targeting Spanish mackerel, L4 fishers can target fin fish species across a variety of habitats including reefs and inshore areas. While there is potential for this fishery to have an impact on regional marine habitats, it will be far smaller when compared to other fishing methods such as net or trawl. This is primarily due to trolling being the primary fishing method used in the GOCLF and the reduced potential for operators to interact directly with regional habitats during a fishing event.

In line fisheries, **loss of fishing gear** is often identified as one of the key impacts on regional habitats. Fishing line is easily lost, particularly if it becomes snagged or tangled on benthic substrate. Within the GOCLF, loss of fishing gear will be a most relevant to demersal line fishing operations. These operations make up a very small component of fishing activities in the GOCLF and, as a consequence, this is considered to be a relatively low risk for this fishery.

While operators may still interact with marine habitats in non-fishing events (*e.g.* anchoring and general boating activities), this ecological component will be at a lower overall risk.

Ecosystem Processes

Trolling, the main line fishing method used in the GOCLF, is not considered to be a high risk to many marine ecosystem processes due to limited contact with the substrate and interactions with fewer species. Of the ecosystem processes taken into consideration as part of this Level 1 assessment (Appendix 1), the most significant risks will be associated with the effects of the removal of predators, depredation and facilitated foraging (*e.g.* scavenging).

Spanish mackerel are considered to be high-order pelagic predators. Several other top order predators (sharks, tuna etc.) also occupy this niche, targeting similar species and exerting similar top down

predator effects. Theoretically, the removal of predators from an ecosystem can affect prey abundance and induce trophic cascades by altering competition dynamics. However, these effects have not been demonstrated for Spanish mackerel and it is unknown if the removal of these fish will result in regional phase shits in species assemblages and or trophic shifts.

Anecdotal evidence from the Gulf of Carpentaria indicates that sharks will interact with the fishery through the depredation of hooked fish (**contact without capture**). A recent study suggested sharks are attracted to the sensory cues emitted by fishing activity, and that sharks may form behavioural associations with fishing vessels causing increased depredation in areas with higher fishing traffic (Mitchell *et al.*, 2018). Dolphins have also been suggested to form behavioural associations with trolling activities for Spanish mackerels and other pelagic fin fish (Zollett & Read, 2006). These interactions likely form an energetically efficient method of feeding (scavenging) but increase the risk of hooking (often leads to **discarding**), entanglement, and retaliation from fishers (Zollett & Read, 2006; Waples *et al.*, 2013). Shifts in migrations, site fidelity or dietary preferences by predators may also result from these interactions (Madigan *et al.*, 2015; Mitchell *et al.*, 2018).

Pelagic sub-surface predators have an important symbiotic relationship with tropical seabirds. Spanish mackerel, amongst other predatory fish *i.e.* tuna, drive prey species to the surface making them available to seabirds (*pers. comm.* B. Congdon). Facilitated foraging is important for tropical breeding seabird populations, with previous studies identifying associations with increased seabird foraging and high densities of predatory fish (Miller *et al.*, 2018). Reductions in large predatory fish biomass can result in poor foraging success, and reduced reproductive output for tropical seabird populations (Devney *et al.*, 2009; Miller *et al.*, 2018). However, there is little information regarding the level of interdependence within this relationship, and whether large scale depletions of Spanish mackerel would result in reduced seabird foraging success.

On the east coast, fishers target Spanish mackerel in spawning aggregations when they migrate north in Spring (Tobin *et al.*, 2014; Buckley *et al.*, 2017). As previously stated, Spanish mackerel spawning aggregations and seasonal migration patterns in the Gulf of Carpentaria are poorly understood (Moore *et al.*, 2003; Roelofs, 2004; Sumpton & O'Neill, 2004; Buckworth *et al.*, 2007). There is little evidence that GOCLF fishers are currently exploiting reproductive aggregations of this species, but if they were, it has the potential to impact ecosystem processes like recruitment, predation, particle feeding and connectivity.

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

4.3.1 Fisheries Related Impacts

Other Fisheries

Within Queensland, Spanish mackerel are retained in smaller proportions in the Gulf of Carpentaria Inshore Fin Fish Fishery (GOCIFFF) (**harvesting**). In recent years (2015–17), the GOCIFFF's harvest of Spanish mackerel has been around 40t per year, and has remained relatively consistent through time (Department of Agriculture and Fisheries, 2019g). Outside of Spanish mackerel, the GOCIFFF and the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (GOCDFFTF) retain a number of species permitted for sale in the GOCLF. In 2017, net fishers from the GOCIFFF harvested 1934t of product from these waters, most of which were fin fish and shark (Department of Agriculture and Fisheries, 2019b). While effort in the GOCDFFTF is depressed at the moment, the fishery targets schooling species including demersal tropical snapper species (Department of Agriculture and Fisheries, 2019f). As the GOCLF takes limited amounts of byproduct, the risk to these species is arguably greater in the GOCIFFF and GOCDFFTF.

Genetic evidence indicates that there at least three biological stocks of Spanish mackerel in northern Australia including one in the Gulf of Carpentaria. The Gulf of Carpentaria Spanish mackerel stock was assessed as sustainable in the SAFS process (Langstreth *et al.*, 2018b). However, the SAFS report also noted otolith microchemistry, parasitological analyses and migratory evidence suggesting Spanish mackerel form smaller biological stocks with limited movements (Lester *et al.*, 2001; Moore *et al.*, 2003; Buckworth *et al.*, 2007; Langstreth *et al.*, 2018b). Uncertainty surrounding the structure of regional Spanish mackerel stocks makes it difficult to determine the extent of the cumulative risk this species is exposed to across jurisdictions. This situation is compounded by the fact that a regional stock assessment has yet to be completed for this species.

While recreational fishers are subject to individual limits, catch reporting is not mandatory and the level of information for this sector is limited. In 2007, a routine monitoring program commenced in the Gulf of Carpentaria for the collection of biological information (length, sex and age) from recreationally and

commercially caught Spanish mackerel (Department of Agriculture and Fisheries, 2018b). Additional information for this sector is collected through periodical recreational fishing surveys (Webley *et al.*, 2015). Unfortunately, data on the recreational catch of Spanish mackerel in the Gulf of Carpentaria is of low confidence and therefore cannot be used to distinguish catch, release or retention rates. However, the 2013/14 recreational fishers' survey reported 55,000 line caught Spanish mackerel across the state (Webley *et al.*, 2015). A dated annual status report also estimated the Gulf of Carpentaria recreational Spanish mackerel catch to be around 15t[7] (**harvesting**, **discarding**) (Department of Agriculture Fisheries and Forestry, 2013). While Spanish mackerel are caught in the charter fishery, less than 1t were reported from this sector in 2017 (Department of Agriculture and Fisheries, 2019g).

When compared to the commercial fishery, recreational and charter fishers target a wider range of species (**harvesting, discarding**). Based on the results of the last recreational fishing survey (Webley *et al.*, 2015), some of the more popular species include mullet, threadfin, barramundi, tropical snapper and sea perch (Department of Agriculture and Fisheries, 2019g)[8]. In comparison, blue threadfin (18t) and school mackerel (7t) were the most prominent species reported from the charter fishing sector (Department of Agriculture and Fisheries, 2019g). As these species can be retained by commercial fishers in the Gulf of Carpentaria (GOCLF and/or GOCIFFF), recreational and charter fishers will be an additional source of fishing mortality. It is noted though that participation rates in both the recreational and charter fishing sectors are lower than on the Queensland east coast. This is partly due to the Gulf of Carpentaria being less accessible.

Outside of **harvesting** and **discarding**, **loss of fishing gear** presents as one of the more notable risks emerging from the recreational and charter fishing sectors. This risk largely relates to the accessibility of recreational fishing, the sector having a higher number of participants and varying levels of experience *i.e.* fishing gear is readily available, is cost effective and can be used by a wide range of people. The impacts of lost and discarded fishing line will be similar to those observed in the commercial fishery including for SOCC subgroups like marine turtles. However, the density of lost line may be higher in and around fishing locations that are more accessible. Given the above factors and the type of line used, the recreational sector will make a significant contribution to the amount of fishing line that is lost or discarded.

Risks relating to the harvest of GOCLF 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 aspects of the fishery may be less stringent and take into account the importance of traditional fishing rights. Catch and effort rates for this sector 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 a lower risk for a number of the ecological components including harvested species, bycatch and marine habitats because of low numbers. This risk though will be highly dependent on the species and their significance to this sector.

4.3.2 External Impacts

Climate Change & Environmental Degradation

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

[7] *Based on a conversion rate of 7.6 kg per fish.*
[8] *Specifically Weipa coastal waters, Karumba coastal waters, Mornington Island coastal waters and the Gulf catchment.*

recent years. In Queensland, the severity of storms, tropical cyclones and extreme rainfall events are predicted to increase by the end of the century (Climate Council, 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. This is perhaps best exemplified by a relatively recent environmental event that resulting in the mass die-off of mangroves in the Gulf of Carpentaria (Duke *et al.*, 2017)

Changes in temperature and oceanic chemistry have been seen 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 GOCLF, 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.

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 GOCLF, 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 strike 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 Environment and Energy, 2015).

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. The risk will also be much larger on the Queensland east coast; particularly in areas with higher population densities *e.g.* south-

east Queensland. To provide some context, the *Marine Wildlife Stranding and Mortality Database* attributes between 60 and 116 turtle mortalities or carapace fractures per year to boat strike (2000–2011 data) across the State (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 (based on 2000–2011 data) (Meager & Limpus, 2012).

Marine Debris & Pollutants

Discarded and lost fishing gear from both commercial and recreational fishing is abundant in the marine environment. Nylon and other synthetic materials are extremely persistent in the marine environment. Plastic marine debris is a significant problem for the health of all marine ecosystems, through the degradation of habitats, ingestion by organism and entangling marine life. 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, will degrade into microplastics, which are easily ingested by many species, including species harvested for human consumption. These 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, 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 corals and seagrass cover, population declines in megafauna and the overall degradation of the marine environment (Brodie *et al.*, 2017). These impacts may not be as prevalent in the GOCLF largely due to the lower level of agricultural development within the Gulf of Carpentaria outside of the main ports and population centres such as Karumba and Weipa.

The GOCLF is likely to represent a comparatively small, but consistent, source of marine pollution. However, these risks are very difficult to quantify and almost impossible to assign to a particular sector or activity, due to the multifaceted sources of this risk. For example, marine pollutants can be sourced from land based runoff and boat emissions, from not only fishers but also recreational boat users and commercial shipping as well. Marine pollutants and emissions present a somewhat unique situation in that they are a risk to the fishery whilst risk is simultaneously increased by fishing activity.

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, 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 the above approach, preliminary assessments for the GOCLF indicated that fishing activities presented a negligible to intermediate risk for all but one of the ecological components. 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 and byproduct species received higher risk ratings due to a) the absence of an overarching control on catch or effort and b) an absence of finer-scale information on stock distributions and biomass estimates for Spanish mackerel;
- target and byproduct species received a higher cumulative risk rating due to their targeting and retention in other fisheries namely the GOCIFFF, the GOCDFFTF and the recreational fishing sector;
- the fishery presented a low risk to the majority of the non-targeted species including a number of the SOCC subgroups;
- the bycatch ecological component was assigned a higher risk rating (low/intermediate) due to an absence of data on discard compositions and discard fates; and
- the highest risk ratings assigned to sharks was driven largely by interactions with hooked fish *i.e.* depredation.

Preliminary risk ratings assigned to each ecological component were influenced by the (largely) one-dimensional nature of the GOCLF. While trolling is the dominant line fishing method, operators are able to target demersal fin fish species with more conventional line fishing techniques. The risk profile for demersal line fishing will be different to trolling and may include a higher number of species. Data for this fishery though indicates that demersal line fishing makes up a small component of the catch and effort reported from the GOCLF. This was reflected in the preliminary risk ratings.

Table 2. *Summary of preliminary risk scores for the GOCLF including the impact of the main fishing activities on key ecological components.*

Ecological Component	Line Fishing Activities							Preliminary Risk Rating	Cumulative impacts Other fisheries
	Harvesting	Discarding	Contact without capture	Loss of fishing gear	Travel to/from grounds	Disturbance due to presence in area	Boat maintenance & emissions		
Target & Byproduct	H	I/H	I	-	-	L	L	H	H
Bycatch (non-SOCC)	L	L/I	L	-	-	L	L	L/I	L
SOCC									
- *Marine turtles*	-	L	L	L	-	L/I	L	L/I	I
- *Sea snakes*	-	L	L	L	-	L	L	L	L
- *Crocodiles*	-	-	-	-	-	-	L	L	L
- *Dugongs*	-	-	L	L	-	L	L	L	L
- *Cetaceans*	-	-	L	L	-	L	L	L	L
- *Protected teleosts*	-	L	L	L	-	L	L	L	L
- *Batoids*	L	L	L	L	-	L	L	L	L
- *Sharks*	L	L	I	L	-	L	L	I	L
Syngnathids	-	-	-	-	-	L	L	L	-
- *Seabirds*	-	L/I	L	L	-	L	L	L/I	L
- *Terrestrial mammal*	-	-	-	-	-	-	-	-	-
Marine Habitats	-	-	-	L	-	L	L	L	L
Ecosystem Processes	I	I	L	-	-	-	-	I	L

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, 2018a).

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, 2018a).

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 preliminary risk ratings of seven ecological components were reduced (Appendix 2). The most notable amendments were to the target & byproduct ecological component and the sharks SOCC subgroup. As operators primarily target Spanish mackerel, the risk rating for target & byproduct species was reduced from high to intermediate/high. This reduction recognises the increased specificity of trolling and the fact that operators interact with and retain a smaller number of species (Department of Agriculture and Fisheries, 2019h). The ability to further reduce this risk rating was limited by an absence of biomass estimates for the key species (Spanish mackerel), uncertainty surrounding the structure of regional Spanish mackerel stocks (Langstreth *et al.*, 2018b), an absence of an effective control on catch or effort and limited information on discard rates and fates for non-target species (Table 3).

The preliminary risk rating for sharks was influenced by **contact without capture**; the only fishing activity to be assigned a risk rating above low for this subgroup (Table 2). This type of interaction is more synonymous with depredation or the targeting of line-caught fish during the retrieval process. The majority of these interactions will result in the loss of the fish with the shark incurring minimal injuries. Accordingly, the risk rating for sharks was reduced from an intermediate to low/intermediate (Table 3, Appendix 2). This risk rating is considered to be precautionary in nature and could be reduced further with additional information on discard compositions, depredation rates and release fates. The remainder of the amendments involved low risk species or subgroups that are unlikely to interact with the GOCLF (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 Gulf of Carpentaria Line Fishery (GOCLF) taking into consideration the likelihood of the risk coming to fruition in the short to medium term.*

Ecological Component	Level 1 Risk Rating	Considerations of Likelihood and Mitigation Measures	Level 2 Required?
Target & Byproduct	Intermediate / High	• Absence of an effective control of catch or effort at a whole of fishery, regional, and species level. • Potential for effort to increase rapidly between fishing seasons *e.g.* in 2017 number of licences active in the fishery increased from 16 to 20 and resulted in a 76% increase in effort (Department of Agriculture and Fisheries, 2019h). • Licence holders primarily target Spanish mackerel and the targeting of this species was influential in the risk profile of this ecological component. While operators can target other species, demersal line fishing only makes up a small component of the GOCLF catch and effort. • Biomass reference points are not available for Spanish mackerel in the Gulf of Carpentaria; although the stock has been assessed as sustainable as part of the SAFS process (Langstreth *et al.*, 2018a). • There is some uncertainty surrounding the structure of regional Spanish mackerel stocks (Langstreth *et al.*, 2018b) and the full extent of fishing mortality may be underestimated due to post-release mortalities and data deficiencies within the recreational fishing sector. • Given the relatively one-dimensional nature of the GOCLF, risks posed to this ecological component are best addressed through the *Monitoring and Research Plan* and the harvest strategy framework. Key considerations should include improving the level of information on stock dynamics, biomass reference points for Spanish mackerel and cumulative fishing pressures (commercial and recreational). • The current management regime provides operators with sufficient flexibility to adjust their fishing behaviours and target a wider array of species *e.g.* to responding to a changing market demand. If this were to occur and/or demersal line fishing becomes	No – Monitoring & Research Plan / Harvest Strategy.

		more prevalent, a review of the risk rating may be necessary. • Various initiatives being considered or implemented as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* will help to refine this assessment. This includes a more expansive stock assessment program, the introduction of electronic logbooks and electronic observation.	
Bycatch (non-SOCC)	Low	• The introduction of a prohibition on the use of multi-hook apparatus (*e.g.* demersal trotlines or droplines) has reduced the risk to this ecological component. • As trolling (the primary line method) is specifically targeted at pelagic species, the GOCLF will interact with a smaller number of demersal fin fish species including non-targeted bycatch. • The majority of discards will now involve non-target pelagic species or Spanish mackerel that are returned to the water due to regulations, poor quality, or health concerns (Kohli *et al.*, 2017). These risks are addressed as part of the target & byproduct species ecological component. • While demersal line fishing will interact with a wider array of species, the dominance of Spanish mackerel suggests that this section of the fishery accounts for a small amount of the total catch and effort. This was reflected in the final risk rating for this ecological component. • In the event that the fishing dynamics change and demersal line fishing becomes more prevalent, a review of the risk rating may be necessary. • Subsequent ERA would benefit from additional information on the bycatch amounts, compositions and fates. • Various initiatives to improve catch reporting processes are being considered as part of the *Queensland Sustainable Fisheries Strategy 2017–2027*. This includes the introduction of electronic logbooks and electronic observation.	No
Species of Conservation Concern (SOCC)			
Marine turtles	Low	• While the fishery overlaps with the distribution of a number of the marine turtle species, direct capture	No

		and entanglement in fishing line will be low. This is primarily due to the species being targeted and the use of trolling as the primary fishing method. • Some marine turtle species have been known to take baited hooks. This is unlikely to occur when trolling for pelagic fin fish and this risk will be more relevant to demersal line fishing operations. In the event that the fishing dynamics change and demersal line fishing becomes more prevalent, a review of the risk rating may be necessary. • This subgroup is particularly susceptible to cumulative risks including lost fishing line (particularly from the recreational fishing sector), boat strikes and customary hunting. • Although interaction rates are anticipated to be low, this assessment will be difficult to quantify without additional measures to validate SOCI interactions. • Various initiatives to improve catch reporting processes are being considered as part of the *Queensland Sustainable Fisheries Strategy 2017–2027*. This includes the introduction of electronic logbooks and electronic observation.	
Sea snakes	Negligible	• While research shows that sea snakes will take a baited hook, this type of interaction is infrequent and more likely to occur in demersal line fisheries or the recreational fishing sector. • In the GOCLF, sea snakes are unlikely to target moving lures/baits that are being actively towed behind the vessel. Therefore, interactions between sea snakes and the GOCLF are unlikely. • Further management of risk not required for this SOCC subgroup.	No
Crocodiles	Negligible	• Negligible to low due to the species being targeted and the fishing method used. • Further management of risk not required for this SOCC subgroup.	No
Dugongs	Low	• Low risk to this ecological component due to the species being targeted, the areas being fished and the fishing method being used. This subgroup are also afforded additional protections from regional	No

		fishing pressures *e.g.* spatial closures protecting key habitats. • Further management of risk not required for this SOCC subgroup.	
Cetaceans	Low	• Low risk to this subgroup due to the species being targeted and the fishing method used. • Contact without capture interactions are possible as species may interact with the vessel and targeting bait or captured fish (*i.e.* depredation). Direct risks posed by line fishing including hooking and entanglements considered to be low. • SOCI reporting requirements are in place for this subgroup and contact with the vessel is classified as an interaction. • Further management of risk not required for this SOCC subgroup.	No
Protected teleosts	Low	• Considered to be low risk due to the species being targeted and the primary fishing method used. • The distribution of all four key species largely centre on the Queensland east coast with only limited accounts of the Queensland groper and Barramundi cod occurring in Gulf of Carpentaria waters (Australian Museum, 2013; 2016b; c; a). • If an interaction were to occur it would be more likely in the demersal line fishery. In the event that the fishing dynamics change and demersal line fishing becomes more prevalent, a review of the risk rating may be necessary.	No
Batoids	Low	• Low risk to this ecological component due to the species being targeted, the areas being fished and the fishing method being used. • A large reliance on trolling will reduce interactions with benthic batoids and pelagic batoids are unlikely to interact with the hook or lure intentionally. • There is limited information on the frequency of batoid interactions and/or species compositions across the GOCLF including in demersal line fishing operations.	No

		• If handled correctly, post interaction survival rates expected to be high. However, the animal may incur injuries during the line retrieval or handling process. • In the event that the fishing dynamics change and demersal line fishing becomes more prevalent, a review of the risk rating may be necessary.	
Sharks	Low / Intermediate	• Strong spatial overlap between key fishing grounds and preferred habitats and higher potential for interactions to occur. • The risk posed to this subgroup has been reduced by management changes that prohibited the use of multi-hook apparatus (*e.g.* demersal trotlines or droplines). These changes have made the retention of sharks in GOCLF less appealing. • Subgroup can still be retained for sale in this fishery; although the majority will be discarded due to poor marketability. Interactions are more likely to occur through depredation. • If handled correctly, post interaction survival rates for discarded sharks will be high. However, poor handling procedures (*e.g.* use of a gaff, injuring the shark during the gear retrieval process) can lead to additional injuries and mortalities. • There is limited information on the frequency of shark interactions and the species compositions. These data deficiencies are partly being addressed through the expansion of the shark and ray logbook program to all commercial net and line fisheries. There is however limited capacity to validate this data (at this point in time). • Various initiatives to improve catch reporting processes are being considered as part of the *Queensland Sustainable Fisheries Strategy 2017–2027*. This includes the introduction of electronic logbooks and electronic observation.	No – Monitoring & Research Plan.
Syngnathids	Negligible	• Negligible to low due to the species being targeted and the fishing method used. • Further management of risk not required for this SOCC subgroup.	No

Seabirds	Low	• At a whole of fishery level, the GOCLF will have limited interactions with this subgroup. • Seabirds are one of the few SOCC subgroups where the risk posed by trolling will be higher. This is because the bait is towed closer to the surface and will be more accessible to birds targeting bait at shallower depths. • Data from the East Coast Spanish Mackerel Fishery (ECSMF) indicates that sea bird entanglements can occur in this type of fishery. • Risks are largely managed through restrictions on number of lines and hooks plus guides on best management and handling. The presence of the operator will help to reduce interaction times in the event that a bird gets caught or becomes entangled in the line. • The collective risk associated with discarded line (*e.g.* commercial, recreational and charter fishing) considered to be more significant for this subgroup and may require further investigation *e.g.* outside the ERA framework.	No
Terrestrial mammal	Negligible	• Negligible to low due to the species being targeted and the fishing method used. • Further management of risk not required for this SOCC subgroup.	No
Marine Habitats	Low	• The majority of the fishing activities involving towing of baited hooks or lures behind the vessel and closer to the water surface. These operations will have minimal impact with the substrate / regional marine habitats. • Most interactions will occur during non-fishing events *e.g.* anchoring and general boating activities. The extent of these interactions will be restricted by the maximum operating potential of the fishery (n = 46 fishery symbols). • The marine habitat ecological component will experience some cumulative risks due to the popularity of recreational and charter fishing. The region though is less accessible and participation rates will be lower when compared to the Queensland east coast.	No

Ecosystem Processes	Intermediate	• Intermediate risks to this ecological component with the removal of predators identified as one of the key factors of influence. • Given the uncertainty surrounding regional stock structures and the risk of post interaction mortalities, the fishery may impact recruitment rates / connectivity. • Risks will be partly mitigated by the size of the fishery, current participation rates and the accessibility of the region for non-commercial fishing sectors (*e.g.* recreational fishers). • Risk profile for this ecological component will change if demersal line fishing becomes more prevalent and/or if operators in the GOCLF start targeting a broader range of species.	No

4.6 Issues Arising

Potential Catch & Effort Increases—Spanish mackerel

While the fishery as a whole may not experience a significant increase in effort, there is considerable potential for effort to increase at a regional level and for individual species. This is because the management regime for the GOCLF does not include an overarching control on catch or effort. Given the current dynamics of the fishery, this risk will be most applicable to Spanish mackerel; the species with the highest levels of catch and effort (Department of Agriculture and Fisheries, 2019h).

Stock status assessments for Spanish mackerel indicate that the species is being fished sustainably in the Gulf of Carpentaria (Langstreth *et al.*, 2018b). However, Spanish mackerel have not been subject to a regional stock assessment, and biomass estimates are not available for this species in the Gulf of Carpentaria. Further, evidence suggests that the stock structure of north Australian Spanish mackerel may be more complicated with the species forming smaller biological stocks that have limited interactions (Lester *et al.*, 2001; Moore *et al.*, 2003; Buckworth *et al.*, 2007; Langstreth *et al.*, 2018b). While the Gulf of Carpentaria stock is classified as sustainable, an absence of biomass estimates and stock uncertainty makes it more difficult to compare potential increases in fishing mortality against key reference points and targets.

There are a number of initiatives being undertaken as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* that will assist in the monitoring and mitigation of this risk. The most notable of these is the expansion of the *Vessel Tracking* program (Department of Agriculture and Fisheries, 2018e). Improved data on fine-scale effort patterns will aid in the refinement of this ERA and help evaluate the impact on the fishery on regional stocks. The stock assessment program has also been extended to include more species and regional assessments for species with larger geographical ranges. It will however take time to obtain the level of data needed to refine the outputs of the Level 1 ERA.

Species Composition Data

In any multi-species fishery, the acquisition of better catch data will continue to be of high priority. Refinements to the logbook reporting system have improved the level of data on GOCLF catch compositions through time. This is most notable in the amount of catch being reported in generic categories like *Unspecified Mackerel*, *Unspecified Shark, Unspecified Fish* (Department of Agriculture and Fisheries, 2019h). Cross checking of logbook data through catch disposal records and unload reporting also occurs where links have been identified (Fisheries Data Validation Plan) (Department of Agriculture and Fisheries, 2018d).

Improved Monitoring & Research was included in the *Queensland Sustainable Fisheries Strategy 2017–2027* as one of four foundation reforms. The improvement of commercial fishing data is now being addressed through a dedicated *Fisheries Data Validation Plan* and through the *Monitoring and Research Plan* (Department of Agriculture and Fisheries, 2018d; c). These reforms along with the expansion of the *Vessel Tracking* program will improve the accuracy of Queensland's catch and effort data. These measures though will take time to develop and implement, and will therefore take time to filter through to the ERA process.

Discard and Non-retention Rates

The overwhelming majority of data compiled through the logbook reporting system relates to the retained portion of the catch. As discards are not accounted for in the logbook data for most species, the reporting systems may mask the true extent of fishing mortality. This heightens the risk that one or more of the ecological components or their subcomponents will experience an undesirable event due to fishing activities. Obtaining additional data on discard and mortality rates will be of central importance to understanding and mitigating this risk. Improved data on all three parameters (species compositions, discards, and total mortality) will also help to quantify the level of risk in each sub-sector and help to direct resources towards areas and species with a higher risk potential.

Efforts are already being undertaken in the Gulf of Carpentaria to improve the level of information on discard rates for some species. As of 1 January 2018, all commercial net and line fishers are required to report all shark catch (retained and discarded) through the logbook system. Discard data for this complex will initially be collected at a higher level and will require additional validation measures. While the scope of this data will be limited, it is the first step towards estimating discard rates for an important complex in this fishery. Information on discard rates for other species including key teleosts will remain limited until they are addressed through the *Fisheries Data Validation Plan* or the *Monitoring and Research Plan* (Department of Agriculture and Fisheries, 2018c; d).

A reliance on trolling to target pelagic fin fish species will reduce the number of species that interact with the fishery; particularly demersal fin fish species, sharks and batoids. This situation is likely to change if or when demersal line fishing becomes more prevalent in the GOCLF *e.g.* due to changing market demands. Based on the available data (Department of Agriculture and Fisheries, 2019h), a notable shift towards demersal line fishing is unlikely in the short to medium term. Accordingly, this risk (at present) could be addressed through routine monitoring to determine the extent of any changes in fishing behaviour and evaluate the need for further assessment.

SOCI Interactions

Species of Conservation Interest or SOCI are a group of species that are afforded additional protections in Queensland waters. Often no-take species, this group includes marine turtles, whales, dolphins,

crocodiles, seabirds, sawfish plus a small number of sharks, rays, teleosts and syngnathids. This group formed the basis of the broader 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.

Operators in the GOCLF have only reported a single interaction with a SOCI since the logbook was introduced in 2003. While noting that SOCI interactions will be lower in this fishery, there is limited capacity for management to verify or validate the veracity of this information. If circumstances change and one or more ecological components are progressed to a Level 2 ERA, species with low or inaccurate data sets may be assigned more conservative risk scores. The provisions of more accurate SOCI data enables risk assessments to be refined and provides managers with greater capacity to differentiate between real and potential risks (refer to the ERA Guidelines; Department of Agriculture and Fisheries, 2018a).

Recreational Fishing Data

The historical data for the Queensland recreational fishing sector is poor with state-wide surveys only commencing in 1997. This lack of historical catch, effort and distribution data contributes to significant difficulties in managing risk within the fishery, particularly as fishing effort is not directly regulated in the recreational sector. However, management measures do include in-possession limits, gear restrictions, size limits and spatial closures.

The majority of information on recreationally caught species is obtained through voluntary localised collection of data (*e.g.* the boat ramp survey program, the Fisheries Monitoring Program) and more expansive voluntary recreational fisher surveys (Webley *et al.*, 2015). Although limited, the data do indicate that the recreational catch for some species is as high, or higher, than the commercial sector. Given these factors, the extent of fishing mortality resulting from the recreational fishing requires further investigation.

5 Summary & Recommendations

The final risk ratings for the GOCLF indicate that the fishery presents as a low risk to most ecological components. For most of these, the targeting of Spanish mackerel has helped reduce the number of interactions (*e.g.* with bycatch) and the potential for an interaction to occur (*e.g.* batoids, marine turtles, dugongs, sea snakes, syngnathids and seabirds). From an ERA perspective, this has reduced the need to progress these ecological components to a finer-scale Level 2 (species-specific) ERA. For target and byproduct species, the ecological component with the highest risk rating, these risks largely relate to Spanish mackerel and will be addressed through the *Queensland Monitoring & Research Plan* and *Harvest Strategy Policy*.

Of note, the above considerations are based on the understanding that a) the GOCLF will continue to target Spanish mackerel and b) demersal line fishing makes a minor contribution to annual catch and effort levels. In the event that the fishing dynamics change and demersal line fishing becomes more prevalent (*e.g.* due to changing market demands), a review of the Level 1 ERA will be required. In the interim, the Level 1 ERA identified key knowledge gaps in the risk profiles of some ecological components. These information needs will be progressed to the Fisheries Queensland *Monitoring and Research Plan* for further consideration. Key information needs required to refine risk profiles in the GOCLF include:

- Improving the level of information on Spanish mackerel stocks in the Gulf of Carpentaria including on the stock structure, biomass reference points and spawning aggregation sites.
- Obtaining greater information on cryptic mortalities including post-release mortalities for key species and depredation rates.
- Improving the level of understanding on species compositions, discard rates and fates for low-priority target species and non-target species.
- Further assessment of regional catch and effort levels in the recreational fishing sector for key species where cumulative fishing impacts present as a higher risk.
- Monitoring of key economic drivers, emerging market trends (*e.g.* line fisheries on the Queensland east coast) and their potential to influence regional fishing behaviours such as an increased focus on demersal fin fish species.

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7 Appendix 1—Ecological Processes Preliminary Assessment

A1—Ecological Processes Categories

Categories taken into consideration as part of the Level 1 preliminary ERA 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	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
SPECIES INTRODUCTIONS	The introduction of exotic species and their spread once established

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 '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 GOCLF.

***Table A1**. Summary of preliminary risk scores for the main fishing activities in the GOCLF on key ecosystem processes.*

	Line fishing—main activities of the fishery							
Category	**Harvesting**	**Discarding**	**Contact without capture**	**Loss of fishing gear**	**Travel to/from grounds**	**Disturbance due to presence in area**	**Boat maintenance & emissions**	**Cumulative impacts**
Sedimentation	-	-	-	-	-	-	-	-
Nutrient cycling / Microbial processes	L	-	-	-	-	-	-	L
Particle feeding	-	-	-	-	-	-	-	-
Primary production	-	-	-	-	-	-	-	-
Herbivory	-	-	-	-	-	-	-	-
Predation	I	L	-	-	-	-	-	L
Bioturbation	-	-	-	-	-	-	-	-
Detritivory	-	-	-	-	-	-	-	-
Scavenging	-	L	L	-	-	-	-	L
Symbiosis	L	-	-	-	-	-	-	-
Recruitment	I	-	-	-	-	-	-	-
Reef building	-	-	-	-	-	-	-	-
Competition	L	-	-	-	-	-	-	L
Connectivity	-	-	-	-	-	-	-	-
Outbreaks of disease	-	-	-	-	-	-	-	-
Species introductions	-	-	-	-	-	-	-	-
Ecosystem Processes (overall)	I	L	L	-	-	-	-	L

8 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 GOCLF. 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. • Potential for effort to increase rapidly between fishing seasons *e.g.* in 2017 number of licences active in the fishery increased from 16 to 20 and resulted in a 79% increase in effort.	High	*Likelihood* • Moderate to high for Spanish mackerel but lower for other target/byproduct species. *Mitigation Measures & Considerations* • This risk rating is driven by the targeting of Spanish mackerel and will be precautionary for the entire ecological component.	Intermediate / High

	• Biomass reference points not available for Spanish mackerel (primary target) and evidence suggests the stock structure for this species in northern Australia may be more complicated. • Post-interaction survival rates tend to be lower in pelagic species and the impact of the fishery on regional stocks may be exacerbated by cryptic or unreported mortalities. • Risk posed to species, outside of Spanish mackerel, reduced by the primary fishing method employed in the region (*i.e.* trolling for pelagic species). • Catch compositions indicate that demersal line fishing is limited in the GOCLF. However, operators could adjust their fishing behaviours to alternate species *e.g.* to responding to a changing market demand. • High potential for effort to be transferred between species and limited understanding of fine-scale effort movements.		• Spanish mackerel have been assessed as sustainably fished in the Gulf of Carpentaria. However there is some uncertainty surrounding the structure of stocks in northern Australia (Langstreth *et al.*, 2018b). This combined with the absence of an effective control on catch or effort has resulted in the ecological component receiving a higher risk rating. • Information on non-commercial catch including from the recreational fishing sector is limited for Spanish mackerel species and the extent of the risk from this subgroup is yet to be fully quantified. • The impact of the fishery on other target and byproduct species will be dependent on the extent of demersal line fishing operations. However, this risk will be partly mitigated by a) the maximum operating potential of the commercial sector and b) regional accessibility constraints (*e.g.* for recreational fishers). • The use of a *Vessel Tracking* system in this fishery helps minimise some of the risks posed by non-compliance. This information will also help refine subsequent ERAs including assessments of fine-scale effort patterns.	

Bycatch (non-SOCC)	• Interactions dependant on selectivity of line fishing method—higher interaction potential with demersal line fishing, low potential for trolling (the main fishing method). • Bycatch in this fishery will largely consist of undersized target species or larger Spanish mackerel that are returned to the water due to health concerns *e.g.* ciguatera. • The remainder of the bycatch will consist mostly of non-target pelagic species or fish that have been damaged during the line retrieval process *e.g.* depredation. • There is limited information on the composition of species returned to the water and on post-interaction mortality rates.	Low / Intermediate	*Likelihood* • Considered to be low given that trolling is the dominant fishing method used in the fishery. *Mitigation Measures & Considerations* • Risks relating to the return of undersize or less marketable Spanish mackerel are addressed as part of the target & byproduct species ecological component. • The risk posed to the bycatch ecological component has been reduced by a prohibition on the use of multi-gear apparatus and a heavy reliance on trolling to target pelagic species. These factors will reduce the number of species that interact with the fishery. • While demersal line fishing is permitted in the fishery, the dominance of Spanish mackerel in the catch data indicates that most operators target pelagic species via trolling. • In the event that the fishing dynamics change and demersal line fishing becomes more prevalent, a review of the risk rating may be necessary.	Low
Species of Conservation Concern (SOCC)				

Marine turtles	• Notable overlap with distribution of key species. • Interaction rates expected to be low but limited information on interaction rates and mortalities including for boat strike. • Subgroup received an elevated risk rating due to the increased potential for boat strike.	Low / Intermediate	*Likelihood* • Low due to the species being targeted and the fishing method used. *Mitigation Measures & Considerations* • While the fishery overlaps with marine turtle distributions, direct capture and entanglement in fishing line will be low. This is primarily due to the species being targeted and the fishing method used. • Interactions with the vessel considered to be more likely when compared to a) direct capture on the hook or b) entanglement in fishing line. • While no interactions have been reported in this fishery, one marine turtle interaction has been recorded in the East Coast Spanish mackerel fishery. • Although interaction rates are anticipated to be low, this assessment will be difficult to quantify without additional measures to validate SOCI interactions. • Some marine turtle species have been known to take baited hooks targeting demersal species and/or can become entangled in demersal fishing lines.	Low

			• In the event that the fishing dynamics change and demersal line fishing becomes more prevalent, a review of the risk rating may be necessary. • The impact of the fishery on marine turtles will be partly mitigated by a) the maximum operating potential of the commercial sector and b) regional accessibility constraints (*e.g.* for recreational fishers). • This subgroup though is particularly susceptible to cumulative risks including lost fishing gear (particularly in the recreational fishing sector), boat strike and customary hunting.	
Sea snakes	• Interaction rates expected to be low but limited information on interaction rates and mortalities. • Direct capture by trolling highly unlikely and mortalities (if applicable) not expected to have a significant or long-term impact on regional populations.	Low	*Likelihood* • Negligible to low due to the species being targeted and the fishing method used. *Mitigation Measures & Considerations* • While research shows that sea snakes will take a baited hook, this is more likely in the demersal line fishery or in the recreational fishing sector. • Sea snakes are unlikely to target moving lures/ baits that are being actively towed behind the vessel.	Negligible

			• SOCI reporting requirements are in place for this subgroup and there are limits on the number of lines and hooks that can be used. • Further management of risk not required for this SOCC subgroup.	
Crocodiles	• Interactions with this subgroup highly unlikely. • Limited spatial overlap between key fishing grounds and preferred habitats.	Low	*Likelihood* • Negligible to low due to the species being targeted and the fishing method used. *Mitigation Measures & Considerations* • Further management of risk not required for this SOCC subgroup.	Negligible
Dugongs	• Limited spatial overlap between key fishing grounds and preferred habitats. • Key drivers of risk do not relate to active fishing *i.e.* traveling to and from fishing grounds.	Low	*Likelihood* • Low due to the species being targeted and the fishing method used. *Mitigation Measures & Considerations* • Risk largely relates to non-fishing related activities *e.g.* boat strike, contact without capture. Direct risks posed by line fishing considered to be negligible. • SOCI reporting requirements are in place for this subgroup and there are limits on the number of lines and hooks that can be used.	Low

			• Further management of risk not required for this SOCC subgroup.	
Cetaceans	• Notable overlap with distribution of key species. • Interaction rates expected to be low but limited information on interaction rates and mortalities including for boat strike.	Low	*Likelihood* • Low due to the species being targeted and the fishing method used. *Mitigation Measures & Considerations* • Contact without capture interactions may be possible in this subgroup *e.g.* dolphins targeting bait, depredation. • Risk largely relates to non-fishing related activities *e.g.* boat strike, contact without capture. Direct risks posed by line fishing considered to be negligible. • SOCI reporting requirements are in place for this subgroup and there are limits on the number of lines and hooks that can be used. • Further management of risk not required for this SOCC subgroup.	Low
Protected teleosts	• Risk to this ecological component will be lower for this subgroup as the fishing method targets pelagic species. • Risk will be higher in operations that target fin fish with demersal line fishing.	Low	*Likelihood* • Considered to be low risk due to the species being targeted and the method used. *Mitigation Measures & Considerations* • Interactions with this subgroup with licence holders targeting Spanish mackerel are	Low

			unlikely. The risk to this subgroup will be higher in demersal line fisheries as the species will be more inclined to take a baited hook/lure. • In the event that the fishing dynamics change and demersal line fishing becomes more prevalent, a review of the risk rating may be necessary. • SOCI reporting requirements are in place for this subgroup and there are limits on the number of lines and hooks that can be used. • Further management of risk not required for this SOCC subgroup.	
Batoids	• Fishery overlaps with a range of benthic and pelagic species. • While operators can retain a range of batoid species, marketability constraints will limit their value to GOCLF fishers. • Interaction rates expected to be low due to the species being targeted and dominant fishing method. • Key fishing method (trolling) does not align with feeding behaviours of most batoids (foraging).	Low	*Likelihood* • Considered to be low risk due to the species being targeted and the method used. *Mitigation Measures & Considerations* • The risk to this subgroup will be higher in demersal line fisheries as the species will be more inclined to take a baited hook/lure. • In the event that the fishing dynamics change and demersal line fishing becomes more prevalent, a review of the risk rating may be necessary.	Low

	• However demersal line fishing is permitted in the fishery and some batoids may target baited hooks or lures.		• Further management of risk not required for this SOCC subgroup.	
Sharks	• Strong spatial overlap between key fishing grounds and preferred habitats and higher potential for interactions to occur. • Subgroup can be retained for sale in this fishery; although the majority will be discarded due to poor marketability. • Absence of control for harvesting of most incidentally caught sharks. • A high percentage of interactions would involve depredation / preying on line-caught fish.	Intermediate	*Likelihood* • Subgroup considered to be at the lower than what is reported in the draft assessment. *Mitigation Measures & Considerations* • The risk posed to this subgroup has been reduced by historical management changes that prohibited the use of multi-hook apparatus (*e.g.* demersal trotlines or droplines). These changes have made the retention of sharks in GOCLF less appealing. • Subgroup can still be retained for sale in this fishery; although the majority will be discarded due to poor marketability. • Interactions may occur as a direct result of their capture and/or through depredation. There is limited information on depredation rates or discard compositions. • If handled correctly, post interaction survival rates expected to be high. However, poor handling procedures (*e.g.* use of a gaff, deliberately injuring the shark to retrieve gear) can lead to injuries and mortalities.	Low / Intermediate

			• The risk to this subgroup will be higher in demersal line fisheries as the species will be more inclined to take a baited hook/lure. • There is limited information on the frequency of shark interactions and the species compositions. These data deficiencies are partly being addressed through the expansion of the shark and ray logbook program to all commercial net and line fisheries. There is however limited capacity to validate this data (at this point in time). • In the event that the fishing dynamics change and demersal line fishing becomes more prevalent, a review of the risk rating may be necessary.	
Syngnathids	• Low interaction rates. • Limited spatial overlap between key fishing grounds and preferred habitats.	Negligible	*Likelihood* • Negligible to low due to the species being targeted and the fishing method used. *Mitigation Measures & Considerations* • Further management of risk not required for this SOCC subgroup.	Negligible
Seabirds	• No interactions reported from the fishery. • A limited number of seabirds interactions have been recorded in the East Coast Spanish Mackerel Fishery (ECSMF).	Low / Intermediate	*Likelihood* • At a whole of fishery level, the GOCLF will have limited interactions with this subgroup. *Mitigation Measures & Considerations*	Low

	• Interactions are more likely to be due to line entanglements *verse* direct capture on the hook. • Loss of fishing gear considered to be a cumulative risk for this subgroup.		• Risks will be most relevant to diving species that target bait fish in the first few meters of the water column. • Risks are largely managed through restrictions on number of lines and hooks plus guides on best management and handling. • One of the few subgroups where the risk posed by trolling will be higher. However, interaction rates will be difficult to validate without additional measures. • The presence of the operator will help to reduce interaction times if a bird gets caught or becomes entangled in the line. • The collective risk associated with discarded line (*e.g.* commercial, recreational and charter fishing) considered to be more significant for this subgroup and may require further investigation *e.g.* outside the ERA framework. • The risk profile of this SOCC subgroup may need to be reviewed if fishing effort and/or participation rates increase in the GOCLF. • Various initiatives being considered to improve catch reporting processes, including	

			the introduction of electronic logbooks and electronic observation.	
Terrestrial mammal	• Negligible interactions or spatial overlap.	Negligible	*Likelihood* • Negligible to low due to the species being targeted and the fishing method used. *Mitigation Measures & Considerations* • Further management of risk not required for this SOCC subgroup.	Negligible
Marine Habitats	• Low degree of contact with marine habitats. • Risks associated with lost gear and line / anchor setting and retrieval.	Low	*Likelihood* • Low *Mitigation Measures & Considerations* • As trolling is one of the more active methods of line fishing, the fishery will have limited contact with the marine environment. Most interactions will occur during non-fishing events *e.g.* anchoring during non-fishing events. • Ecological component may experience cumulative risks or impacts *e.g.* from commercial, charter and recreational fishing. However risks will be partly mitigated by the size of the fishery, current participation rates and the accessibility of the region for non-commercial fishing sectors (*e.g.* recreational fishers).	Low

			• Media encouraging best practice such as ensuring rubbish (fishing lines plastic bags are disposed of correctly.	
Ecosystem Processes	• Potential to interact with a wide range of species with varying trophic levels. • Risks will be of low range impact but mostly relate to the removal of predators, potential to impact food chains and recruitment processes.	Intermediate	*Likelihood* • Intermediate. *Mitigation Measures & Considerations* • Risks largely relate to the removal of predators from the system. • Given the uncertainty surrounding regional stock structures and the risk of post-interaction mortalities, the fishery may impact recruitment rates / connectivity. • Risks will be partly mitigated by the size of the fishery, current participation rates and the accessibility of the region for non-commercial fishing sectors (*e.g.* recreational fishers). • Risk profile for this ecological component will change if demersal line fishing becomes more prevalent and/or if operators in the GOCLF start targeting a broader range of species.	Intermediate