Department of Agriculture and Fisheries

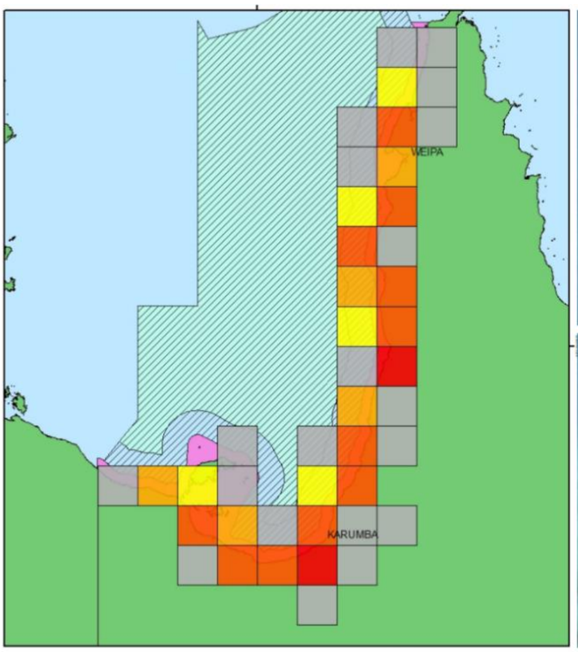
Sustainable Fisheries Strategy

2017–2027

Gulf of Carpentaria Inshore Fishery

Level 2 Ecological Risk Assessment

Species of Conservation Concern



Queensland Government

Gulf of Carpentaria Inshore Fishery
Level 2 Ecological Risk Assessment
Species of Conservation Concern

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Executive Summary

In December 2019, a whole-of-fishery or Level 1 ERA was released for the *Gulf of Carpentaria Inshore Fishery* (GOCIF; Jacobsen *et al.*, 2019a). The Level 1 ERA provided a broad risk profile for the GOCIF, identifying key drivers of risk and the ecological components most likely to experience an undesirable event. As part of this process, the Level 1 ERA considered both the current fishing environment and what can occur under the current management regime. In doing so, the outputs of the Level 1 ERA helped to differentiate between low and high-risk elements and established a framework that can be built upon in subsequent ERAs.

The Level 1 ERA identified a number of high-risk elements that have now progressed to a finer-scale or species-specific Level 2 ERA. This includes target and byproduct species, bycatch, marine turtles, dugongs, dolphins, batoids and sharks (Jacobsen *et al.*, 2019a). Under the ERA Guidelines (Department of Agriculture and Fisheries, 2018c), species with ongoing conservation concerns including those classified as Threatened, Endangered and Protected were prioritised for assessment (referred to herein as *Species of Conservation Concern* or SOCC). For this ERA, risk will be evaluated across the entire GOCIF and will include all gillnet operations fishing in the N3 (largely inshore), N12 (offshore) and N13 (offshore) fisheries. While GOCIF has a small mesh net (N11) fishery, catch, effort and (overall) risk levels for this sector are smaller (Department of Agriculture and Fisheries, 2019b; Jacobsen *et al.*, 2019a). This sector will not be assessed as part of the first interaction of the GOCIF Level 2 ERA process.

The Level 2 ERA was compiled using a *Productivity & Susceptibility Analysis* (PSA) and takes into consideration a range of biological (*age at sexual maturity*, *maximum age*, *fecundity*, *maximum size*, *size at sexual maturity*, *reproductive strategy*, and *trophic level*) and fisheries-specific attributes (*availability*, *encounterability*, *selectivity* and *post-capture mortality*). As the PSA can over-estimate risk for some species (Zhou *et al.*, 2016), this Level 2 ERA also included a Residual Risk Analysis (RRA). The RRA gives further consideration to risk mitigation measures that were not explicitly included in the PSA and/or any additional information that may influence the risk status of a species (Australian Fisheries Management Authority, 2017). The primary purpose of the RRA is to minimise the number of false positives or instances where the risk level has been overestimated.

The scope of the GOCIF SOCC Level 2 assessment was based on the outputs of the Level 1 ERA (Jacobsen *et al.*, 2019a) and considered the risks posed to marine turtles, dolphins, dugongs and a select number of shark and rays. A review of relevant legislation and international instruments produced a preliminary list of 84 species that were considered for inclusion in the Level 2 ERA. This list was rationalised to 27 species consisting of six marine turtles, six dolphins, four sharks, 10 batoids (stingrays, wedgefish, guitarfish) and a single *Sirenia* species (the dugong). The remaining 57 species were excluded from the analysis as their geographical distribution did not overlap with the GOCIF or the species had a limited or low potential to interact with the fishery.

When the outputs of the PSA and RRA were taken into consideration, all 27 species were categorised as high risk from fishing activities in the GOCIF. The final risk ratings were heavily influenced by the life-history and biological constraints of each species with attributes based on reproduction and longevity identified as the key drivers of risk. Scores assigned in the *susceptibility* analysis displayed more interspecific variability; although *selectivity* and *post-capture mortality* were scored consistently high across all subgroups. While not uniform, data deficiencies were a factor of influence in a number of the risk profiles. These deficiencies were most evident in assessments involving the *post-capture mortality* attribute. However, scores for this attribute also considered the effectiveness of the current net attendance provisions which are set at 5–6 nautical miles (nm) in rivers, creeks and nearshore waters (Department of Agriculture and Fisheries, 2019b).

Of the species classified as high risk, 12 were viewed as *precautionary* and were considered more representative of the potential risk. For these species, the risk to the individual is significant as an interaction is more likely to end in mortality. However, the frequency and extent of these interactions are not expected to have a significant or long-term impact on the sustainability of the species and/or regional populations. **Management of the risk posed to species with precautionary ratings, beyond what is already being undertaken as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017), is not considered an immediate priority.** In most instances, these risks are best addressed through the *Monitoring & Research Plan.* With improved information, a number of these species could be excluded from future iterations of the GOCIF SOCC Level 2 ERA.

For the remainder of the species (*n* = 15), the final rating is more representative of the risk posed by gillnet fishing activities across the GOCIF. They are viewed as higher priorities and the management of this risk may require more formal arrangements *e.g.* bycatch mitigation strategies for non-target species, harvest strategies for target species and refining management arrangements for byproduct species. For a number of these species, management of this risk will need to consider actions at a whole-of-fishery and species-specific level. The outputs of the GOCIF SOCC Level 2 ERA will assist in this process and the following recommendations have been identified as areas where risk profiles can be refined and the level of risk reduced. These recommendations are complimented within the report by complex-specific recommendations aimed at reducing risk or improving the accuracy of the assessments involving individual species. A number of these recommendations are being actively considered and progressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027*.

General recommendations

1. *Implement measures to improve fine-scale effort movement information, with particular emphasis on increasing understanding of how gillnets are used in habitats critical to the survival of key species.*

2. *Identify mechanisms to monitor the catch of target and non-target species effectively (preferably in real or near-real time) and minimise the risk of non-compliance with Species of Conservation Interest (SOCI) reporting requirements.*

3. *Identify avenues/mechanisms that can be used to monitor the catch of target and non-target species effectively (preferably in real or near-real time), validate data submitted through the logbook program, and minimise the risk of non-compliance with Species of Conservation Interest (SOCI) reporting requirements.*

4. *Review the suitability, applicability, and value of data submitted through the logbook program on the dynamics of the fishery (the type of gear being used, net configurations, soak times etc.). As part of this process, it is recommended that the reporting requirements be extended to include information on what fishing symbol is being used.*

5. *Review the suitability and applicability of the current net attendance provisions including their effectiveness at a) improving detection of a marine megafauna interaction, b) minimising the duration of a marine megafauna interaction with the net and c) reducing the number of in-situ mortalities.*

6. *Provide a synthesis of habitat data and distributions of key species in a format that is easily compared/overlayed with the effort footprint of the GOCIF.*

7. *Examine options to integrate data collected through the SOCI logbook program with ancillary programs like the Marine Wildlife Stranding and Mortality Database (i.e. StrandNET).*

8. *Review nomenclature used in fisheries legislation to ensure that it reflects the best available information with consideration given to expanding the definition for hammerhead sharks and devilrays.*

9. *Establish a measure to estimate the gear-affected area and, when available and appropriate, reassess the risk posed to key species using a more quantitative ERA method, such as the base Sustainability Assessment for Fishing Effects (bSAFE).*

Summary of the outputs from the Level 2 ERA for the Species of Conservation Concern (SOCC) that interact with the Gulf of Carpentaria Inshore Fishery (GOCIF).

Common name	Species name	Productivity	Susceptibility	Risk rating
Marine Turtles				
Green turtle	*Chelonia mydas*	2.29	2.75	High
Loggerhead turtle	*Caretta caretta*	2.43	2.75	Precautionary High
Hawksbill turtle	*Eretmochelys imbricata*	2.29	2.75	High
Flatback turtle	*Natator depressus*	2.43	2.75	High
Olive ridley turtle	*Lepidochelys olivacea*	2.14	2.75	High
Leatherback turtle	*Dermochelys coriacea*	2.43	2.50	Precautionary High
Sirenia				
Dugong	*Dugong dugon*	2.71	2.50	High
Dolphins				
Australian humpback dolphin	*Sousa sahulensis*	2.71	3.00	High
Australian snubfin dolphin	*Orcaella heinsohni*	2.57	3.00	High
Common bottlenose dolphin	*Tursiops truncatus*	2.86	2.50	Precautionary High
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	2.71	2.75	Precautionary High
False killer whale	*Pseudorca crassidens*	2.86	1.75	Precautionary High
Spinner dolphin	*Stenella longirostris*	2.43	2.25	Precautionary High
Sharks				
Speartooth shark	*Glyphis glyphis*	2.43	2.75	High
Great hammerhead shark	*Sphyrna mokarran*	2.86	2.75	High
Scalloped hammerhead shark	*Sphyrna lewini*	2.86	2.75	High
Winghead shark	*Eusphyra blochii*	2.43	2.75	High

Common name	Species name	Productivity	Susceptibility	Risk rating
Batoids				
Reef manta ray	*Mobula alfredi*	2.86	1.50	Precautionary High
Kuhl's devilray	*Mobula kuhlii*	2.57	2.00	Precautionary High
Largetooth sawfish	*Pristis pristis*	2.86	2.50	High
Narrow sawfish	*Anoxypristis cuspidata*	2.57	2.75	High
Green sawfish	*Pristis zijsron*	2.86	2.75	High
Dwarf sawfish	*Pristis clavata*	2.86	2.75	High
Bottlenose wedgefish	*Rhynchobatus australiae*	2.57	2.75	Precautionary High
Eyebrow wedgefish	*Rhynchobatus palpebratus*	2.57	2.75	Precautionary High
Giant shovelnose ray	*Glaucostegus typus*	2.43	2.75	Precautionary High
Estuary stingray	*Hemitrygon fluviorum*	2.14	2.75	Precautionary High

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Definitions & Abbreviations

AEEZ	–	Australian Exclusive Economic Zone.
AFMA	–	*Australian Fisheries Management Authority.*
AFZ	–	Australian Fishing Zone.
BMP	–	Bycatch Management Plan.
bSAFE	–	*base Sustainability Assessment for Fishing Effects*. The *Sustainability Assessment for Fishing Effects* or SAFE is one of the two ERA methodologies that can be used as part of the Level 2 assessment. This method can be separated into a base SAFE (bSAFE) and enhanced SAFE (eSAFE). The data requirements for eSAFE are higher than for a bSAFE, which aligns more closely to a PSA.
CAAB	–	*Codes for Australian Aquatic Biota.*
CMS	–	*Convention on the Conservation of Migratory Species of Wild Animals.*
CITES	–	*Convention on International Trade in Endangered Species of Wild Fauna and Flora.*
CSIRO	–	*Commonwealth Scientific and Industrial Research Organisation .*
ECIF	–	*East Coast Inshore Fishery*. The fishery formally referred to as the *East Coast Inshore Fin Fish Fishery* or ECIFFF.
EPBC Act	–	*Environment Protection and Biodiversity Conservation Act 1999.*
ERA	–	Ecological Risk Assessment.
ERAEF	–	*Ecological Risk Assessment for the Effects of Fishing*. A risk assessment strategy established by Hobday *et al*. (2011) and employed by the AFMA.
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.
Gillnets	–	Gillnets include general purpose mesh nets (excluding ring nets), set mesh nets and nets that are neither fixed nor hauled *i.e.* general gillnet fishing under the N3, N12 and N13 fishery symbols including

		anchored and drifting gillnets. For the purpose of this ERA, the definition of gillnets does not include small mesh net fishing activities conducted under the N11 fishery symbol.
LCA	–	*Likelihood & Consequence Analysis.*
NDF	–	*Non-Detriment Finding*. A NDF is required for all CITES species that are exported for sale and provides an assessment of the current management arrangements and exploitation status.
PSA	–	*Productivity & Susceptibility Analysis.* One of the two ERA methodologies that can be used as part of the Level 2 assessments.
RRA	–	Residual Risk Analysis.
SAFE	–	*Sustainability Assessment for Fishing Effects*. One of the two ERA methodologies that can be used as part of the Level 2 assessments. This method can be separated into a base SAFE (bSAFE) and enhanced SAFE (eSAFE). The data requirements for eSAFE is higher than a bSAFE which aligns more closely to a PSA.
SAFS	–	The National *Status of Australian Fish Stocks*. Refer to www.fish.gov.au for more information.
SOCC	–	*Species of Conservation Concern*. Term used in the Level 1 and Level 2 ERA to categorise the list of species with ongoing concern. The SOCC includes both no-take species and species that are targeted within the ECIF.
SOCI	–	*Species of Conservation Interest.* No-take species that are subject to additional reporting requirements if caught in a commercial fishery operating in Queensland.
StrandNET	–	Reporting system used by the *Department of Environment and Science* (DES) to complete the *Marine Wildlife Stranding and Mortality Database*. StrandNET summarises all records of sick, inured or dead marine wildlife reported through DES and annual reports can be accessed at: https://environment.des.qld.gov.au/wildlife/animals/caring-for-wildlife/marine-strandings/data-reports/annual-reports#document_availability .
TACC	–	Total Allowable Commercial Catch Limit.
TEP	–	Threatened, Endangered & Protected.

1 Introduction

Ecological Risk Assessments (ERA) are important tools for sustainable natural resource management and they are being used increasingly in commercial fisheries to monitor long-term risk trends for target and non-target species. In Queensland, ERAs have previously been developed on an as-needed basis and these assessments have often employed alternate methodologies (Department of Agriculture and Fisheries, 2019a). This process has now been formalised as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* and risk assessments are being completed for priority fisheries (Department of Agriculture and Fisheries, 2018c). Once completed, the ERAs will inform a range of management initiatives including the development of harvest strategies, identifying key research needs and implementing detailed bycatch mitigation strategies (Department of Agriculture and Fisheries, 2018b; c; d; 2020a).

In December 2019, a whole-of-fishery or Level 1 ERA was released for the *Gulf of Carpentaria Inshore Fishery* (GOCIF; Jacobsen *et al.*, 2019a).[1] The Level 1 ERA provided a broad-scale assessment of the risks posed by this fishery including the key drivers of risk and the ecological components most likely to experience an undesirable event. These outputs were based on considerations given to the current fishing environment (*e.g.* catch and effort levels, participation rates) and actions that are permissible under the current management regime (*e.g.* shifting effort, increasing fishing mortality). In the context of the broader ERA, these results were used to differentiate between low and high-risk elements and determine what ecological components should be progressed to a finer-scale assessment (Department of Agriculture and Fisheries, 2018c).

For the Level 2 ERA, the focus of the analysis shifts to a species-specific level and the scope of the assessment is refined to the current fishing environment. Applying more detailed assessment tools, Level 2 ERAs establish risk profiles for individual species using one of two methods: the semi-quantitative *Productivity & Susceptibility Analysis* (PSA) or the quantitative *Sustainability Assessment for Fishing Effects* (SAFE) (Department of Agriculture and Fisheries, 2018c; Hobday *et al.*, 2007; Zhou & Griffiths, 2008). While both methods have been developed for use in data-limited fisheries, the use of the PSA or SAFE will be dependent on the species being assessed, the level of information on gear effectiveness, and the distribution of the species in relation to fishing effort (Hobday *et al.*, 2011).

Under the ERA Guidelines (Department of Agriculture and Fisheries, 2018c), species with ongoing conservation concerns including those classified as Threatened, Endangered and Protected (TEP) will be prioritised for assessment (referred to herein as *Species of Conservation Concern* or SOCC). The primary aim of this assessment is to identify the key drivers of risk for individual species and provide further advice on how key aspects of the GOCIF may affect their long-term conservation status. In doing so, the Level 2 ERA will inform discussions surrounding the development of harvest strategies and assist in the development of bycatch management plans for non-target species. The GOCIF SOCC Level 2 ERA is complimented by an analogous assessment on the risk posed by this fishery to key target & byproduct species (Department of Agriculture and Fisheries, 2018c; Walton *et al.*, 2021).

[1] *The Gulf of Carpentaria Inshore Fishery (GOCIF) has previously been referred to as the Gulf of Carpentaria Inshore Fin Fish Fishery or GOCIFFF.*

2 Methods

2.1 The Fishery

The GOCIF extends from Slade Point near the tip of Cape York Peninsula westward to the Queensland – Northern Territory border and operates in all tidal waterways. Due to the similarities in fishing methods and target species, the GOCIF is frequently compared to the net sector of the *East Coast Inshore Fishery* (ECIF; Jacobsen *et al.*, 2019b). The GOCIF though is smaller in terms of licence numbers and annual catch and effort levels. The licencing system used in the GOCIF is also simpler; consisting of four fishery symbols (N3, N11, N12 and N13) compared to 17 in the ECIF (Business Queensland, 2016; Department of Agriculture and Fisheries, 2019b; f).

The GOCIF is a net only fishery with most effort reported against the N3 and N12 fishery symbols (Business Queensland, 2016). The N3 fishery operates in estuarine and foreshore waters out to a 7 nautical mile (nm) limit. The fishing area of the N12 fishery is further offshore and restricted to waters between the 7nm limit and the boundary of the Australian Fishing Zone (AFZ). The fishing area of the N13 fishery is more restricted, with operators only permitted to fish outside 25nm off the Queensland coastline. While noting these nuances, the N12 and N13 fishery uses similar gear, targets similar species and will have similar risk profiles (Department of Agriculture and Fisheries, 2019b). For these reasons, the Level 2 ERA assesses the N12 and N13 fisheries as a single entity.

While operators retain a wide range of species, only licence holders with an N3 symbol can target barramundi (*Lates calcarifer*). Similarly only N12 and N13 operators are permitted to target shark, other than the white shark (*Carcharodon carcharias*), the sand tiger shark (*Odontaspis ferox*), the grey nurse shark (*Carcharias taurus*) and the speartooth shark (*Glyphis glyphis*). The take of key target species is primarily managed through input controls and the regime for some species (*e.g.* sharks) is less developed when compared to the Queensland east coast (Department of Agriculture and Fisheries, 2019b; f). Inshore operations are also subject to less restrictive net attendance provisions with operators only required to be within 5 or 6nm (~9–11 kilometres [km]) when fishing in rivers, creeks and nearshore waters (Department of Agriculture and Fisheries, 2019b; Jacobsen *et al.*, 2019a).

In addition to the three large mesh net symbols, a fourth net symbol is permitted for use in the GOCIF, the N11. The N11 or small mesh net fishery, makes a smaller contribution to annual catch and effort levels. Operators in this fishery are restricted to the use of a cast, scoop or seine net and are subject to more stringent provisions regarding the permitted mesh size, net length and attendance distances (Department of Agriculture and Fisheries, 2019b). The profile for this sector differs considerably from the N3, N12 and N13 fisheries and these operations are viewed as a lower risk to the species being assessed. For these reasons, the N11 fishery was not included in this iteration of the GOCIF SOCC Level 2 ERA (Department of Agriculture and Fisheries, 2019b).

The management regime for the entire GOCIF is being reviewed as part of the *Queensland Sustainable Fisheries Strategies 2017–2027* (Department of Agriculture and Fisheries, 2017). As part of this process, alternate management strategies are being developed and considered for the fishery *e.g.* regional management, increased use of species-specific quotas and the development of a dedicated bycatch management plan (Department of Agriculture and Fisheries, 2019e). This review is ongoing and a number of the alternative strategies are still in development, have yet to be adopted or fully implemented. For these reasons, the GOCIF SOCC Level 2 ERA only considered arrangements that were in place at the time of the assessment.

In addition to the management reforms, the SOCC Level 2 ERA includes species that may interact with the recreational and charter fishing sectors or be impacted on by other marine-based activities. These cumulative risks were taken into consideration as part of the Level 1 ERA (Jacobsen *et al.*, 2019a) and, when and where appropriate, will be given further consideration as part of this assessment. It is noted though that these impacts or cumulative risks involve a wider range of stakeholders and are difficult to address through a fisheries management framework. Accordingly, cumulative risk comparisons may only be used to provide further context on the extent of the risk posed by commercial fishing activities to key species or species complexes.[2]

2.2 Information sources / baseline references

Where possible, baseline information on the life history constraints and habitat preferences for each species were obtained from peer-reviewed articles. In the absence of peer-reviewed data, additional information was sourced from grey literature and publicly accessible databases such as *FishBase* (www.fishbase.org), *SeaLifeBase* (www.sealifebase.ca), *Fishes of Australia* (www.fishesofaustralia.net.au), *Seamap Australia* (www.seamapaustralia.org) and the *IUCN Red List of Threatened Species* (www.iucnredlist.org). Additional information including on the distribution of key seabirds, fish and endangered species was obtained through the *Atlas of Living Australia* (www.ala.org.au), *Species Profile and Threats Database* (Department of Environment and Energy, *www.environment.gov.au/cgi-bin/sprat/public/sprat.pl*) and resources associated with the management and regulation of marine national parks *e.g.* the North Marine Parks Network, *Great Barrier Reef Marine Park*, *Moreton Bay Marine Park* and *Great Sandy Marine Park.* Where possible regional distribution maps were sourced for direct comparison with effort distribution data (Whiteway, 2009).

Fisheries data used in the Level 2 ERA were obtained through the fisheries logbook program (including *Species of Conservation Interest* or SOCI logbook), a previous *Fisheries Observer Program* (FOP), the *Fishery Monitoring Program* (FMP)[3] and the *Statewide Recreational Fishing Survey* (Department of Agriculture and Fisheries, 2021; Teixeira *et al.*, 2021; Webley *et al.*, 2015). This information was supplemented with data from ancillary sources including from the *Marine Wildlife Stranding and Mortality Database* also referred to as *StrandNET* (Department of Environment and Science, www.environment.des.qld.gov.au/wildlife/caring-for-wildlife/marine_strandings.html).

2.3 Species Rationalisation Processes

The scope of the GOCIF Level 2 ERA was determined by the outcomes of the whole-of-fishery (Level 1) assessment (Jacobsen *et al.*, 2019a). This assessment identified a number of high-risk elements that were to be progressed to a finer-scale (Level 2) ERA including target & byproduct species, bycatch, marine turtles, dugongs, dolphins, batoids and sharks (Table 1). Of these ecological components, marine turtles, dugongs, dolphins and a subset of shark and ray species with additional protections or conservation concerns were included in the GOCIF SOCC Level 2 ERA. The remaining

[2] *A number of the species caught in the GOCIF attract significant levels of attention from the recreational fishing sector (Department of Agriculture and Fisheries, 2021; Teixeira et al., 2021; Webley et al., 2015). The use of nets in the recreational fishing sector is regulated and the risks posed by this sector will be more applicable to the target and byproduct species. Risks associated with recreational fishing will be given further considerations as part of the target and byproduct species Level 2 ERA.*

[3] *The Fishery Monitoring Program was previously known as the Long-Term Monitoring Program (LTMP).*

ecological components (target & byproduct species and bycatch) have been or will be assessed in analogous risk assessments (Walton *et al.*, 2021).

In Queensland, the list of *Species of Conservation Interest* formed the basis of Level 2 assessment. *Species of Conservation Interest* or SOCI refers specifically to a limited number of non-target species that are subject to mandatory commercial reporting requirements. This list was expanded though a review of Commonwealth and State legislation (*e.g.* the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), *Fisheries Declaration 2019*, the *Nature Conservation Act 1992*) and international conventions with the potential to influence fishing activities in Queensland such as the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) and the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

For the purposes of this ERA, the expanded list of species was collectively referred to as the *Species of Conservation Concern* or SOCC. This classification aligns with the Level 1 ERA (Jacobsen *et al.*, 2019a) and reflects the fact that the subgroup includes species that can be retained for sale in Queensland and species afforded additional protections under State or Commonwealth legislation. As the preliminary list included species with limited potential to interact with the GOCIF, a final review was undertaken to ensure that all of the SOCC included in the analysis were relevant to this fishery.

A summary of the species rationalisation process and the justifications used to include or omit a species from the analysis has been provided in Appendix A and B respectively.

Table 1. *Summary of the outputs from the Level 1 (whole-of-fishery) Ecological Risk Assessment for the Gulf of Carpentaria Inshore Fishery (GOCIF).*

Ecological Component	Level 1 Risk Rating	Progression
Target & Byproduct	High	Level 2 ERA
Bycatch*	Medium / High	Level 2 ERA
Species of Conservation Concern (SOCC)		
Marine turtles	High	Level 2 ERA (this report)
Dugongs	Medium / High	Level 2 ERA (this report)
Whales	Low / Medium	Not progressed further
Dolphins	High	Level 2 ERA (this report)
Sea snakes	Low	Not progressed further
Crocodiles	Low	Not progressed further
Protected teleosts	Low	Not progressed further
Batoids	High	Level 2 ERA (this report)**
Sharks	High	Level 2 ERA (this report)**
Syngnathids	Negligible	Not progressed further
Seabirds	Low	Not progressed further
Terrestrial mammals	Negligible	Not progressed further
Marine Habitats	Low	Not progressed further
Ecosystem Processes	Precautionary High	Not progressed, data deficiencies

**Does not include Species of Conservation Concern or target & byproduct species that were returned for to the water due to regulations like minimum legal size limits and poor quality product that could be retained.*

***As they can be retained in the GOCIF, a number of shark and ray species will be assessed as part of the GOCIF Target & Byproduct Species Level 2 ERA.*

2.4 ERA Methodology

Methodology used to construct the Level 2 ERA aligns closely with the *Ecological Risk Assessment for the Effects of Fishing* (ERAEF) and includes two assessment options: the *Productivity & Susceptibility Analysis* (PSA) and the *Sustainability Assessment for Fishing Effects* (SAFE) (Australian Fisheries Management Authority, 2017; Hobday *et al.*, 2011; Zhou & Griffiths, 2008). Data inputs for the two methods are similar and both were designed to assess fishing-related risks for data-poor species (Zhou *et al.*, 2016). Similarly, both methods include precautionary elements that limit the potential for false negatives or high-risk species being incorrectly assigned a lower risk rating. However, the PSA tends to be more conservative and research has shown that it has a higher potential to produce false positives. That is, low-risk species being assigned a higher risk score due to the conservative nature of the method, data deficiencies *etc.* (Hobday *et al.*, 2011; Hobday *et al.*, 2007; Zhou *et al.*, 2016).

In the PSA, the level of risk (low, medium or high) is defined through a finer scale assessment of the life-history constraints of the species (*Productivity*), the potential for the species to interact with the fishery and the associated consequences (*Susceptibility*). In comparison, the SAFE method quantifies risk by comparing the rate of fishing mortality against key reference points including the level of fishing mortality associated with *Maximum Sustainable Fishing Mortality* (F_{msm}), the point where biomass is assumed to be half that required to support a maximum sustainable fishing mortality (F_{lim}) and fishing mortality rates that, in theory, will lead to population extinction in the long term (F_{crash}) (Zhou & Griffiths, 2008; Zhou *et al.*, 2016; Zhou *et al.*, 2011). As SAFE is a quantitative assessment, the method provides an absolute measure of risk or a continuum of values that can be compared directly to the above reference points (Hobday *et al.*, 2011). This contrasts with the PSA which provides an indicative measure (low, medium, high) of the potential risk (Hobday *et al.*, 2007).

While research has shown that SAFE produces fewer false-positives, it requires a sound understanding of the fishing intensity and the degree of overlap between a species distribution and fishing effort (Hobday *et al.*, 2011; Zhou *et al.*, 2009). These requirements mean that SAFE may not be suitable for species with insufficient data; typically protected species (especially mammals, reptiles and seabirds) and marine invertebrates (Australian Fisheries Management Authority, 2017). The method also requires a sound understanding of the gear-affected area (Zhou & Griffiths, 2008) or the proportion of the fished area that a species resides in that is impacted on by the apparatus (Zhou *et al.*, 2019; Zhou *et al.*, 2014).

In the GOCIF, the ability to determine the gear-affected area is limited by the complexity of the fishery. In the Gulf of Carpentaria, net operators are permitted the use of multiple nets providing that the total net length does not exceed that permitted under each symbol or within a particular region (Department of Agriculture and Fisheries, 2019b). For example, some N3 operations can use up to six nets in a river or creek system providing that a) their combined length is no longer than 360m and b) the distance between the first and last net is no longer than five nautical miles (Department of Agriculture and Fisheries, 2019b). These operational nuances are of some importance as the number of nets being used, their configuration, the distance between each net and the extent of any overlap will have a bearing on the gear-affected area.

At a whole-of-fishery level, commercial net fishers are only required to submit information on the mesh size, total net length used (or combined net length) and, if using a drift or set gillnet, soak times. Operators are not required to nominate the symbol they are fishing under and are only required to report the dominant mesh size used across the entire operation. These factors will have a bearing on the accuracy of SAFE estimates involving the affected fishing area, net *selectivity* and the *encounterability* potential (Zhou *et al.*, 2011; Zhou *et al.*, 2008).

Given the complexity of the current fishing arrangements, uncertainty in determining the gear-affected area and the limitations of SAFE in assessing risk for key groups (*e.g.* marine mammals and reptiles), the PSA was adopted for the first phase of the GOCIF SOCC Level 2 ERA. As a high number of the initiatives instigated under the *Queensland Sustainable Fisheries Strategy 2017–2027* are designed to improve information levels (Department of Agriculture and Fisheries, 2017), there may be more avenues to apply SAFE in subsequent ERAs.

2.4.1 Productivity & Susceptibility Analysis (PSA)

The PSA was largely aligned with the ERAEF approach employed for Commonwealth fisheries (Australian Fisheries Management Authority, 2017; Hobday *et al.*, 2011). As a detailed overview of the methodology and the key assumptions are provided in Hobday *et al*. (2007), only an abridged version will be provided here.

The *productivity* component of the PSA examines the life-history constraints of a species and the potential for an attribute to contribute to the overall level of risk. These attributes are based on the biology of the species and include the *size and age at sexual maturity*, *maximum size and age*, *fecundity*, *reproductive strateg*y and *trophic level* (Table 2). *Productivity* attributes used in the Level 2 assessment were consistent with the ERAEF (Hobday *et al.*, 2011) and were applied across all ecological components subject to a PSA. Criteria used to assign each attribute a score of low (1), medium (2) or high (3) risk are outlined in Table 2.

Table 2. *Scoring criteria and cut-off scores for the productivity component of the Productivity & Susceptibility Analysis (PSA) utilised as part of the GOCIF SOCC Level 2 ERA. Attributes and scores/criteria align with national (ERAEF) approach (Hobday et al., 2011).*

Attribute	High Productivity (Low risk, score = 1)	Medium Productivity (Medium risk, score = 2)	Low Productivity (high risk, score = 3)
Age at sexual maturity*	<5 years	5–15 years	>15 years
Maximum age*	<10 years	10–25 years	>25 years
Fecundity**	>20,000 eggs per year	100–20,000 eggs per year	<100 eggs per year
Maximum size*	<100cm	100–300cm	>300cm
Size at sexual maturity*	<40cm	40–200cm	>200cm
Reproductive strategy	Broadcast spawner	Demersal egg layer	Live bearer (& birds)
Trophic Level	<2.75	2.75–3.25	>3.25

** Where only ranges for species attributes were provided, the most precautionary measure was used. **Fecundity for broadcast spawners was assumed to be >20,000 eggs per year (Miller & Kendall, 2009).*

For the *susceptibility* component of the PSA, ERAEF attributes were used as the baseline of the assessment and included *availability*, *encounterability*, *selectivity* and *post-capture mortality* (Hobday *et al.*, 2011; Hobday *et al.*, 2007). The following provides an overview of the *susceptibility* attributes used in the PSA with Table 3 detailing the criteria used to assign scores for this part of the analysis.

- **Availability**—Where possible, *availability* scores were based on the overlap between fishing effort and the portion of the species range that occurs within the broader geographical spread of the fishery. To account for inter-annual variability, percentage overlaps were calculated for three years (2016, 2017 and 2018) and the highest value used as the basis of the *availability* assessment. Regional distribution maps were sourced from the *Atlas of Living Australia*, the *Species Profile and Threats Database* (Department of Environment and Energy, www.environment.gov.au/cgi-bin/sprat/public/sprat.pl), the *Commonwealth Scientific and Industrial Research Organisation* (CSIRO) and, where possible, refined using bathymetry and topographical data (Whiteway, 2009).

  In instances where a species did not have a distribution map, *availability* scores were based on a broader geographic distribution assessment (global, southern hemisphere, Australian endemic) described in Hobday *et al.* (2007) (Table 3). A full summary of the overlap percentages used to assess *availability* has been provided in Appendix C.

- **Encounterability**—*Encounterability* considers the likelihood that a species will encounter the fishing gear when it is deployed within the known geographical range (Hobday *et al.*, 2007). The *encounterability* assessment is based on the behaviour of the species as an adult and takes into consideration information on the preferred habitats and bathymetric ranges. For the PSA, both parameters (adult habitat overlap and bathymetric range overlap) are assigned an individual risk score with the highest value used as the basis of the *encounterability* assessment. The notable exceptions to this are air breathing species which, under the ERAEF framework, are assigned the highest score due to their need to access the surface and their potential to interact with the gear during the deployment and retrieval process (Hobday *et al.*, 2007).

- **Selectivity**—*Selectivity* is effectively a measure of the likelihood that a species will get caught in the apparatus. Factors that will influence the *selectivity* score include the fishing method, the apparatus used and the body size of the species in relation to the mesh size. As the maximum mesh size used in the GOCIF is comparable to a Commonwealth managed shark gillnet fishery (Australian Fisheries Management Authority, 2018a), the same criteria were applied to gillnet operations in the GOCIF (Table 3).

- **Post-capture mortality**—*Post-capture mortality* (PCM) is one of the more difficult attributes to assess in a marine environment; particularly for non-target species. For target and byproduct species that fall within the prescribed regulations, the survival rate will be zero as they will (most likely) be retained for sale. Survival rates for the remainder of the species will be more varied and scores assigned to this attribute could be influenced by data limitations or require further qualitative input or expert opinion.

  In the GOCIF, *post-capture mortality* assessments will need to consider the available data and confounding factors such as the effectiveness of net-attendance provisions employed across the N3, N12 and N13 fisheries.

Table 3. *Scoring criteria and cut-off scores for the susceptibility component of the Productivity & Susceptibility Analysis (PSA). Where possible, attributes and the corresponding scores/criteria were aligned with national (ERAEF) approach (Hobday et al., 2011).*

Attribute	Low susceptibility (Low risk, score = 1)	Medium susceptibility (Medium risk, score = 2)	High susceptibility (High risk, score = 3)
Availability			
Option 1. Overlap of species range with fishery.	<10% overlap.	10–30% overlap.	>30% overlap.
Option 2. Global distribution & stock proxy considerations.	Globally distributed.	Restricted to same hemisphere / ocean basin as fishery.	Restricted to same country as fishery.
Encounterability			
Option 1. Habitat type	Low overlap with fishery area.	Medium overlap with fishery area.	High overlap with fishery area.
Option 2. Depth check	Low overlap with fishery area.	Medium overlap with fishery area.	High overlap with fishery area.
Selectivity	Low potential for capture / Species < mesh size or >5m in length or width	Moderate potential for capture. Species 1 - 2 times mesh size, 4-5m in length or width	High potential for capture. Species >2 times mesh size to 4m in length or width
Post-capture mortality	Evidence of post-capture release and survival.	Released alive with uncertain survivability.	Retained species, majority dead when released, interaction likely to result in death or life-threatening injuries.

2.4.2 PSA Scoring

Each attribute was assigned a score of 1 (low risk), 2 (medium risk) or 3 (high risk) based on the criteria outlined in Table 2 and Table 3 (Brown *et al.*, 2013; Hobday *et al.*, 2011; Patrick *et al.*, 2010). In instances where an attribute has no available data and in the absence of credible information to the contrary, a default rating of high risk (3) was used (Hobday *et al.*, 2011). This approach introduces a precautionary element into the PSA and helps minimise the potential occurrence of false-negative assessments. The inherent trade off with this approach is that the outputs of the Level 2 ERA can be conservative and may include a number of false positives (Zhou *et al.*, 2016). Issues associated with false positives and the overestimation of risk will be examined further as part of the Residual Risk Analysis (RRA).

Risk ratings (R) were based on a two-dimensional graphical representation of the *productivity* (x-axis) and *susceptibility* (y-axis) scores (Fig. 1). Cross-referencing of the *productivity* and *susceptibility* scores provides each species with a graphical location that can be used to calculate the Euclidean distance or the distance between the species reference point and the origin (*i.e.* 0, 0 on Fig. 1). This distance is calculated using the formula $R = ((P - X_0)^2 + (S - Y_0)^2)^{1/2}$ where P represents the *productivity* score, S represents the *susceptibility* score and X_0 and Y_0 are the respective x and y origin coordinates (Brown *et al.*, 2013). The further a species is away from the origin the more at risk it is considered to be. For the purpose of this ERA, cut offs for each risk category were aligned with previous assessments with scores below 2.64 classified as low risk, scores between 2.64 and 3.18 as medium risk and scores >3.18 classified as high risk (Brown *et al.*, 2013; Hobday *et al.*, 2007; Zhou *et al.*, 2016).

As the PSA includes an *uncertainty* assessment and RRA (refer to section *2.4.3 Uncertainty* and *2.4.4 Residual risk*), the initial risk ratings may be subject to change. To this extent, scores assigned as part of the PSA analysis can be viewed as a measure of the potential for risk each species may experience (Hobday *et al.*, 2007) with the final risk scores determined on the completion of the RRA.

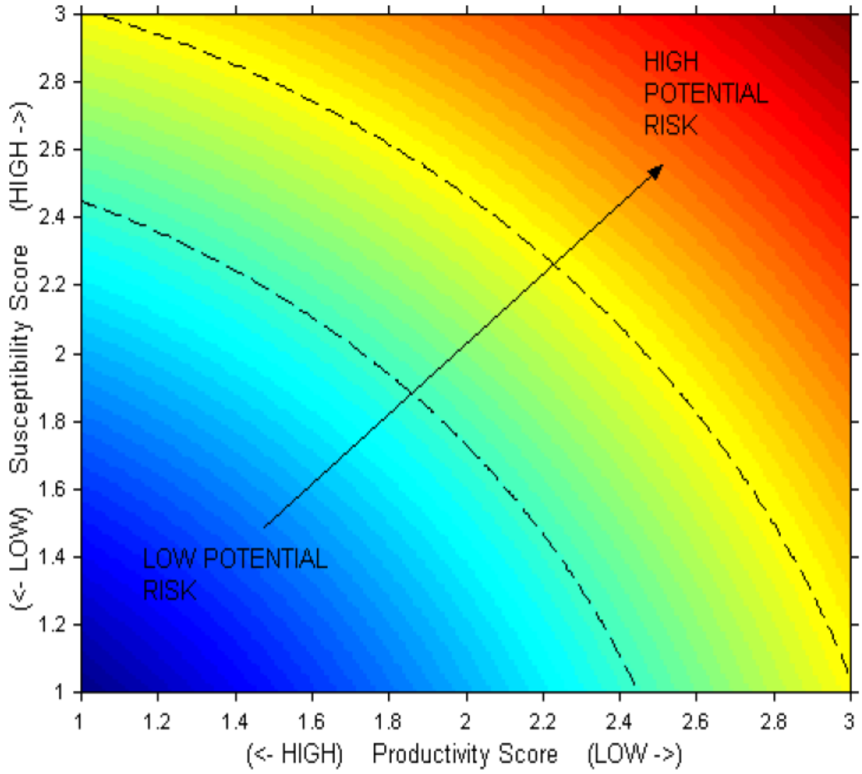

Figure 1. *PSA plot demonstrating the two-dimensional space on which species units are plotted. PSA scores for species units represent the Euclidean distance or the distance between the origin and the productivity (x axis), susceptibility (y axis) intercept (excerpt from Hobday. et al., 2007).*

2.4.3 Uncertainty

A number of factors including imprecise or missing data and the use of averages or proxies can contribute to the level of uncertainty surrounding the PSA. Examples of which include the use of a default high score for attributes missing data and the use of values based at a higher taxon *i.e.* genera or family level (Hobday *et al.*, 2011). In the Level 2 ERA uncertainty is examined through a baseline assessment of each risk profile to determine the proportion of attributes assigned a precautionary high-risk rating due to data deficiencies. As species with greater data deficiencies are more likely to attract the default high-risk rating, their profiles are more likely to fall on the conservative side of the spectrum. In these instances, it may be more appropriate to address these risks and data deficiencies through measures like the *Queensland Sustainable Fisheries Strategy—Monitoring and Research Plan* (Department of Agriculture and Fisheries, 2018d).

2.4.4 Residual Risk Analysis (RRA)

Precautionary elements in the PSA combined with an undervaluation of some management arrangements can result in more conservative risk assessments and a higher number of false positives. Similarly, the effectiveness of some attributes may be exaggerated and subsequent risks could be underestimated (false negatives). To address these issues, PSA results were subject to a RRA. The RRA gives further consideration to risk mitigation measures that were not explicitly included in the attributes and any additional information that may influence the risk status of a species (Australian Fisheries Management Authority, 2017). In doing so, the RRA provides management with greater capacity to differentiate between potential and actual risks (Department of Agriculture and Fisheries, 2018c) and helps refine risk management strategies.

The RRA framework was based on guidelines established by CSIRO and the *Australian Fisheries Management Authority* (AFMA) (Australian Fisheries Management Authority, 2018b). These guidelines identify six avenues where additional information may be given further consideration as part of a Level 2 assessment. Given regional nuances and data variability, a degree of flexibility was required with respect to how the RRA guidelines were applied to commercial fisheries in Queensland and the justifications used. The RRA was also expanded to include a seventh guideline titled *Additional Scientific Assessment & Consultation*. While a version of this guideline has been used in previous risk assessments involving Commonwealth Fisheries, it has since been removed as part of a broader RRA procedural review (Australian Fisheries Management Authority, 2018b). In Queensland, this guideline was retained as the broader ERA framework includes a series of consultation steps that aid in the development and finalisation of both the whole-of-fishery (Level 1) and species-specific ERAs (Department of Agriculture and Fisheries, 2018c).

In instances where the RRA resulted in an amendment to the preliminary score, full justifications were provided (Appendix D) including the guidelines in which the amendments were considered. A brief summary of each guideline and the RRA considerations is provided in Table 4.

Table 4. *Guidelines used to assess residual risk including a brief overview of factors taken into consideration. Summary represents a modified excerpt from the revised AFMA Ecological Risk Assessment, Residual Risk Assessment Guidelines (Australian Fisheries Management Authority, 2018b).*

Guidelines	Summary
Guideline 1*: Risk rating due to missing, incorrect or out of date information.*	Considers if *susceptibility* and/or *productivity* attribute data for a species is missing or incorrect for the fishery assessment and is correct using data from a trusted source or another fishery.
Guideline 2*: Additional Scientific assessment & consultation.*	Considers any additional scientific assessments on the biology or distribution of the species and the impact of the fishery. This may include verifiable accounts and data raised through key consultative processes including but not limited to targeted consultation with key experts and oversite committees established as part of the *Sustainable Fisheries Strategy 2017–2027 e.g. Fisheries Working Groups* and the *Sustainable Fisheries Expert Panel*.

Guidelines	Summary
Guideline 3*: At risk with spatial assumptions.*	Provides further consideration to the spatial distribution data, habitat data and any assumptions underpinning the assessment.
Guideline 4*: At risk in regards to level of interaction / capture with a zero or negligible level of susceptibility.*	Considers observer or expert information to better calculate susceptibility for those species known to have a low likelihood or no record of interaction nor capture with the fishery.
Guideline 5*: Effort and catch management arrangements for Target & Byproduct species.*	Considers current management arrangements based on effort and catch limits set using a scientific assessment for key species.
Guideline 6*: Management arrangements to mitigate against the level of bycatch.*	Considers management arrangement in place that mitigate against bycatch by the use of gear modifications, mitigation devices and catch limits.
Guideline 7*: Management arrangements relating to seasonal, spatial and depth closures.*	Considers management arrangements based on seasonal, spatial and/or depth closures.

3 Results

3.1 PSA

Cross-referencing the expanded SOCC list (*n* = 84 species) with the GOCIF effort footprint produced a list of 27 species with the potential to interact with the N3, N12 and N13 fisheries. Of those species identified for inclusion in the Level 2 ERA, batoids (stingrays, devilrays, guitarfish *etc.*) had the highest representation with 10 species, followed by marine turtles (*n* = 6 species), dolphins (*n* = 6 species), sharks (*n* = 4 species) and dugong (Appendix A & B). Some of these species have low or infrequent interactions with the GOCIF and were assessed as a precautionary measure (Appendix B).

Based on the prescribed criteria, all of the SOCC had *productivity* scores higher than 2.00 (*average* = 2.60; *range* = 2.14–2.86). The estuary stingray (2.14) had the lowest *productivity* score and nine species registered an assessment-high score of 2.86 (Table 5). Of the six *productivity* attributes assessed, *fecundity* (*average* = 3.00) and *maximum age* (*average* = 2.77) were assigned the highest overall scores. Conversely, *maximum size* and *size at sexual maturity* had the lowest average *productivity* score at 2.15 and 2.35 respectively (Table 5).

In the *susceptibility* analysis, all SOCC registered scores of between 2.00 and 3.00 at an average of 2.74 (Table 5). Seven species were assigned the maximum score for all four attributes; three batoids and four dolphins. Two attributes, *encounterability* and *post-capture mortality* had an average score of 3.00 with *availability* having the highest degree of variability; average of 2.27 across all 27 species (Table 5).

When the *productivity* and *susceptibility* scores were taken into consideration, dolphins had the highest preliminary risk score (*average* = 3.93), followed by the dugong (3.86), batoids (*average* = 3.81) and sharks (*average* = 3.76). Based on these results all 27 species were assigned preliminary PSA scores in the high-risk category (Table 5).

Table 5. *Preliminary risk ratings compiled as part of the Productivity & Susceptibility Analysis (PSA) and the scores assigned to each attribute used in the assessment. Final PSA values are calculated using the scores assigned to each attribute and in accordance with the methods outlined in Hobday et al. (2007). Pink boxes with '*' represent attributes that were assigned precautionary score due to an absence of species-specific data.*

Common name	**Species Name**	**Age at sexual maturity**	**Maximum age**	**Fecundity**	**Maximum size**	**Size at sexual maturity**	**Reproductive strategy**	**Trophic level**	**Productivity**	**Availability**	**Encounterability**	**Selectivity**	**Post-capture mortality**	**Susceptibility**	***PSA score***
Marine Turtles															
Green turtle	*Chelonia mydas*	3	3	3	2	2	2	1	2.29	2	3	3	3	2.75	**3.58**
Loggerhead turtle	*Caretta caretta*	3	3	3	1	2	2	3	2.43	2	3	3	3	2.75	**3.67**
Hawksbill turtle	*Eretmochelys imbricata*	3	3	3	1	2	2	2	2.29	2	3	3	3	2.75	**3.58**
Flatback turtle	*Natator depressus*	3	3	3	1	2	2	3	2.43	2	3	3	3	2.75	**3.67**
Olive ridley turtle	*Lepidochelys olivacea*	2	3	3	1	2	2	3	2.29	2	3	3	3	2.75	**3.58**
Leatherback turtle	*Dermochelys coriacea*	3	3	3	2	2	2	3	2.57	2	3	3	3	2.75	**3.76**
Sirenia															
Dugong	*Dugong dugon*	3	3	3	3	3	3	1	2.71	2	3	3	3	2.75	**3.86**
Dolphins															
Australian humpback dolphin	*Sousa sahulensis*	3*	3	3	2	3*	3	3	2.86	3	3	3	3	3.00	**4.14**

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Susceptibility	*PSA score*
Australian snubfin dolphin	*Orcaella heinsohni*	2	3	3	2	2	3	3	2.57	3	3	3	3	3.00	**3.95**
Common bottlenose dolphin	*Tursiops truncatus*	2	3	3	3	3*	3	3	2.86	3*	3	3	3	3.00	**4.14**
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	2	3	3	2	3	3	3	2.71	3*	3	3	3	3.00	**4.05**
False killer whale	*Pseudorca crassidens*	2	3	3*	3	3	3	3	2.86	2	3	1	3	2.25	**3.64**
Spinner dolphin	*Stenella longirostris*	2	2	3	2	2	3	3	2.43	2	3	3	3	2.75	**3.86**
Sharks															
Speartooth shark	*Glyphis glyphis*	3*	3*	3*	2	2	3	2	2.57	2	3	3	3*	2.75	**3.76**
Great hammerhead	*Sphyrna mokarran*	2	3	3	3	3	3	3	2.86	2	3	1	3	2.25	**3.64**
Scalloped hammerhead	*Sphyrna lewini*	2	3	3	3	3	3	3	2.86	2	3	3	3	2.75	**3.97**
Winghead shark	*Eusphyra blochii*	2	2	3	2	2	3	3	2.43	2	3	3	3	2.75	**3.67**
Batoids															
Reef manta ray	*Mobula alfredi*	2	3*	3	3	3	3	3*	2.86	2	3	1	3*	2.25	**3.64**

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Susceptibility	*PSA score*
Kuhl's devilray	*Mobula kuhlii* (aka *M. eregoodootenkee or M. eregoodoo*)[4]	3*	3*	3	2	2	3	3	2.71	2	3	3	3*	2.75	**3.86**
Largetooth sawfish	*Pristis pristis*	2	3	3*	3	3	3	3	2.86	2	3	1	3*	2.25	**3.64**
Narrow sawfish	*Anoxypristis cuspidata*	1	2	3	3	3	3	3	2.57	2	3	3	3*	2.75	**3.76**
Green sawfish	*Pristis zijsron*	2	3	3*	3	3	3	3	2.86	2	3	1	3*	2.25	**3.64**
Dwarf sawfish	*Pristis clavata*	2	3	3*	3	3	3	3*	2.86	2	3	3	3*	2.75	**3.97**
Bottlenose wedgefish	*Rhynchobatus australiae*	3*	3*	3*	2	2	3	3	2.71	3*	3	3	3*	3.00	**4.05**
Eyebrow wedgefish	*Rhynchobatus palpebratus*	3*	3*	3*	2	2	3	3*	2.71	3*	3	3	3*	3.00	**4.05**
Giant shovelnose ray	*Glaucostegus typus*	2	2	3*	2	2	3	3*	2.43	2	3	3	3*	2.75	**3.67**
Estuary stingray	*Hemitrygon fluviorum*	2	2	3*	1	1	3	3	2.14	3*	3	3	3*	3.00	**3.69**

[4] *The taxonomy of the Kuhl's devilray (M. Kuhlii) and the longhorn devilray (M. eregoodoo) requires further investigations. Combined morphological and molecular data led Last et al. (2016) and White et al. (2017b) to conclude that M. eregoodootenkee (synonym of M. eregoodoo) is a junior synonym of M. kuhlii. However, Hosegood et al. (2019) suggested these were separate species, which was supported by Notarbartolo di Sciara et al. (2020). The range or both M. kuhlii and M. eregoodoo is poorly defined in Australia due to these taxonomic issues and scientific advice recommended that they be treated the same until their status can be clarified (pers. comm. P. Kyne).*

3.2 Uncertainty

Productivity assessments for marine turtles, dugongs and sharks were all largely supported by scientific evidence with data deficiencies more prevalent in *productivity* assessments involving batoids and dolphins (Table 5 & 6). For a number of the SOCC, these data deficiencies were linked to their conservation status and challenges associated with undertaking biological assessments on species with small populations or geographical ranges *e.g.* defining age and growth parameters or sexual maturity through non-lethal methods.

Data deficiencies were more influential in assessments involving the *fecundity*, *maximum age* and *age at sexual maturity* attributes (Table 6). While the *fecundity* attribute had the largest number of precautionary high (3) scores, all belonged to the shark, batoid and dolphin subgroups (Table 5). Research has shown that *fecundity* levels for these subgroups are low with individuals typically producing fewer than 20 offspring per year (Hammond *et al.*, 2012; Last *et al.*, 2016; Last & Stevens, 2009; Parra *et al.*, 2017a; Parra *et al.*, 2017b; Wells *et al.*, 2019; White *et al.*, 2014; White *et al.*, 2006). As this is well below the 100 eggs/offspring limit used in the criteria (Table 2), the use of precautionary scores will not have a significant impact on the risk profiles of the affected species.

When compared to *fecundity*, the use of precautionary values for *age at sexual maturity* and *maximum age* had a larger influence on the preliminary risk scores (Table 5 & 6). This was particularly evident in assessments involving the sawfish, devilrays and stingrays. While not universal, research on the age and growth of sharks and rays indicate that a high proportion reach sexual maturity before 15 years (e.g. Cortés, 2000; Geraghty *et al.*, 2013; Jacobsen & Bennett, 2011; White *et al.*, 2014; White & Dharmadi, 2007). Based on this research, precautionary scores assigned to the *age at sexual maturity* attribute could be considered a risk overestimate for most of these species. The situation surrounding *maximum age* is more complicated as shark and ray longevity estimates fall either side of the 25 year limit (Table 2). For this attribute, the extent of any (potential) risk overestimation will be dependent on the species in question.

In the *susceptibility* analysis, all scores assigned to the *encounterability* and *selectivity* attributes were supported by information on their morphology and habitat/bathymetric preferences (Table 6). A high percentage of the species assessed also had *availability* scores based on a direct comparison between the known distribution and the effort footprint. The exceptions being the two bottlenose dolphins, the eyebrow wedgefish, giant shovelnose ray and the estuary stingray where *availability* was assessed using the alternate criteria (Table 3). *Post-capture mortality* estimates were available for the three hammerhead shark species (*Sphyrna* spp. & *E. blochii*) and there was sufficient evidence to support the allocation of a high (3) risk rating for all of the air breathing species. The remaining 11 species were assigned a precautionary risk rating in the absence of additional information (Table 6).

3.3 Residual Risk Analysis

The GOCIF SOCC Level 2 ERA covers a wide array of species with varying life-history traits, habitat preferences and information gaps. This complexity was reflected in the RRA where a number of the risk profiles were amended to consider additional information, mitigation measures and input from key stakeholders. The following provides an overview of the changes that were adopted as part of the RRA (Table 7). A full overview of the RRA including the key considerations for each species has been provided in Appendix D.

Table 6. *Summary of the number of attributes that were assigned a precautionary high (3) score as part of the Productivity & Susceptibility Analysis (PSA) due to data deficiencies.*

	Productivity							**Susceptibility**			
	Age at sexual maturity	**Maximum age**	**Fecundity**	**Maximum size**	**Size at sexual maturity**	**Reproductive strategy**	**Trophic level**	**Availability**	**Encounterability**	**Selectivity**	**Post-capture mortality**
Species with data	22	22	18	27	25	27	23	23	27	27	16
Species with missing attribute data	5	5	9	0	2	0	4	5	0	0	11
% Unknown Information	19%	19%	33%	0%	7%	0%	15%	19%	0%	0%	41%

3.3.1 Marine Turtles

Due to the precautionary nature of the PSA, scores assigned to the *fecundity* attribute for the marine turtle complex were based on the lowest published estimate for eggs produced per year, years between reproductive events and number of clutches per reproductive season. For at least three of the species, the loggerhead turtle, olive ridley turtle and leatherback turtle, these estimates provided an unrealistic account of the species *fecundity*. To address these issues, the number of offspring per year was recalculated using mean values for each of the aforementioned parameters (Appendix D). As a result of these amendments scores assigned to the *fecundity* attribute for the loggerhead turtle, olive ridley turtle and leatherback turtle were downgraded from high (3) to medium (2) (Table 7). *Productivity* scores for the three remaining marine turtle species were not altered as part of the RRA.

Two changes were made to preliminary scores assigned to the *susceptibility* attributes (Table 7). The leatherback turtle is more commonly reported from coastal waters in central eastern Australia, southeast Australia and in south-western Western Australia (Limpus, 2009). The species is sparsely distributed in Queensland waters, and it is understood to prefer deeper, pelagic waters along the continental shelf. Major rookeries for this species are also located outside the Gulf of Carpentaria region (Department of National Parks Sport and Racing, 2016; Limpus, 2009). Similarly, research suggests that key rookeries for the loggerhead turtle are found on the Queensland east coast with the species more likely to be observed in the ECIF (Limpus, 2008c). These factors were considered sufficient to reduce scores assigned to the *encounterability* attribute from high (3) to medium (2) (Table 7; Appendix D).

As a result of the above changes, PSA scores for the loggerhead, the olive ridley and the leatherback turtle were reduced. These reductions were not sufficient to change the final risk ratings of these species (Table 7).

Table 7. *Residual Risk Assessment (RRA) of the preliminary scores assigned as part of the Productivity and Susceptibility Analysis (PSA). Pink shaded squares represent attribute scores that were amended as part of the RRA. Refer to Appendix D for a full account of the RRA including key justifications*

Common name	**Species Name**	**Age at sexual maturity**	**Maximum age**	**Fecundity**	**Maximum size**	**Size at sexual maturity**	**Reproductive strategy**	**Trophic level**	**Productivity**	**Availability**	**Encounterability**	**Selectivity**	**Post-capture mortality**	**Susceptibility**	***PSA score***
Marine Turtles															
Green turtle	*Chelonia mydas*	3	3	3	2	2	2	1	2.29	2	3	3	3	2.75	**3.58**
Loggerhead turtle	*Caretta caretta*	3	3	2	2	2	2	3	2.43	2	2	3	3	2.75	**3.49**
Hawksbill turtle	*Eretmochelys imbricata*	3	3	3	1	2	2	2	2.29	2	3	3	3	2.75	**3.58**
Flatback turtle	*Natator depressus*	3	3	3	1	2	2	3	2.43	2	3	3	3	2.75	**3.67**
Olive ridley turtle	*Lepidochelys olivacea*	2	3	2	1	2	2	3	2.14	2	3	3	3	2.75	**3.49**
Leatherback turtle	*Dermochelys coriacea*	3	3	2	2	2	2	3	2.43	2	2	3	3	2.50	**3.49**
Sirenia															
Dugong	*Dugong dugon*	3	3	3	3	3	3	1	2.71	2	2	3	3	2.50	**3.69**
Dolphins															
Australian humpback dolphin	*Sousa sahulensis*	2	3	3	2	2	3	3	2.71	3	3	3	3	3.00	**3.95**
Australian snubfin dolphin	*Orcaella heinsohni*	2	3	3	2	2	3	3	2.57	3	3	3	3	3.00	**3.95**
Common bottlenose dolphin	*Tursiops truncatus*	2	3	3	3	3	3	3	2.86	2	2	3	3	2.50	**3.80**

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Susceptibility	*PSA score*
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	2	3	3	2	3	3	3	2.71	2	3	3	3	2.75	**3.86**
False killer whale	*Pseudorca crassidens*	2	3	3	3	3	3	3	2.86	2	1	1	3	1.75	**3.35**
Spinner dolphin	*Stenella longirostris*	2	2	3	2	2	3	3	2.43	2	1	3	3	2.25	**3.31**
Sharks															
Speartooth shark	*Glyphis glyphis*	2	3	3	2	2	3	2	2.43	2	3	3	3	2.75	**3.67**
Great hammerhead	*Sphyrna mokarran*	2	3	3	3	3	3	3	2.86	2	3	3	3	2.75	**3.97**
Scalloped hammerhead	*Sphyrna lewini*	2	3	3	3	3	3	3	2.86	2	3	3	3	2.75	**3.97**
Winghead shark	*Eusphyra blochii*	2	2	3	2	2	3	3	2.43	2	3	3	3	2.75	**3.67**
Batoids															
Reef manta ray	*Mobula alfredi*	2	3	3	3	3	3	3	2.86	2	1	1	1	1.50	**3.23**
Kuhl's devilray	*Mobula kuhlii* (aka *M. eregoodootenkee* or *M. eregoodoo*)[5]	2	3	3	2	2	3	3	2.57	2	2	2	2	2.00	**3.26**
Largetooth sawfish	*Pristis pristis*	2	3	3	3	3	3	3	2.86	2	3	3	3	2.50	**3.64**

[5] *The taxonomy of the Kuhl's devilray (M. Kuhlii) and the longhorn devilray (M. eregoodoo) requires further investigations. Combined morphological and molecular data led Last et al. (2016) and White et al. (2017b) to conclude that M. eregoodootenkee (synonym of M. eregoodoo) is a junior synonym of M. kuhlii. However, Hosegood et al. (2019) suggested these were separate species, which was supported by Notarbartolo di Sciara et al. (2020). The range or both M. kuhlii and M. eregoodoo is poorly defined in Australia due to these taxonomic issues and scientific advice recommended that they be treated the same until their status can be clarified (pers. comm. P. Kyne).*

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Susceptibility	*PSA score*
Narrow sawfish	*Anoxypristis cuspidata*	1	2	3	3	3	3	3	2.57	2	3	3	3	2.75	**3.97**
Green sawfish	*Pristis zijsron*	2	3	3	3	3	3	3	2.86	2	3	3	3	2.75	**3.76**
Dwarf sawfish	*Pristis clavata*	2	3	3	3	3	3	3	2.86	2	3	3	3	2.75	**3.97**
Bottlenose wedgefish	*Rhynchobatus australiae*	2	3	3	2	2	3	3	2.57	2	3	3	3	2.75	**3.76**
Eyebrow wedgefish	*Rhynchobatus palpebratus*	2	3	3	2	2	3	3	2.57	2	3	3	3	2.75	**3.76**
Giant shovelnose ray	*Glaucostegus typus*	2	2	3	2	2	3	3	2.43	2	3	3	3	2.75	**3.67**
Estuary stingray	*Hemitrygon fluviorum*	2	2	3	1	1	3	3	2.14	3	2	3	3	2.75	**3.49**

3.3.2 Cetaceans (dolphins)

As a number of the dolphins lacked regional data, the PSA used substitute values from populations outside of Australia. In the RRA, these risk profiles were refined with additional input from experts more familiar with Australian populations and/or the inclusion of additional (unpublished) data. These changes resulted in a reduction of the *productivity* score for the Australian humpback dolphin (Table 7; Appendix D). Preliminary *productivity* scores for the remaining species were retained for the final risk assessment.

The RRA of the PSA *susceptibility* scores was more substantive with four of the six species having at least one of their scores amended. In the PSA, distributional data limitations required the two bottlenose dolphins to be assessed against the alternative criteria for the *availability* attribute: *global distribution & stock proxy considerations* (Table 3). Under these criteria and considerations (Hobday *et al.*, 2007), both species were allocated a high-risk (3) score for this attribute (Table 5). As the common and Indo-Pacific bottlenose dolphin have wide geographical distributions, these values were considered to be an overestimate and the attribute was reassessed using distribution maps from the IUCN (Hammond *et al.*, 2012; Wells *et al.*, 2019). This resulted in a lowering of the scores assigned to the *availability* attribute for each species (Table 7; Appendix D).

Outside of the *availability* attribute, three species had their *encounterability* score reduced (Table 7). Further consultation and review of the available data indicated that the common bottlenose dolphin, the false killer whale and the spinner dolphin are more likely to be encountered in pelagic environments and in some instances are considered oceanic species (Appendix D). While these species are found in shallower waters, this preference for deeper water environments reduces both the likelihood and frequency of a large-mesh net interaction. In terms of the Level 2 ERA, these factors were addressed through the RRA and resulted in a downgrading of the *encounterability* scores for all three species (Table 7; Appendix D).

Risk score reductions implemented as part of the RRA were not sufficient to drop the species below the threshold for a high-risk rating. At 3.31 and 3.35 (respectively), risk scores for the spinner dolphin and false killer whale were in close proximity to the medium/high risk threshold (Table 7; Fig 1).

3.3.3 Dugongs

GOCIF operators fish in a range of inshore and offshore habitats including those preferred by dugongs. In the PSA, this was reflected in the score assigned to the *encounterability* attribute (Table 5). In the Gulf of Carpentaria there are a number of measures in place that provide dugongs with additional protections from net fishing including those instigated under the *North Marine Parks Network* (Director of National Parks, 2018), a prohibition on commercial fishing in key rivers along the Queensland coast of the Gulf of Carpentaria and the establishment of the *Wellesley Islands Protected Wildlife Area* (Department of Agriculture and Fisheries, 2013; Marsh, 1990). As these factors are not easily accounted for in the PSA framework, they were given further consideration as part of the RRA. A decision was subsequently made to reduce the *encounterability* score for dugongs to medium (2) (Appendix D). This score reduction did not alter the final risk rating for this species (Table 7).

3.3.4 Sharks

The RRA resulted in minimal amendments being made to the risk profiles of the four shark species. The risk profile of the speartooth shark was refined with additional information on the biology of the species (Appendix D). A second amendment was made to the *selectivity* assessment for the great hammerhead shark. As body size was used as the primary determinant for scores assigned to the *selectivity* attribute, the great hammerhead shark was initially assessed as low risk (Table 3; Table 5). However, research has shown that the morphology of the hammerhead shark cephalofoil makes them highly susceptible to net entanglements across a wide range of size classes (Ellis *et al.*, 2017; Harry *et al.*, 2011b), Due to this increased susceptibility, the *selectivity* score for the great hammerhead shark was increased from low to high (Appendix D). In both instances, amendments made as part of the RRA did not alter the final risk ratings.

3.3.5 Batoids

All of the batoid *productivity* score amendments involved the *age at sexual maturity* attribute and species assigned precautionary scores due to data deficiencies (Table 5). In the RRA, these scores were replaced with proxies from morphologically and taxonomically similar species (Table 7, Appendix D). These changes refined a number of the risk profiles and the amended values better reflect available data on batoid age and growth.

Changes made to the *susceptibility* components were more diversified and involved the *availability*, *encounterability* and *selectivity* attributes (Table 7). *Availability* scores for the bottlenose wedgefish and the eyebrow wedgefish were refined using alternate distribution maps. A review of the preferred habitats and net effort also facilitated an *encounterability* score reduction for three species; the Kuhl's devilray, reef manta ray and the estuary stingray (Table 7; Appendix D).

Outside of the *encounterability* attribute, two adjustments were made to PSA scores assigned to the *selectivity* attribute. In the PSA, the largetooth sawfish and the green sawfish were both assessed as low (1) risk as their maximum total length exceeds 5m (Last *et al.*, 2016). Criteria used to assess the *selectivity* risk (Table 3) are less suited to this family as they possess a blade-like rostrum armed with enlarged, lateral, tooth-like denticles (Last & Stevens, 2009). This rostrum is highly susceptible to net entanglements and it is a risk that will apply across a wide range of total lengths. For this reason, *selectivity* scores for all four sawfish species were set at high (3) regardless of the estimated maximum total length (Table 7; Appendix D).

4 Risk Evaluation

4.1 Gillnets (General)

When the results of the PSA and RRA were taken into consideration, the Level 2 ERA indicates that fishing activities in the GOCIF present a high risk to the assessed SOCC (Table 7). Biological and life-history constraints were a key driver of risk for most species and in some instances were the main contributor of risk. If for example, all of the *susceptibility* attributes were assigned the lowest value possible (1), the majority of species (59%, *n* = 16 out of 27) would still register a medium-risk rating. If just one of the *susceptibility* attributes were assigned a higher risk score (*e.g.* medium, 2), 85% of the species would be classified as a medium risk. This highlights the inherent challenge of managing fishing-related risks for species with *k*-selected life histories.

In the *susceptibility* analyses, the drivers of risk were more varied and were often dependent on the importance of the species to the fishery (target or non-target) and their general life-history (benthic or pelagic). However, a number of common themes emerged from the study that increased the level of risk across multiple subgroups and the level of uncertainty. These include the increased risk of drowning for air breathing species (marine turtles, dugongs and cetaceans), an inability to monitor catch rates, underreporting of interactions with non-target species and poor species resolution in the retained catch data. In these instances, these risks will need to be managed across the entire GOCIF and through the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017).

Across the study, all 27 species were assigned a risk score of medium (2) or high (3) for the *availability* attribute. This contrasts with the ECIF SOCC Level 2 ERA where 60% of the species (*n* = 20 out of 32) received a low (1) risk rating (Jacobsen *et al.*, 2021). The above differential is primarily linked to the GOCIF being a smaller fishery (when compared to the ECIF) and effort being distributed across a larger percentage of the prescribed area. The notable caveats being that the GOCIF has fewer licences, lower participation rates and lower levels of effort (Department of Agriculture and Fisheries, 2019b; f). These factors are considered to be of particular importance as a) *availability* does not take into consideration fishing intensity and b) the assessment may have been unduly influenced by low-effort grids. This in turn would have contributed to the production of more conservative risk assessments.

In addition to fishing intensity, the use of more generalised distribution maps contributed to a number of the SOCC receiving higher *availability* scores. With improved information on fine-scale effort movements, regional species distributions and the level of overlap with key habitats, a number of the scores could be refined and potentially reduced (Table 7). At a whole-of-fishery level, this information will be of particular importance when discussing risk variations between the N3, N12 and N13 fishery symbols (Department of Agriculture and Fisheries, 2019b). Of note, this deficiency is already being addressed through the *Queensland Sustainable Fisheries Strategy 2017–2027* and *Vessel Tracking* is now required on all GOCIF vessels (Department of Agriculture and Fisheries, 2018g; 2020a). When made available for use in an ERA, this data will be used to make further refinements and will (likely) result in a number of risk score reductions.

An inability to monitor catch compositions and release fates was another factor that contributed to the production of more conservative risk assessments. These deficiencies were most influential in assessments involving the *encounterability* and *post-capture mortality* attributes. In a Level 2 ERA, catch and release data (including confirmed low interaction rates) can be used to provide additional context on the likelihood of the species being encountered in a fishery and the sectors they are more likely to interact with. These refinements are of particular importance for species with broad habitat definitions or indicative distribution maps *e.g.* marine turtles, dolphins and cetaceans (Department of the Environment, 2018; 2019ac; 2020b). In the GOCIF SOCC Level 2 ERA, the scope of these refinements were limited by ongoing uncertainty surrounding total interaction rates, the number of fishing mortalities (*in-situ* and post-release) and the accuracy of the *Species of Conservation Interest* (SOCI) data (Jacobsen *et al.*, 2019a).

Assessing post-capture mortalities in the marine environment is inherently difficult and it was the attribute most affected by data deficiencies (Table 6). While fisheries-specific information is lacking, the risk of a net interaction ending in mortality will be higher for most air-breathing SOCC. In the Gulf of Carpentaria and on the Queensland east coast, this risk is mitigated through the use of net attendance provisions. In the N12 and N13 fisheries, net attendance provisions mirror those used in the ECIF with operators required to be within 100m of a net when in operation (Department of Agriculture and Fisheries, 2019b; f). A default high-risk rating (3) may over-estimate the *post-capture* *mortality* risk for these symbols as there is an increased probability that a marine megafauna interaction will be detected by the operator. This inference though is difficult to quantify without validated data on catch compositions and release fates (Jacobsen *et al.*, 2019a).

In the N3 fishery, net attendance provisions are more expansive with operators required to be within 5nm (~9km) of nets used in rivers or creeks and 6nm (~11km) of nets used in nearshore waters (Department of Agriculture and Fisheries, 2019b). The use of extended net attendance provisions can be partly attributed to the remoteness of the areas being fished, operational constraints and external factors including environmental conditions and safety considerations. While noting these constraints, these provisions increase the risk of non-target species becoming enmeshed and the probability of the interaction going undetected. These two factors increase the likelihood of an interaction ending in mortality and it is viewed as a significant risk factor for this fishery (Jacobsen *et al.*, 2019a).

On the Queensland east coast, the *Marine Wildlife Stranding and Mortality Database* (StrandNET) was used to provide further context on the extent of SOCC interactions in the ECIF (Department of Environment and Science, 2017). In the Gulf of Carpentaria, these types of comparisons are more limited as StrandNET relies heavily on public reports. These issues are compounded by the fact that raw SOCI data are not made available for direct entry into StrandNET.[6] Instead, StrandNET collects information on fishing-related strandings and mortalities through direct observations, reports from fishers, annual reports, necropsies and a weight-of-evidence approach. In the Gulf of Carpentaria, this process is complicated by operational and economic constraints associated with undertaking research and monitoring in more remote areas.

Improving the level of information on interaction and mortality rates will be essential if we are to understand how the GOCIF contributes to the cumulative risks. While the outputs of this assessment were at the higher end of the spectrum, mortality rates for a number of the subgroups will be low when compared to boat strike, subsistence fishing by Aboriginal peoples and Torres Strait Islander peoples and the impact of ghost nets (Department of Environment and Science, 2017; Ghost Nets Australia, 2018). These factors are considered to be of particular relevance to dugongs and the marine turtle complex. While more difficult to quantify, habitat degradation and climate change will also be a risk factor for most of the species assessed including the speartooth shark, sawfish and estuary rays (Compagno *et al.*, 2009; D'Anastasi *et al.*, 2013; Kyne *et al.*, 2013a; Kyne *et al.*, 2013b; Simpfendorfer, 2013).

The above highlight the importance of taking a regional approach when considering the risk posed by fishing activities in the GOCIF. Central to this will be the need to determine if the fishery is a contributor of risk or a main driver of risk, and (if applicable) the extent and scale of any management intervention *i.e.* across the entire GOCIF, at a fishery-symbol level or a regional level. There are however a number of areas where risk levels could be reduced across multiple species or subgroups and the accuracy of the risk profiles improved. As most of these measures relate to the collection of data, catch monitoring and compliance, their implementation would benefit a wide range of species not just those included in the GOCIF SOCC Level 2 ERA.

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[6] *This data is supplemented with information from annual SOCI reports that are made available to the public e.g. the species, apparatus and release fate (Department of Agriculture and Fisheries, 2019d).*

General recommendations

1. *Implement measures to improve fine-scale effort movement information, with particular emphasis on increasing understanding of how gillnets are used in habitats critical to the survival of key species.*

2. *Identify mechanisms to monitor the catch of target and non-target species effectively (preferably in real or near-real time) and minimise the risk of non-compliance with Species of Conservation Interest (SOCI) reporting requirements.*

3. *Identify avenues/mechanisms that can be used to monitor the catch of target and non-target species effectively (preferably in real or near-real time), validate data submitted through the logbook program, and minimise the risk of non-compliance with Species of Conservation Interest (SOCI) reporting requirements.*

4. *Review the suitability, applicability, and value of data submitted through the logbook program on the dynamics of the fishery (the type of gear being used, net configurations, soak times etc.). As part of this process, it is recommended that the reporting requirements be extended to include information on what fishing symbol is being used.*

5. *Review the suitability and applicability of the current net attendance provisions including their effectiveness at a) improving detection of a marine megafauna interaction, b) minimising the duration of a marine megafauna interaction with the net and c) reducing the number of in-situ mortalities.*

6. *Provide a synthesis of habitat data and distributions of key species in a format that is easily compared/overlayed with the effort footprint of the GOCIF.*

7. *Examine options to integrate data collected through the SOCI logbook program with ancillary programs like the Marine Wildlife Stranding and Mortality Database (i.e. StrandNET).*

8. *Review nomenclature used in fisheries legislation to ensure that it reflects the best available information with consideration given to expanding the definition for hammerhead sharks and devilrays.*

9. *Establish a measure to estimate the gear-affected area and, when available and appropriate, reassess the risk posed to key species using a more quantitative ERA method like bSAFE.*

A number of the above recommendations are already being addressed or implemented as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* including mandating the use of *Vessel Tracking*, establishing a *Fisheries Data Validation Plan*, reviewing the use of new or improved monitoring tools (*e.g.* electronic logbooks) and through the development of new and innovated technologies (Department of Agriculture and Fisheries, 2018b; d; g). In the GOCIF, many of the proposed changes represent a significant step forward in terms of the long-term management of both target and non-target species. These initiatives though will take time to develop and implement; particularly in a multidimensional, multifaceted fishery like the GOCIF.

4.2 Species-Specific Assessments

At the subgroup level, it is important to note that a number of the species were included in the Level 2 ERA as a precautionary measure. Most of these species have wide geographical distributions and there is limited information on their potential to interact with the GOCIF. They have however been observed in habitats and water depths where gillnets are utilised and they may still interact with this fishery. The inclusion of these species provides the Level 2 ERA with additional scope and will assist management if the current fishing environment changes significantly. This approach also minimises the potential of an at-risk species being omitted from the analysis due to misidentifications. Examples of which include hammerhead sharks where only the scalloped hammerhead (*S. lewini*) is listed under the EPBC Act and devilrays (*Mobula* spp.) where protection levels vary between species.

The inherent trade off with the above approach is that the final ratings for some species may represent a false positive or a risk overestimation. **For these species, the Level 2 ERA reflects the potential risk *verse* an actual risk and the results were classified as *precautionary*. Management of *precautionary* risks, beyond what is already being undertaken as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017), is viewed as less of a priority.** The decision to classify these assessments as *precautionary* was supported by an ad-hoc *Likelihood & Consequence Analysis* which provided further insight into the probability of the risk coming to fruition over the short to medium term (Appendix E).[7] With improved information, a number of the species with *precautionary* risk ratings could be excluded from future iterations of the GOCIF SOCC Level 2 ERA.

The following provides an overview of the key drivers of risk for all species included in the Level 2 ERA. Where possible, these evaluations include recommendations on where risk may be reduced within a particular subgroup and avenues that could be used to improve the accuracy of the risk assessments for key species. When and where appropriate, precautionary high-risks have also been identified.

4.2.1 Marine Turtles

Species	Sub-fishery / Apparatus	Risk Rating
Green turtle *(C. mydas)*	N3 & N12/N13 fishery	High
Hawksbill turtle *(E. imbricata)*	N3 & N12/N13 fishery	High
Flatback turtle *(N. depressus)*	N3 & N12/N13 fishery	High
Olive ridley turtle *(L. olivacea)*	N3 & N12/N13 fishery	High
Loggerhead turtle *(C. caretta)*	N3 & N12/N13 fishery	Precautionary High
Leatherback turtle *(D. coriacea)*	N3 & N12/N13 fishery	Precautionary High

Final risk ratings for the marine turtle complex displayed limited interspecific variability with all six registering scores in the high-risk category (Table 7; Fig. 1). At least five of the species are expected to utilise the Gulf of Carpentaria as a migratory pathway and/or for foraging; the exception being the leatherback turtle (*Dermochelys coriacea*). At least four species, the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys imbricata*), the flatback turtle (*Natator depressus*) and the olive ridley turtle (*Lepidochelys olivacea*), have nesting sites in the south, east or north-eastern Gulf of

[7] In the Level 2 ERA, the Likelihood & Consequence Analysis (LCA) was used to provide further insight into the probability of the risk coming to fruition over the short to medium term (Appendix E). The LCA is a fully qualitative assessment and was used to provide an indicative assessment of how conservative the PSA might be. As the LCA is qualitative and lacks the detail of the PSA, the outputs should not be viewed as an alternate or competing risk assessment, and the results of the PSA/RRA will take precedence over the LCA.

Carpentaria (Department of Environment and Science, 2018a; Department of National Parks Sport and Racing, 2016). Of the six species assessed, these four are most likely to be encountered in GOCIF net operations (Department of Agriculture and Fisheries, 2019f).

While the loggerhead turtle (*Caretta caretta*) is not known to nest in the Gulf of Carpentaria, the species may migrate or forage in these waters utilising subtidal/intertidal seagrass meadows and reefs (Department of National Parks Sport and Racing, 2016; Great Barrier Reef Marine Park Authority, 2018; Limpus, 2008c). However, information on migrations and post-hatching dispersal patterns suggests that loggerhead turtle interactions are more likely to occur on the Queensland east coast (Department of Environment and Science, 2018a; Department of National Parks Sport and Racing, 2016). For these reasons, the loggerhead turtle risk rating (Table 7) was considered precautionary and viewed as being more representative of the potential risk.

The leatherback turtle is sparsely distributed in Queensland waters and it is understood to prefer deeper, pelagic waters along the continental shelf. Satellite telemetry also suggests that key migration routes circumvent the Gulf of Carpentaria. For these reasons, the leatherback turtle was assigned a precautionary risk rating. While noting this assessment and the rarity of the species in the Gulf of Carpentaria, sightings and sporadic nesting activity have been recorded in this region and in the Northern Territory (Atlas of Living Australia, 2020a; Department of Agriculture and Fisheries, 2019b; Department of the Environment, 2019af). Similarly, significant concerns have been raised about their long-term conservation status and the cumulative risks posed to this species across their known distribution (*pers. comm.* C. Limpus; Limpus, 2009). This places added importance on obtaining accurate information on interaction rates and release fates in the GOCIF (if applicable).

The above inferences are supported by information compiled through the logbook reporting system, a previous *Fisheries Observer Program* and ancillary programs like StrandNET (Department of Agriculture and Fisheries, 2015; Department of Environment and Science, 2017; Stapley & Rose, 2009; Zeller & Snape, 2006). Around 80% of the Gulf of Carpentaria marine turtle-net interactions (including ghost nets) recorded in StrandNET involve the olive ridley turtle (29%), green turtle (15%), hawksbill turtle (15%) and the flatback turtle (12%) (1999 - 2011 data; Biddle & Limpus, 2011; Greenland & Limpus, 2003; 2004; Greenland *et al.*, 2002; Haines *et al.*, 1999; Meager & Limpus, 2012). This trend was partly mirrored in the SOCI data where the majority of interactions involved the green and hawksbill turtle (Department of Agriculture and Fisheries, 2019b).

While all six species were assessed as high risk, the risk posed by gill net fishing in the Gulf of Carpentaria will not be uniform. Marine turtles are not evenly distributed across the fished area and they will be observed in higher densities at key times, locations and/or habitats along the coastline (*pers. comm.* C. Limpus). At present, it is difficult to assess the extent of this variability and all six risk profiles would benefit from an improved synthesis of the available information on the distribution of net effort in biologically important areas and habitats critical to the survival of the species (Department of the Environment and Energy, 2017). This information will be of significant importance when determining how best to mitigate risk for this subgroup at a regional level and across the entire GOCIF. This risk is now being actively addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* with the expansion of the *Vessel Tracking* program (Department of Agriculture and Fisheries, 2017; 2018g).

As marine turtles are air-breathers, there are significant post-interaction risks for individuals that encounter a gillnet. A marine turtle caught in a gill net may find it difficult to access the surface to breath and will experience higher levels of stress. In protracted events, exhaustion will also be a contributing factor in terms of the number of *in-situ* (within net) and post-release mortalities. In the GOCIF, this risk will be present for both inshore (N3) and offshore (N12/13) operations but will be more prevalent in the N3 fishery. This is because net attendance provisions for this sector are set at maximum of 5nm (~9km) in rivers or creeks and 6nm (~11km) in nearshore waters (Department of Agriculture and Fisheries, 2019b). At these distances, the ability of the operator to detect a marine turtle interaction and release the animal unharmed would be severely compromised.

Data compiled through the SOCI logbooks includes 46 Gulf of Carpentaria marine turtle / net interactions (2003–2019 inclusive); all of which were reported as 'live releases' (Department of Agriculture and Fisheries, 2019b; d). For comparative purposes, StrandNET includes 16 confirmed commercial gillnet interactions (2003–2011 inclusive) and 11 mortalities.[8] These cross-study comparisons suggest that total rates of fishing mortality (*in-situ* plus post release) are higher than what is reported through the SOCI logbook program (Department of Agriculture and Fisheries, 2019b). However, the extent of any potential underreporting and the associated post-interaction risk can only be determined with improved catch monitoring and validation techniques.

By improving the level of information on catch and interaction rates, management can provide further context on how the GOCIF compares to external risks. For example, StrandNET recorded 136 marine turtle entanglements with ghost nets between 2003–2011 including 133 mortalities (Biddle & Limpus, 2011; Department of Environment and Science, 2017; Greenland & Limpus, 2003; 2004; Greenland *et al.*, 2002; Meager & Limpus, 2012). Research has shown that only 10% of the collected ghost nets originate from Australian managed fisheries with the majority coming from Indonesian vessels operating in the Arafura Sea (Ghost Nets Australia, 2018). Of the nets that are collected, over 60% comes from trawl fisheries (mostly Indonesian), 14% from gill nets and the remainder (~25%) from indeterminate sources. Based on these figures, the GOCIF is not expected to make a significant contribution to the number of ghost nets found in the Gulf of Carpentaria. These figures further suggest that ghost-nets are a more prominent risk for this subgroup. However, further investigations are required on how this risk varies across the fishery including between N3 and N12/N13 operations (Department of Agriculture and Fisheries, 2019b).

Outputs of the Level 2 ERA demonstrate that net fishing presents as a comparatively high risk to any marine turtle that interacts with this fishery. With that said, the precautionary nature of the methodology combined with data deficiencies have contributed to the production of more conservative risk assessments. Risk assessments for marine turtles could be refined with more accurate data on total interaction rates, an improved understanding of the current fishing dynamics and further examination of the level of fishing intensity in habitats classified as critical to their survival (Department of the Environment and Energy, 2017). The green, hawksbill, flatback and olive ridley

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[8] *Figures only contain instances where commercial gill net fishing was confirmed as the source of the interaction or mortality. Data does not include instances where circumstantial evidence suggested that commercial gill net fishing was responsible for a mortality but could not be confirmed. Data does not include mortalities connected with ghost nets / ghost net fishing. Accounts based on data contained within the Marine Wildlife Stranding Annual Reports (2011 is the last report available). Reports prior to 2003 used categories that were less defined e.g. tangled rope / fishing / live / bags, ghost nets. Catch categories from 2003 onwards were more prescriptive (e.g. commercial fishing, gill nets; ghost net entanglement) and provided greater avenues for direct comparison with the SOCI data.*

turtles should be prioritised in this process. However, this data could be used to refine the assessments of all six marine turtle species. More importantly, it will provide further context on how gillnet fishing impacts regional marine turtle populations and how this compares to other risk factors (ghost nets, subsistence fishing, disease *etc.*).[9] This information will be of central importance when determining if gillnet fishing is a key driver of risk or a contributor or risk for individual species and the extent of any management response.

Species-specific recommendations

1. ***Provide a synthesis of regional distribution data for green, hawksbill, flatback and olive ridley turtles to evaluate a) the level of overlap with net effort in the Gulf of Carpentaria, b) identify key areas that have no or low levels of effort but can be still accessed by the fishery and c) the level of protection already afforded to these species through marine park reserves, fisheries closures etc.***

   Distribution maps for marine turtles provided little insight into regional movements, abundances and habitat usage. These deficiencies contributed to the production of more conservative risk assessments and a (potential) overestimation of risk for one or more of these species. Obtaining a more accurate account of the distribution of these species in the Gulf of Carpentaria will help to refine risk profiles and provide further insight on the suitability and applicability of any risk mitigation strategies.

2. ***Improve the level of understanding on the extent of marine turtle interactions in the GOCIF.***

   This recommendation is intimately linked with the first recommendation and those made for the entire fishery (refer section 4.1). This information is of central importance when attempting to understand the impact of net fishing activities on regional marine turtle interactions, how these impacts compare to external risk factors (ghost nets from other fisheries, boat strike etc.) and the extent of any inter-specific risk variability.

   At present all six species are classified as being at a high or precautionary high risk from net fishing activities in the GOCIF. This risk is unlikely to be uniform and may be lower for some of the species assessed. These variations could not be explored in great detail as part of the Level 2 ERA due to data deficiencies and an inability to validate catch compositions or interaction rates.

3. ***Establish a process where data on marine turtle interactions submitted through the SOCI logbook program can be integrated more effectively into the Marine Wildlife Stranding and Mortality Database (i.e. StrandNET).***

   Unless an interaction is reported through both programs, raw SOCI data is not made available for direct entry into StrandNET. Instead, StrandNET collects information on fishing-related strandings and mortalities through direct observations or reports from fishers, necropsies and a weight-of-evidence approach. This data is supplemented with information from annual SOCI reports that are made available to the public *e.g.* the species, apparatus and release fate (Department of Agriculture and Fisheries, 2019d).

[9] *Additional information on the cumulative risks has been provided in the whole-of-fishery (Level 1) Ecological Risk Assessment (Jacobsen et al., 2019a).*

Providing safeguards are put in place to protect commercially sensitive material, it is recommended that the SOCI data be made available for direct input into StrandNET. This would allow for the development of datasets that are more comprehensive and cover a wider sample area. It would also provide greater insight into the cumulative pressures being exerted on a species and allow for direct comparisons with other risk factors such as mortalities stemming from boat strike. From an ERA perspective, homogenising the two datasets would provide a clearer understanding of the extent of any under-reporting and further context on the extent of the overall risk when compared to other, more significant risks *e.g.* boat strike and disease (Jacobsen *et al.*, 2019a).

4.2.2 Dugongs

Species	Sub-fishery	Risk Rating
Dugong (*D. dugong*)	Primary risks: N3 fishery	High

As air breathing marine mammals, the risk profile for dugongs (*Dugong dugon*) shares a number of similarities with the marine turtle subgroup. At 2.71, dugongs had one of the highest *productivity* scores in the Level 2 ERA. This score would have been considerably higher had it not been for the *trophic level* attribute which was assigned the lowest value possible (Table 7). These biological constraints limit the ability of the species to absorb fishing mortalities and contributed to a historic decline in dugong population numbers (Marsh *et al.*, 2005; Meager *et al.*, 2013). As dugongs are already no-take species and the *productivity* assessment is based on their biology, these risks will be difficult to address through a fisheries reform agenda.

Survey estimates place the Gulf of Carpentaria dugong population at around 35,000 individuals, compared to ~30,500 in the Torres Strait, ~25,500 in northern Great Barrier Reef and ~27,000 in the southern Great Barrier Reef (Department of the Environment, 2018). In the Gulf of Carpentaria, the majority of the population inhabit waters outside of Queensland's management jurisdiction, namely the western and south-western coastline. In the PSA, the use of a broader distribution map may not have adequately accounted for this factor (Table 7). With improved information on regional distributions and fine-scale effort movements, scores assigned to the *availability* attribute could be refined. While a score reduction for the *availability* attribute will not reduce the overall rating, this information will better inform discussions on where dugong interactions are more likely to occur.

In Queensland managed waters, the Wellesley Island and Mornington Island region has been identified as a key area for this species (*pers. comm.* A. Grech; Marsh *et al.*, 2008). Within this area, spatial closures are used to provide dugongs with additional protection from net fishing activities (Department of Agriculture and Fisheries, 2013; Director of National Parks, 2018). Dugongs will also derive benefit from regional closures designed to manage resource accessibility across the commercial and indigenous fishing sectors (*pers. comm.* T. Ham; Department of Agriculture and Fisheries, 2013). In the Level 2 ERA, these factors were taken into account as part of the *encounterability* attribute RRA (Table 7; Appendix D).

While dugongs are afforded additional protection from commercial net fishing, interactions will still occur in the GOCIF. These interactions are more likely to occur in the N3 fishery where operators target teleosts in areas where dugongs are more likely to be encountered *e.g.* nearshore and intertidal waters where seagrass beds are more prevalent. While dugongs may still interact with the N12/13 fishery, these operations fish further out from the coastline and in deeper water environments (Department of Agriculture and Fisheries, 2019b). *Species of Conservation Interest* data for the fishery includes three interactions since 2003; two in 2016 and one in 2018. There is however limited capacity within the current management regime to validate or verify the accuracy of this data. This inability to validate data or monitor catch in real or near-real time increases uncertainty in the catch data and elevates the risk of underreporting (Department of Agriculture and Fisheries, 2019b; Jacobsen *et al.*, 2019a).

Cross-comparisons with the StrandNET data provided limited insight into the potential for underreporting. The majority of dugong mortalities in the Gulf of Carpentaria were associated with traditional hunting with net fishing only implicated in two pre-2016 deaths. In both of these instances, the origins and legality of the nets could not be confirmed. As noted, StrandNET datasets for the Gulf of Carpentaria are less developed and the program will not include all fishing-related interactions (Department of Environment and Science, 2017). For this reason, StrandNET arguably provides greater insight into the extent of external risks and mortalities *e.g.* ghost nets, boat strikes, disease and subsistence fishing. With greater alignment of the SOCI logbooks and StrandNET, the coverage of both programs could be improved and advancements made in terms of quantifying regional interaction rates.

Once caught within the net, the risk of a dugong interaction ending in a mortality will be high; even with the use of net-attendance provisions. While data on dugong interactions in the GOCIF is limited, the extent of the mortality risk can be partly inferred from the ECIF. Provisions governing the use of large mesh nets on the Queensland east coast are comparable to that used in offshore waters including net attendance provisions (Department of Agriculture and Fisheries, 2019b; f). Data submitted from this sector of the ECIF indicates that around 43% of dugong interactions end in mortality (Department of Agriculture and Fisheries, 2019b; f).[10] In the Gulf of Carpentaria, the risk of a dugong interaction ending in mortality will be higher in nearshore waters and rivers/creeks (N3 fishery) as net attendance provisions are set at 5 and 6nm respectively (Department of Agriculture and Fisheries, 2019b).

The GOCIF will be a contributor of risk for this subgroup and a source of mortality for regional dugong populations. Based on the available information, it is anticipated that dugongs have low and infrequent interactions with the GOCIF. It is further hypothesised that, based on current participation rates and effort distribution, the number of interactions will be lower than on the Queensland east coast (Department of Agriculture and Fisheries, 2019b; f). There are however limited avenues to test the strength of the above hypothesis, quantify interaction rates or identify priority areas for monitoring. It is further recognised that the conservative life-history of these species will amplify the risks posed by this fishery. These risks will be present at low levels of fishing mortality and this was the reason why dugongs were not assigned a *precautionary* risk rating. It also places added importance on providing a synthesis of the available data on key dugong habitats and a more refined assessment of the effort overlap in key areas.

[10] *Based on data submitted through the SOCI logbook from 2003–2017 (inclusive).*

Species-specific recommendations

1. ***Provide a synthesis of regional distribution data, critical habitats and movement patterns for comparison with the distribution of effort in the GOCIF.***

   While there is considerable information on dugong populations and habitats, the information has yet to be summarised, mapped or presented in a way that can be easily compared to effort distribution maps. If it is determined that some form of management intervention is required, a more detailed map showing key habitats and populations across the state will inform discussions and help identify priority areas for risk management. Ideally, this information would be provided in a shapefile that could be overlayed with a map depicting the distribution of effort in the fishery.

2. ***Undertake a review of the spatial closures implemented in the Gulf of Carpentaria through State (Queensland, Northern Territory) and Commonwealth legislation to evaluate current protections and the intensity of fishing effort in adjacent areas.***

   In addition to the distribution maps, it is recommended that a review of spatial closures and protections be undertaken. This information will provide insight into the amount of critical habitat that is already protected from commercial fishing in Queensland managed waters and adjacent jurisdictions (State and Commonwealth). The mapping of these closures will assist with for fine-scale assessments of the fishing intensity (*i.e.* in areas adjacent to the closures) and provide regional context on the interaction potential of this species.

3. ***Establish a process where data on dugong interactions submitted through the SOCI logbook program can be integrated more effectively into the Marine Wildlife Stranding and Mortality Database (i.e. StrandNET).***

   Unless an interaction is reported through both programs, raw SOCI data is not made available for direct entry into StrandNET. Instead StrandNET collects information on fishing-related strandings and mortalities through direct observations or reports from fishers, necropsies and a weight of evidence approach. This data is supplemented with information from annual SOCI reports that are made available to the public *e.g.* the species, apparatus and release fate (Department of Agriculture and Fisheries, 2019d).

   Providing safeguards are put in place to protect commercially sensitive material, it is recommended that the SOCI data be made available for direct input into StrandNET. This would allow for the development of datasets that are more comprehensive and cover a wider sample area. It would also provide greater insight into the cumulative pressures being exerted on a species and allow for direct comparisons with other risk factors such as mortalities stemming from boat strike. From an ERA perspective, homogenising the two datasets would provide a clearer understanding of the extent of any under-reporting and further context on the extent of the overall risk when compared to other, more significant risks *e.g.* boat strike and disease (Jacobsen *et al.*, 2019a).

4.2.3 Cetaceans

The cetacean subgroup registered one of the highest average scores for the *productivity* component of the PSA (Table 5). All six species were assigned the maximum score for at least three of the *productivity* attributes and these biological constraints were significant in terms of the final risk ratings

(Table 7). As dolphins are air breathing mammals, a number of the risks identified in the *susceptibility* analysis will apply to all species included in the assessment.

Once a dolphin becomes enmeshed in a gillnet, the risk of the interaction ending in a mortality will increase with the length/duration of the interaction. In the GOCIF, this risk will be higher in nearshore waters due to the fishery operating under less-stringent net attendance provisions (Department of Agriculture and Fisheries, 2019b). Set at a maximum of 5 or 6nm (~9–11km), current net attendance provisions provide licence holders with little opportunity to detect a dolphin interaction and/or take measures to limit the extent of the interaction. Likely consequences of which include increased stress on the animal, increased risk of injury, an increased risk of *in-situ* (within net) and post-interaction mortalities.

Data obtained through the SOCI logbooks (2003–2019 inclusive) includes seven dolphin interactions: two common (offshore) bottlenose dolphins (*T. truncatus*), two snubfin dolphins (*O. heinsohni*), two false killer whales (*P. crassidens*) and one unknown (Department of Agriculture and Fisheries, 2019b; d). A further five bottlenose dolphin interactions were reported by Fisheries Observers[11] during the 2000–2002 period (Meager *et al.*, 2012; Roelofs *et al.*, 2003). For comparative purposes, StrandNET includes 12 dolphin interactions with commercial fishing nets (1999–2015 inclusive). The majority of these interactions involved bottlenose dolphins (*n* = 9) and nets used in the N12/N13 fishery[12] (Department of Environment and Science, 2017; Meager, 2013; 2016a; Meager *et al.*, 2012).

As with marine turtles and dugongs, the risk of non-compliance and non-reporting is elevated by the absence of an effective mechanism to monitor fishing activities. This inability to validate SOCI data makes it difficult to quantify species-specific rates of fishing mortality or assess the longer-term risks for this subgroup. However, the available data suggests that dolphin interactions in this fishery are low and potentially infrequent. For some of these species, current interaction rates and mortality levels could be tolerated or sustained by regional populations. Other species including the snubfin and Australian humpback dolphin may find it more difficult to respond or rebound from these declines.

In the Level 2 ERA, the above factors were considered for three groups a) the Australian snubfin and humpback dolphins, b) bottlenose dolphins and c) the false killer whale and spinner dolphin. These divisions are largely based on similarities in their respective risk profiles including the key drivers of risk, the likelihood of an interaction occurring in the fishery and extent of these interactions including the frequency.

4.2.3.1 Australian Snubfin & Australian Humpback Dolphin

Species	Sub-fishery / Apparatus	Risk Rating
Australian snubfin dolphin (*O. heinsohni*)	Primary risks: N3 fishery Secondary risks: N12/N13 fishery	High
Australian humpback dolphin (*S. sahulensis*)	Primary risks: N3 fishery Secondary: N12/N13 fishery	High

[11] *The Fishery Observer Program ceased operations in 2012. Use of the Species of Conservation Interest (SOCI) logbook commenced in 2003.*

[12] *Records refer to the N9 fishery which were transitioned to the N12 and N13 fishery symbols as part of a broader Gulf of Carpentaria fisheries review (Department of Agriculture and Fisheries, 2018a).*

The Australian snubfin dolphin (*Orcaella heinsohni*) and the Australian humpback dolphin (*Sousa sahulensis*), referred to herein as the snubfin and humpback dolphin, are two of the more vulnerable cetacean species included in the Level 2 ERA. Up until recently, the two were identified as alternate species and assessed accordingly. The snubfin dolphin was originally classified as the Irrawaddy dolphin (*O. brevirostris*) with the humpback dolphin considered conspecific with the Indo-Pacific humpback dolphin (*S. chinensis*) (Parra *et al.*, 2017b). These four species have now been separated using taxonomic and genetic analyses, resulting in a recalibration of their known distributions. The distribution of the Irrawaddy and Indo-Pacific humpback dolphin is now largely confined to south-east Asia (Jefferson & Rosenbaum, 2014; Jefferson *et al.*, 2017; Minton *et al.*, 2017) with the snubfin and humpback dolphin inhabiting waters of northern Australia and Papua New Guinea (Parra *et al.*, 2017a; Parra *et al.*, 2017b).

In Australia, the snubfin dolphin and the humpback dolphin are sympatric over most of their range (Brown *et al.*, 2014). While the snubfin dolphin has been reported as far south as Moreton Bay in south-east Queensland, the species is more prevalent in waters north of Keppel Bay and records south of this point are considered rare and extralimital (Parra *et al.*, 2017a). When compared, humpback dolphins are more widely distributed along the Queensland coastline and are observed with more frequency in southern Queensland (Department of Environment and Science, 2018b; Meager, 2016a; Parra *et al.*, 2017b). Range descriptions for both species though are largely inferred and require further investigations to determine if they have patchy and localised distributions or are found in a continuum along the coastlines of eastern Queensland and Gulf of Carpentaria (Parra *et al.*, 2017a; Parra *et al.*, 2017b).

Information gaps in the distributional data creates uncertainty surrounding the level of overlap each species has with the footprint of the GOCIF. These uncertainties reflect a broader deficiency in the amount of information that is available on their ecology and biology (Allen *et al.*, 2012; Cagnazzi, 2017; Parra *et al.*, 2006b). Snubfin and humpback dolphins are frequently observed in protected coastal habitats such as inlets, estuaries and bays (Brown *et al.*, 2016; Parra *et al.*, 2017a; Parra *et al.*, 2017b). This is reflected in the depth profile of both species which occupy shallow water environments (<20 m), often in close proximity to river mouths and estuaries (Parra *et al.*, 2006b). Based on these preferences, the N3 fishery is expected to pose a higher risk to these species as operators principally target teleosts in rivers, creeks and nearshore waters (Department of Agriculture and Fisheries, 2019b).

Only two snubfin dolphin interactions have been reported through the SOCI logbook since 2003 and there are no reports of an operator interacting with a humpback dolphin (Department of Agriculture and Fisheries, 2019b). As this data does not include contact without capture events and post-release mortalities, it is likely that these figures underestimate the number of interactions that occur in this fishery (Jacobsen *et al.*, 2019a). While noting these factors and the risk posed by underreporting (Jacobsen *et al.*, 2019a), it is anticipated that both the snubfin dolphin and humpback dolphin will have low interaction rates in the GOCIF.

While acknowledging the potential for underreporting, interaction rates for these two species are likely to be low. For widely dispersed species with larger populations, low interaction rates often equate to a lower level of risk. However, the snubfin and humpback dolphin form small (<100 individuals), genetically distinct populations that are unlikely to sustain even very low rates of fishing mortality (Brown *et al.*, 2014; Parra *et al.*, 2017a; Parra *et al.*, 2017b; Parra *et al.*, 2004; Parra *et al.*, 2006a).

Due to these reasons, there is a considerable risk that fishing-related mortalities will contribute to a decline in the viability of regional populations, reduce genetic diversity and lead to further fragmentation of regional populations (Appendix E).

For the snubfin and Australian humpback dolphin, the outputs of the Level 2 ERA are considered to be more representative of an actual or real risk (Table 7). As the two species exist in low densities and have (potentially) fragmented distributions, their capture in the GOCIF has the potential to affect the viability of regional populations and contribute to a long-term downgrade of their conservation status. The key determinants in this equation being a) the size, structure and distribution of regional populations, b) the location of habitat critical to the survival of the species and c) the frequency and intensity of fishing events/effort within these areas. Without this information it is difficult to determine if the outputs of the Level 2 ERA are conservative or are consistent with what is occurring in the current fishing environment. From a management perspective, a lack of understanding of where the species occurs, population numbers and their relationship with the GOCIF, particularly the N3 fishery, will hamper efforts to manage this risk effectively.

Species-specific recommendations

1. ***Provide a synthesis of regional distribution data for snubfin and humpback dolphins to evaluate a) the level of overlap with GOCIF effort and b) the level of protection already afforded to the species in the region.***

   While the level of information is improving, there are inherent challenges with documenting the distribution and population health of species that aggregate in smaller abundances. Range, habitat and abundance data for both the snubfin and humpback dolphin is fragmented and further investigations are required. From a fisheries management perspective, this type of uncertainty makes it difficult to assess how extensive the risk is for these species and the (potential) long-term consequences of their interactions with the fishery. Obtaining a more comprehensive overview of the available information on their distribution and habitat preferences would assist in this process. Ideally, this information would be provided in a shapefile that could be overlayed with a map depicting the distribution of net effort in the Gulf of Carpentaria.

2. ***Depending on the outcomes of the spatial analysis review (recommendation 1), assess the conservation value, suitability and applicability of introducing further protection measures for snubfin and humpback dolphins.***

   The suitability and applicability of this recommendation will be dependent on the outcomes of the spatial analysis review and will be best addressed through the Fisheries Working Group framework.

   This review (recommendation 1) will provide further insight into the areas where these species are observed in greater abundance and help identify areas where the fishing-related risks will be higher. If this review determines that intervention is required, management of this risk will be most effective at a regional level. Any risk mitigation strategy will need to consider how best to compliment and maximise protections that are already in place.

4.2.3.2 Bottlenose Dolphins

Species	Sub-fishery / Apparatus	Risk Rating
Indo-Pacific bottlenose (*T. aduncus*)	N3 & N12/N13 fishery	Precautionary High
Common bottlenose (*T. truncatus*)	N3 & N12/N13 fishery	Precautionary High

When compared to the snubfin and humpback dolphin, there are fewer concerns surrounding the conservation status of the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*T. aduncus*). Population estimates for the common bottlenose dolphin indicate that the species is relatively abundant throughout its range (Wells *et al.*, 2019). This has contributed to the species receiving an IUCN redlist classification of *Least Concern* (Wells *et al.*, 2019). Population estimates for the Indo-Pacific bottlenose dolphin are less certain and information gaps have resulted in the species being classified as *Data Deficient.* Despite this, there is evidence that this species has a comparatively high aggregate abundance in coastal waters (Hammond *et al.*, 2012).

The distribution of the common bottlenose and Indo-Pacific bottlenose dolphin extends well beyond the Australian Exclusive Economic Zone (AEEZ). In Australia, their distribution incorporates the entire northern coastline, the Gulf of Carpentaria and the Queensland east coast (Hammond *et al.*, 2012; Wells *et al.*, 2019). Within these areas, bottlenose dolphins will regularly interact with commercial net fisheries including prawn trawl operations. Given the behaviour of the species, this will include incidental net interactions and actions instigated by the animal *e.g.* preying on enmeshed fish. These two species will be responsible for the majority of dolphin-net interactions observed and reported from the Gulf of Carpentaria and on the Queensland east coast (Department of Agriculture and Fisheries, 2019b; f; Jacobsen *et al.*, 2019a; b).

Bottlenose dolphins have depth profiles and habitat preferences that align closely with the GOCIF effort footprint. Indo-Pacific bottlenose dolphins are often associated with shallow-water environments including inshore coastal waters, estuaries, bays and river mouths (Brown *et al.*, 2016; Cribb *et al.*, 2013; Department of Agriculture and Fisheries, 2019b; Fury & Harrison, 2008; Lukoschek & Chilvers, 2008). While common bottlenose dolphins also inhabit inshore waters, they are regularly observed in larger aggregations in offshore waters (Bearzi *et al.*, 2009; Bilgmann *et al.*, 2019; Great Barrier Reef Marine Park Authority, 2013). These habitat preferences will expose both species to a wide range of net fishing activities and increase their interaction potential. For the Indo-Pacific bottlenose dolphin, these risks will extend across the N3 and N12/13 fisheries. However, the common bottlenose dolphin will arguably be at greater risk from activities in the N12/N13 fishery (Department of Agriculture and Fisheries, 2019b).

For an individual, net fishing presents as a significant risk with notable consequences. A dolphin that interacts with a net and becomes enmeshed may be injured as a result of their capture or die during the fishing event. The extent of this risk will be different at a population and species level. This is because interaction and *encounterability* rates in the GOCIF are unlikely to lead to a decline in the long-term conservation status of the two bottlenose dolphin species. Population numbers for each species are seemingly robust (Hammond *et al.*, 2008; Wells *et al.*, 2019) and there is little evidence to suggest that they form sub-populations in the Gulf of Carpentaria or exhibit behaviours that would limit their genetic diversity. For these reasons, outputs produced from the Level 2 ERA are viewed as precautionary and management of this risk through species-specific reforms may not be required.

This situation may change if, for example, evidence emerges that dolphin interactions are significantly higher than what is being reported or there is a considerable shift in the frequency and number of interactions.

Species-specific recommendations

1. ***Improve the level of understanding on the extent and type of interactions (e.g. captures, contact without capture events) the GOCIF has with regional bottlenose dolphin populations.***

   This information is of central importance when attempting to understand the impact of net fishing activities on bottlenose dolphin populations, how these impacts compare to external risk factors (ghost nets from other fisheries, boat strike etc.) and the extent of any inter-specific risk variability. Implementing measures to monitor catch rates and release fates (in real or near-real time) would greatly assist with this process.

4.2.3.3 False Killer Whale & Spinner Dolphin

Species	Sub-fishery / Apparatus	Risk Rating
False killer whale (*P. crassidens*)	N12/N13 fishery	Precautionary High
Spinner dolphin (*S. longirostris*).	N12/N13 fishery	Precautionary High

The false killer whale (*Pseudorca crassidens*) and the spinner dolphin (*Stenella longirostris*) were included in the Level 2 ERA as a precautionary measure and in response to feedback received as part of the species rationalisation process (Appendix B). There are no reports of a spinner dolphin interacting with a commercial net fishery in the Gulf of Carpentaria or on the Queensland east coast. The first two reports of a false killer whale interacting with a fishery occurred in 2019 and involved the use of anchored gillnets in the GOCIF (Department of Agriculture and Fisheries, 2019d). While noting these recent developments, both species will have low and infrequent interactions with the GOCIF. This situation is not expected to change over the short to medium term unless the current fishing environment changes significantly (Department of Agriculture and Fisheries, 2019b).

While *productivity* assessments for both species were comparable to the other cetaceans, it was more influential in the risk profile of the false killer whale. In this assessment, biological constraints were the key driver of risk and negated what was the lowest *susceptibility* score in the Level 2 ERA (Table 7). *Susceptibility* scores for both species though were lower than that recorded for the Australian humpback, Australian snubfin and bottlenose dolphins. This was largely attributed to the species receiving lower scores for the *encounterability* attribute (Table 7).

While all four *susceptibility* attributes are given equal weighting, this approach is arguably less suited to the false killer whale and spinner dolphin. Their Australian distribution is less defined and maps depicting their range cover most if not all of the GOCIF; hence their inclusion in the Level 2 ERA. In reality, the overlap between net effort and the preferred habitats and bathymetric ranges would be much lower. For example, the false killer whale is more often associated with relatively deep, offshore waters where net fishing is limited (Baird, 2018; Department of the Environment, 2019v). The spinner dolphin is found more readily in inshore waters but is commonly observed around oceanic islands or forming large aggregations hundreds of kilometres offshore (Braulik & Reeves, 2018; Department of the Environment, 2019k). These reasons make false killer whale and spinner dolphin interactions unlikely in the N3 fishery and limits the interaction potential for N12 and N13 fisheries.

Where possible, the habitat preferences of both species were given additional consideration as part of the RRA (Appendix D). This resulted in the *encounterability* scores being downgraded to low (1). These revised scores better reflect the low probability of false killer whales and spinner dolphins interacting with the GOCIF in high numbers or with increased frequency (Appendix E). Despite these changes, both species were assessed as high risk from fishing activities in the GOCIF. Based on the available information on their distribution and interaction rates, this is considered to be a false-positive result or a risk overestimate. Accordingly, risk ratings for the false killer whale and spinner dolphin were classified as precautionary. This situation may change if the dynamics of the fishery change significantly or the footprint of the fishery extends further into deeper water environments. Alternatively, improved information of vessel movements and fine-scale effort usage may facilitate the removal of these species from subsequent ERAs.

Species-specific recommendations

Not applicable at the species level. However, future ERAs would benefit from the collection of additional data on interaction rates in the GOCIF and the fine-scale movement of effort; particularly in the N12/13 fishery (see general recommendations). With improved information, both species could potentially be omitted from future ERAs involving this fishery.

4.2.4 Sharks

Hammerhead sharks (*Family Sphyrnidae*) and the speartooth shark (*Glyphis glyphis*) differ with respect to how they interact with the fishery and the key drivers of risk. These differences influence how risk can be addressed in the GOCIF and how best to manage this risk through the reform process. Operators in the GOCIF can retain hammerhead sharks and the fishing-related risks for this subgroup will need to be considered as part of the harvest strategy development process (Department of Agriculture and Fisheries, 2017). As the speartooth shark is a no-take species, these risks will need to be addressed as part of a broader bycatch management strategy. For these reasons, the outputs of the risk assessment for hammerhead sharks and the speartooth shark were discussed separately.

4.2.4.1 Hammerhead Sharks

Species	Sub-fishery / Apparatus	Risk Rating
Scalloped hammerhead (*S. lewini*)	Primary risks: N12/N13 fishery Secondary risks: N3 fishery	High
Great hammerhead (*S. mokarran*)	Primary risks: N12/N13 fishery Secondary risks: N3 fishery	High
Winghead shark (*E. blochii*)	Primary risks: N12/N13 fishery Secondary risks: N3 fishery	High

If criteria used to construct the species list was strictly adhered to (Appendix A), only the scalloped hammerhead shark (*Sphyrna lewini*) would have been included in the Level 2 ERA. The scalloped hammerhead is listed as *Conservation Dependent* on the EPBC threatened species list and there is an ongoing review into the sustainability of the species in Australian waters (Department of the

Environment and Energy, 2019a). At present, no other hammerhead shark is listed under the EPBC Act or afforded species-specific protections in Queensland waters. Despite this, the decision was made to include the scalloped hammerhead shark, great hammerhead shark (*S. mokarran*) and the winghead shark (*Eusphyra blochii*) in the Level 2 ERA (Appendix B). This decision was based on the fact that hammerhead sharks can be difficult to differentiate between in an active fishing environment; particularly when dealing with juveniles and sub-adults.

Outputs of the Level 2 ERA classified all three hammerhead sharks as being at high risk from fishing activities in the GOCIF (Table 7). While acknowledging these results, the risk posed to this subgroup is not expected to be as uniform. Under provisions governing the take of sharks in the Gulf of Carpentaria, only licence holders with a N12 or N13 fishing symbol are allowed to actively target sharks for commercial sale. While N3 licence holders can retain shark product, this can only occur if they are caught as a byproduct while targeting other species *e.g.* barramundi, threadfin, jewfish *etc*. (Department of Agriculture and Fisheries, 2019b). Due to these restrictions, these species are more likely to be retained in higher quantities by operators in the N12 and N13 fisheries.

At a species-specific level, the more immediate risks and sustainability concerns involve the scalloped hammerhead shark and the great hammerhead shark. These two have widespread distributions and, as migratory species, have sustainability concerns that extend to waters outside of Australia (Rigby *et al.*, 2019a; Rigby *et al.*, 2019c). Evidently, the targeting of scalloped and great hammerhead sharks across jurisdictions (*i.e.* cumulative fishing pressures) was the catalyst for their inclusion in Appendix II of CITES and their listing as a migratory species under the CMS. As seen with the EPBC Act listing of scalloped hammerhead sharks, these global concerns can affect commercial fisheries operating in Queensland. By extension, the management of the species in Queensland waters will be considered as part of third-party assessments including threatened species assessments conducted under the EPBC Act and *Wildlife Trade Operation* (WTO) approvals.

Datasets for the winghead shark are less complete but research suggests that the species has a patchy localised distribution (Smart & Simpfendorfer, 2016). Given this, the winghead shark risk profile may be of more relevance when considering regional fishing pressures and risks. As winghead sharks are faster growing and experience lower levels of fishing pressure, there is also the possibility that the risk profile overestimates the level of risk posed to this species (Table 7). This species though will interact with fisheries in adjacent jurisdictions (*e.g.* the Northern Territory Offshore Net and Line Fishery) and the GOCIF will be a contributor of risk for the winghead shark.

As with most species included in the SOCC ERA, life-history constraints were highly influential in the final risk ratings. These constraints were sufficient to assign the great hammerhead shark and the scalloped hammerhead shark with the highest risk score for all but one of the *productivity* attributes (Table 7). In addition to their biology, there are a number of traits that increase hammerhead shark's *susceptibility* to net fishing activities. For example, the distinctive shape of the hammerhead shark head makes them highly susceptible to net entanglements across a wide range of size classes (Department of the Environment and Energy, 2014; Harry *et al.*, 2011b). In other shark species, this risk is often mitigated by body size as larger animals tend to outgrow the *selectivity* of the net, therefore, helping to minimise the number of entanglements. This risk is further compounded by the fact that hammerhead sharks have a low tolerance for net entanglements and are more likely to die without relatively rapid intervention (Harry *et al.*, 2011b).

Hammerhead sharks can be retained for sale in the GOCIF and can be actively targeted by operators with an N12 or N13 fishery symbol (Department of Agriculture and Fisheries, 2019b). This introduces a degree of complexity that is not found in the risk profiles of most other SOCC. In the GOCIF, the take of hammerhead sharks is managed through a combined 50t TACC limit. This limit applies to the scalloped and great hammerhead shark[13] and is supported by decision rules that restrict their take as the fishery approaches the TACC limit (Department of Agriculture and Fisheries, 2018e). As the winghead shark belongs to a different genus (*Eusphyra*), the take of this species is not included in the hammerhead shark TACC and retention rates for this species are not subject to regional commercial limits. This difference is important as it theoretically allows the retained winghead shark catch to increase to levels not permitted under the *Sphyrna* spp. TACC limit. While this is unlikely to occur in the current fishing environment (Department of Agriculture and Fisheries, 2019b), it is a risk that can actively be addressed through the management reform framework.

At a whole-of-fishery level, the introduction of a hammerhead shark TACC limit was a significant step forward with respect to managing the take of the resource in the Gulf of Carpentaria. This limit is based on a CITES-linked Non-Detriment Finding (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2019; Department of the Environment and Energy, 2014) and considers cross-jurisdictional fishing pressures *e.g.* Northern Territory, Gulf of Carpentaria and the Queensland east coast. It is also at the lower end of the spectrum with respect to the combined MSY estimate for the scalloped hammerhead, great hammerhead and winghead shark in the Gulf of Carpentaria (40–174t; Leigh, 2015).

Multi-species TACCs are useful for groups like hammerhead sharks where morphological similarities make it difficult to differentiate between species in an active fishing environment. The disadvantage of this approach is that multi-species TACCs may not be flexible enough to respond to a changing fishing environment or detect overfishing events for individual species and regional stocks. In the GOCIF, one of the more significant risks is that an overfishing event (*i.e.* fishing a hammerhead shark stock above sustainability reference points) will go undetected. This risk is likely to be exacerbated by an inability to account for discards in annual catch limits. This again has the potential to undermine the effectiveness of the TACC limit as total catch and rates of fishing mortality will be higher than what is reported through the logbook program.

Hammerhead shark MSY estimates in the Gulf of Carpentaria are lower than on the Queensland east coast and, depending on the simulation, may be lower than the TACC limit (Leigh, 2015). This is of particular relevance to the great hammerhead shark where more conservative simulations place the MSY at between 10.4t and 78.9t (Leigh, 2015). This example, while at the lower limits of the available MSY scenarios, demonstrates a) the potential for a species to be fished above biomass reference points under the current management regime and b) the inherent risk of managing the hammerhead shark subgroup under a multi-species TACC limit. While noting this risks, best available data indicates that stocks are not being overfished in the Gulf of Carpentaria within the current fishing environment (Department of Agriculture and Fisheries, 2018f; Department of the Environment and Energy, 2014; Leigh, 2015).

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[13] This TACC theoretically includes the smooth hammerhead shark (S. zygaena). The smooth hammerhead shark is considered to be a more temperate species and interactions are viewed as highly unlikely in the GOCIF. Catch reported as 'unspecified hammerhead shark' is also accounted for in the annual Gulf of Carpentaria hammerhead shark TACC limit.

Catch data for the GOCIF shows that the fishery is operating well below the hammerhead shark TACC limit. While the data shows some variability, the annual catch of hammerhead sharks (*Sphyrna* spp.) tends to be less than 20t and is often below 10t. The two notable exceptions being 2013 and 2014 where the combined catch of *Sphyrna* spp. increased to 40t and 45t respectively (Department of Agriculture and Fisheries, 2019b; 2020b). Historical catch data for this complex has low species resolution and a high percentage is reported under more generic catch categories such as *Hammerhead Shark*. Of the species included in the TACC limit, only the scalloped hammerhead shark has species-specific data with annual catches ranging from <1t to 10t (Department of Agriculture and Fisheries, 2019b; 2020b). While the great hammerhead shark has yet to be reported from the fishery, this anomaly is more than likely the result of misidentifications and the use of generic identifiers.

While the species is not included in the TACC limit, the GOCIF catch does include winghead sharks. The reported catch for this species is lower than the scalloped hammerhead shark with most years registering catch levels <2t (Department of Agriculture and Fisheries, 2019b; 2020b). These figures are expected to be an underestimate as a proportion of the winghead shark catch will be included in the *Hammerhead Shark* catch category (Department of Agriculture and Fisheries, 2019b). For this reason, it is difficult to assess how the fishery would operate against alternate TACC arrangements including ones that include winghead sharks in the total catch limit.

Uncertainties in the catch data makes it difficult to quantify individual rates of fishing mortality and assess the longer-term overexploitation risk. These deficiencies are being addressed through the management framework with operators now required to report all retained hammerhead shark catch to species level and document the number of discards (Department of Agriculture and Fisheries, 2018e). These measures are being built upon through the *Queensland Sustainable Fisheries Strategy 2017–2027* and efforts are being undertaken to validate the composition of the hammerhead shark catch, assess the sustainability of regional stocks, and document fine-scale catch and effort movements. Examples of which include the expanded use of *Vessel Tracking* (Department of Agriculture and Fisheries, 2018g), a dedicated shark monitoring project, an increased reliance on species-specific TACC limits, and efforts to support the real or near-real time monitoring of target and non-target species (Department of Agriculture and Fisheries, 2018b).

In the longer-term, it is envisaged that the majority of fishing-related risks for the hammerhead shark complex will be addressed through a formal harvest strategy and cross-jurisdictional management of the resource (*i.e.* by Queensland and the Northern Territory). On this basis, the Level 2 ERA should represent the worst case scenario in terms of the risk posed to this subgroup by the GOCIF. It will however take time to implement these measures and obtain the level of data needed to refine and inform the ERA process. As a consequence, some of the more prominent sustainability risks will remain for this subgroup. For example, there is still limited capacity to validate catch compositions or discard rates under the current management system. Without this validation, it is difficult to assess the accuracy of the logbook data and make informed decisions on where to set mortality rate limits. This situation is complicated by the fact that hammerhead sharks are retained in adjacent fisheries; namely the *Northern Territory Offshore Net and Line Fishery* (Northern Territory Government, 2020).

Species-specific recommendations

1. ***Include the winghead shark in management arrangements targeted specifically at hammerhead sharks e.g. the 50t TACC limit.***

The above could be achieved by changing the legislative definition of a hammerhead shark from *Sphyrna* spp. to *Family Sphyrnidae*. This change would ensure that hammerhead shark provisions are applied consistently across the entire complex. In the unlikely event that the hammerhead shark 50t TACC is exhausted, it would also remove a (potential) compliance risk *e.g.* operators retaining more hammerhead sharks than are permitted under the regulations but reporting them as the winghead shark. It would however also have implications for other fisheries, namely the ECIF.

As the hammerhead shark TACC is smaller than on the Queensland east coast, the inclusion of the winghead shark may have greater implications for the GOCIF. While the combined hammerhead shark catch (great, scalloped and unknown) sits below the TACC limit, the fishery has previously registered catches greater than 45t (Department of Agriculture and Fisheries, 2019b). By including wingheads in the TACC, there is an increased probability that the fishery will reach the 75% catch trigger. When this trigger is reached, the commercial take of hammerhead sharks is subject to more stringent in-possession and processing limits.

2. ***Implement measures that a) improve the effectiveness of the hammerhead shark catch reporting program and b) assists in quantifying total rates of fishing mortality (retained plus discards) for individual species.***

   On 1 January 2018, new reporting requirements for hammerhead sharks were introduced (Department of Agriculture and Fisheries, 2018e). These measures were introduced across the State and have improved the level of information on hammerhead shark catch compositions and discard rates. With the program going into a third year, it is recommended that a review of hammerhead shark monitoring be undertaken to identify data limitations and areas where improvements can be made. As part of this process, further consideration needs to be given to initiatives that will maximise the value of the discard data and allow it to be used as a tool for their broader management.

3. ***Move towards species-specific TACC limits or introduce measures to minimise the risk that one or more of the hammerhead shark species are being fished above sustainability reference points.***

   While the hammerhead shark complex is managed under a combined TACC limit, this presents as a higher risk when compared to individual or species-specific limits. Under the *Queensland Sustainable Fisheries Strategy 2017–2027*, the use of species-specific TACC limits will become more prevalent, as will the use of harvest strategies. While recognising that it may not be feasible in the current fishing environment, the use, suitability and applicability of species-specific hammerhead shark catch limits should be explored further.

   If it is determined that the current management structure should be retained, measures should be introduced that allow for greater scrutiny of the logbook data, greater capacity to verify catch compositions and enable discards to be included in the combined TACC limit. These measures will increase the responsiveness of the current management system and help mitigate risks relating to the over-exploitation of one or more of the hammerhead shark species.

4. ***Undertake a review of the resources made available to licence holders to assist in the identification of hammerhead shark species.***

Providing licence holders with additional information on hammerhead shark identification may improve the resolution of catch data provided through the logbook program. review of the current resources would help identify some of the current shortfalls and areas where licence holders would benefit from additional information. This could (theoretically) include a range of options such as more detailed hammerhead shark identification guides, dedicated workshops and/or the development of electronic, user-friendly guides that can be readily accessed during a fishing event. These measures are not necessarily restricted to this subgroup and could be applied to a wider array of shark and ray species.

4.2.4.2 Speartooth Sharks

Species	Sub-fishery / Apparatus	Risk Rating
Speartooth shark (*G. glyphis*)	Primary risks: N3 fishery Secondary risks: N12/N13 fishery	High

The geographical distribution of the speartooth shark (*Glyphis glyphis*) is highly contracted and the species is known to inhabit a few scattered locations in northern Australia and New Guinea (Compagno *et al.*, 2009; Department of the Environment, 2019p; Last *et al.*, 2016; White *et al.*, 2017a). The species has previously been reported from estuarine and riverine systems in both northern Australia and far north Queensland (Last & Stevens, 2009). However, this information may now be outdated with regional surveys failing to detect or observe the species across their preferred habitats on the Queensland east coast. This absence of reports has led to suggestions that the species may now be extirpated from this region (Pillans *et al.*, 2009). Consequently, the Gulf of Carpentaria is considered to be of significant importance in terms of the long-term conservation status of this species (Compagno *et al.*, 2009; Department of the Environment, 2015; Last & Stevens, 2009; Peverell *et al.*, 2006).

In the Gulf of Carpentaria, the distribution of the speartooth shark is restricted to a few highly turbid, tidal rivers and estuaries (Stevens *et al.*, 2005). While there is uncertainty surrounding their complete range, evidence suggests that interactions with this species are more likely to occur in and around the Port Musgrave Catchment, Wenlock River and Ducie River regions (Lyon, 2020; Pillans *et al.*, 2009; Pillans *et al.*, 2008; Stevens *et al.*, 2005). Commercial fishing does occur in this area with the majority of effort being reported from the inshore net (N3 fishery) and mud crab (C1) fisheries (Department of Agriculture and Fisheries, 2019b; c; Walton & Jacobsen, 2020).

Fishing activities (commercial, recreational and indigenous) have been identified as a key threat for this species across its range (Department of the Environment, 2015; Stevens *et al.*, 2005). To date there have been no reports of a speartooth shark being caught in either the GOCIF or the Gulf of Carpentaria mud crab fishery (Department of Agriculture and Fisheries, 2019b; c). There have however been limited reports of the species interacting with commercial fisheries in adjacent jurisdictions (*e.g.* the Northern Territory Offshore Net and Line Fishery) and with recreational fishers (Field *et al.*, 2013; Kyne & Feutry, 2017; Lyon *et al.*, 2017).

A number of factors would have contributed to the absence of speartooth shark interactions in the GOCIF. As speartooth sharks tend to have smaller adult populations (Compagno *et al.*, 2019; Compagno *et al.*, 2009), interaction rates for this species are expected to be low. When an interaction does occur, there is a higher probability of the species being misidentified with some of the more commonly caught species, namely bull sharks (*C. leucas*) (Last & Stevens, 2009; Stevens *et al.*, 2005). The potential for misidentifications combined with infrequent interactions increase the probability that regional rates of fishing mortality are being underestimated. It is recognised though that non-reporting of speartooth shark interactions may also be a contributing factor.

The risk profile of the speartooth shark is complicated by historical range contractions (Compagno *et al.*, 2009; Department of the Environment, 2019p; Last *et al.*, 2016; White *et al.*, 2017a). These contractions will amplify the impact of fishing activities at key locations and increase the probability of the species experiencing an undesirable event. These events and impacts could include a reduction in the viability of regional populations, reduced genetic diversity, and further fragmentation of remnant populations in the Gulf of Carpentaria. Given the restricted nature of their range, the structure of the adult population and cumulative fishing pressures, these consequences may occur at low levels of fishing mortality.

Based on the available information and the above considerations, the rating assigned to this species is viewed as being more representative of a real or actual risk. This risk is unlikely to be uniform and will be highly dependent on the area being fished. In the GOCIF, this risk will be more prevalent in the N3 fishery where operators target key teleosts in rivers, creeks and adjacent waters (Department of Agriculture and Fisheries, 2019b). The extent of this risk is largely unknown and further investigations are required into how this fishery impacts regional speartooth shark populations and how it compares to other sectors and fisheries.

Going forward, future ERAs would benefit from additional information on the overlap of effort with key habitats and the areas more likely to be impacted by cumulative fishing pressures *e.g.* commercial fishing (net and crab), recreational fishing (line and crab) and indigenous fishing. This information should be complimented by further research on the movement of speartooth sharks (*e.g.* Port Musgrave Catchment / Wenlock River / Ducie River regions). This information will be of significant importance when considering if further management of this risk is required and, if applicable, where it will be most effective.

Species-specific recommendations

Speartooth sharks and sawfish (*Family Pristidae*) occupy similar habitats, are subject to similar threats and have similar data deficiencies. For these reasons, the conservation of river sharks (*Glyphis* spp.) and sawfish are often discussed or researched in unison (Department of the Environment, 2015; Kyne & Pillans, 2014; Stevens *et al.*, 2005). While the Level 2 ERA provides species-specific recommendations, those provided for the speartooth shark and sawfish have a degree of commonality. In these instances, it may be more beneficial to consider research initiatives and management strategies that, if applicable, can simultaneously reduce risk across both subgroups.

1. ***Increase the level of information on key speartooth shark habitats, movements and population dynamics in the Gulf of Carpentaria.***

   This information will underpin discussions surrounding the suitability and applicability of any management strategy involving this species. As a starting point, efforts should be undertaken to obtain a more complete picture of the available data and the level of protection provided to the species in key areas. This will enable comparisons to be made with the distribution of commercial fishing effort and identify shortfalls and information gaps that require further investigation.

2. ***Improve the level of information on fine-scale effort movements and shark catch compositions in habitats critical to the long-term survival of the species in the Gulf of Carpentaria.***

   This recommendation is being actively addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* with the expanded use of *Vessel Tracking* and the establishment of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017; 2018b; g). As the risk posed by GOCIF operations will vary, this information will provide further insight into the extent of the risk and how it may vary between fishing seasons and regions.

3. ***Increase the level of information on cumulative fishing pressures exerted on regional speartooth shark populations in key areas/habitats and identify measures that minimise the (collective) risk of an overfishing event.***

   This recommendation is not limited to the GOCIF and reflects the need to establish a regional management strategy for this species. As noted, the speartooth shark has a contracted range and limited population numbers. These factors increase the susceptibility of species to cumulative fishing pressures and may lead to a reduced rebound capacity after potential declines. Taking a broader risk management approach that considers the impact of other sectors and fisheries (*e.g.* commercial and recreational crab fishing) will help to address these issues.

4.2.5 Batoids

The batoid ecological subcomponent is one of the more diverse complexes assessed as part of the GOCIF SOCC Level 2 ERA. It includes a variety of species with varying morphological traits, habitat preferences and conservation threats. Accordingly, the outputs of the Level 2 ERA were considered separately for sawfish, guitarfish and wedgefish, devilrays and stingrays. This division is largely based on taxonomic and morphological considerations.

4.2.5.1 Sawfish

Species	Sub-fishery / Apparatus	Risk Rating
Narrow sawfish *(A. cuspidata)*	Primary risks: N3 fishery Secondary risks: N12/N13 fishery	High
Green sawfish *(P. zijsron)*	Primary risks: N3 fishery Secondary risks: N12/N13 fishery	High
Largetooth sawfish *(P. pristis)*	Primary risks: N3 fishery Secondary risks: N12/N13 fishery	High
Dwarf sawfish *(P. clavata)*	Primary risks: N3 fishery Secondary risks: N12/N13 fishery	High

Risk profiles for the sawfish complex share a number of similarities with the speartooth shark. While historic data indicates that sawfish were widespread, these species have experienced significant range contractions particularly on the Queensland east coast (D'Anastasi *et al.*, 2013; Department of the Environment, 2015; Kyne *et al.*, 2013a; Kyne *et al.*, 2013b; Simpfendorfer, 2013). For two of the species, the largetooth sawfish (*Pristis pristis*) and the dwarf sawfish (*P. clavata*), these contractions are significant enough to suggest that they may now be extirpated from the Queensland east coast (*pers. comm.* B. Wueringer, C. Simpfendorfer, *ECIF bycatch management workshop Townsville 14-15*

May 2019). For these reasons, the Gulf of Carpentaria and northern Australia are widely viewed as key strongholds for the sawfish complex.

There are considerable concerns surrounding the long-term conservation of all four species and each requires additional information on their biology, population structure and fine-scale movements (Dulvy *et al.*, 2014). Both the largetooth sawfish and the green sawfish (*P. zijsron*) are listed as *Critically Endangered* by the IUCN with the dwarf sawfish and narrow sawfish (*Anoxypristis cuspidata*) classified as *Endangered* (D'Anastasi *et al.*, 2013; Kyne *et al.*, 2013a; Kyne *et al.*, 2013b; Simpfendorfer, 2013). In Australia, these concerns are reflected in legislative protections with the largetooth, dwarf and green sawfish listed as *Vulnerable* under the EPBC Act, and the *Family Pristidae* listed as no-take under the *Fisheries (General) Regulation 2019* (Department of Agriculture and Fisheries, 2019g; Department of the Environment, 2019d; e; f; 2020a; Queensland Government, 2019a).

At a species-specific level, the risk profiles were heavily influenced by the *productivity* assessment. For the green, largetooth and dwarf sawfish, all but one of the *productivity* scores were assigned the highest risk rating. In the narrow sawfish assessment, *age at sexual maturity* and *maximum age* were the only attributes to score less than three (Table 7). These *productivity* assessments provided the complex with a baseline risk score of between 2.76 and 3.03.[14] This meant that the green, largetooth and dwarf sawfish would all be classified as high risk if one the *susceptibility* attributes were assigned the maximum score of 3. The thresholds for a high-risk rating were marginally higher for the narrow sawfish due to the species registering a lower *productivity* score (Table 7). Even so, all four species easily exceeded the threshold for the high-risk classification (*high risk = score* >3.18).

Sawfish are generally found in shallow water environments and inhabit estuaries, rivers, creeks and embayments (Department of the Environment, 2015). In terms of the GOCIF, these habitat preferences increase the probability of an interaction occurring in the N3 fishery and potentially the small mesh net (N11) fishery[15] (Department of Agriculture and Fisheries, 2019b). However, both the largetooth sawfish (*P. pristis*) and the narrow sawfish (*A. cuspidata*) have been observed in offshore waters including in areas where the N12 fishery operates (Department of the Environment, 2015; Peverell, 2005; 2010).

When a sawfish does encounter a net, the morphology of their rostrum increases the probability of an entanglement. As the general shape and structure of the rostrum is not size or sex dependent, this risk applies across a wide range of size and age classes. In the Level 2 ERA, this elevated risk was accounted for in the RRA where all *selectivity* scores were increased to high (3) (Appendix D). In the GOCIF, the entanglement risk will be highest for gillnet operations situated in inshore, riverine and estuarine waters (N3 fishery). In these areas, there will be closer alignment between the drop of the net and the depth of the water being fished. For benthic species like sawfish, this increases the entanglement potential as it will be more difficult for the animal to circumvent the net *e.g.* by

[14] *The baseline risk score is the risk rating that would be assigned to the species if all of the susceptibility scores were given the lowest possible value (1). The baseline risk score provides insight into the level of influence biological constraints have on the final risk rating.*

[15] *N11 or small mesh net fishery, makes a minor contribution to annual GOCIF catch and effort levels with operations limited to the use of cast, mesh scoop or seine nets with more stringent mesh size and net length restrictions. While sawfish may interact with this aspect of the GOCIF, N11 operations are viewed as a lower risk when compared to the N3, N12 and N13 (Department of Agriculture and Fisheries, 2019b).*

swimming under it. This risk is expected to be lower in the N12 and N13 fisheries as nets are set further offshore and in deeper water environments (Department of Agriculture and Fisheries, 2019b).

Of the 641 sawfish-net interactions reported from the Gulf of Carpentaria (2003–2019 inclusive), the majority involved the narrow sawfish (25.6%), largetooth sawfish (25.2%) and the green sawfish (20.2%). Over the last four years (2016–2019), there has been a notable shift in the species composition data with the narrow sawfish becoming more prevalent (Appendix F). For example, around 47% of the interactions reported since 2016 involved with the narrow sawfish. This increase corresponds with a decrease in the number of largetooth sawfish being reported from the fishery (12.4%) and the number being reported with generic identifiers *i.e. Unknown Sawfish* (Appendix F).

Data submitted as part of the SOCI logbook program indicates that the majority (86%) of sawfish were released alive and uninjured. Around 6% of the reported interactions resulted in the death of the animal, with a further 7% released alive but with identifiable injuries (2003–2019 inclusive; Department of Agriculture and Fisheries, 2015; Department of Agriculture and Fisheries, 2019b; d). While the accuracy of this data is difficult to verify, anecdotal evidence suggests that sawfish can survive the initial entanglement providing that the gills are not damaged or significantly impeded *(ECIFFF bycatch management worksho*p, Townsville, 14-15 May 2019; Kyne & Pillans, 2014). However, the ability of an animal to survive a fishing event will be dependent on a range of factors including the size of the animal, the extent of the entanglement, the handling procedures employed and a number of confounding factors including internal injuries and the presence of larger predators.

At a whole-of-fishery level, the total number of sawfish mortalities (*in-situ*, post-release and unreported) will be higher than what is reported through the SOCI logbooks. Of the animals that are released, it is anticipated that a number will die as a result of injuries incurred during the fishing event, due to increased stress or poor handling techniques. Non-compliance and the intentional harming of an animal may also be a contributing factor with respect to the overall rate of fishing mortality. Examples of where this may occur include when there is a significant entanglement, where there is a perceived safety risk (*e.g.* releasing a large adult), when the preservation of gear supersedes the welfare of the animal, and the retention of regulated products (*e.g.* removing the rostrum). In the marine turtle and dugong assessments, insight into the number of additional net-related mortalities could be obtained through StrandNET (Department of Environment and Science, 2017). This cannot be done for sawfish as there is limited information on interaction rates in ancillary databases.

Based on the available data and the outputs of the Level 2 ERA, fishing activities in the GOCIF present a higher risk to the sawfish complex. For at least three of these species, the largetooth, green and dwarf sawfish, the risk will be higher than in the ECIF (Jacobsen *et al.*, 2021). This risk is not uniform and further information is required on the dynamics of regional sawfish populations and how they interact with the GOCIF. This information will be of considerable importance when discussing how this risk could be managed in the GOCIF, and areas where management intervention would be most beneficial.

Species-specific recommendations

Sawfish (*Family Pristidae*) and the speartooth shark (*G. glyphis*) occupy similar habitats, are subject to similar threats and have similar data deficiencies. For these reasons, the conservation of sawfish and river sharks (*Glyphis* spp.) are often discussed or researched in unison (Department of the Environment, 2015; Kyne & Pillans, 2014; Stevens *et al.*, 2005). While the Level 2 ERA provides species-specific recommendations, those provided for sawfish and the speartooth shark have a degree of commonality. In these instances, it may be more beneficial to consider research initiatives and management strategies that, if applicable, can simultaneously reduce risk across both subgroups.

1. ***Improve the level of information on what GOCIF sectors interact with sawfish, fine-scale movements of net effort, catch compositions and mortalities.***

   While all four species received the same rating, the risk posed to this subgroup is unlikely to be uniform and/or be applicable to the entire GOCIF. Future ERAs would benefit from additional information on where sawfish interactions are more likely to occur and the fishing symbol being used (*i.e.* N11, N3, N12 or N13). This information will provide further insight into the extent of the risk across the fishery and how it may vary between regions and seasons. From a risk management perspective, it would allow for a more informed assessment and help identify priority species/areas for management intervention.

   This recommendation is already being actively addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* with the expanded use of *Vessel Tracking* and the establishment of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017; 2018b; g). However, it is also recommended that alternate avenues be explored to improve the level of information for this subgroup *e.g.* via StrandNET, improved collaboration with regional universities and researchers.

2. ***Increase the level of information on cumulative fishing pressures exerted on sawfish populations in key areas/habitats and identify measures that minimise the (collective) risk of an overfishing event.***

   This recommendation is not limited to the GOCIF and reflects the need to establish a regional sawfish management strategy. Sawfish have contracted distributions, limited population numbers, and will be more susceptible to cumulative fishing pressures. Taking a broader risk management approach will help to address these issues. This information will underpin any discussion surrounding the suitability and applicability of any management strategy involving these species. As a starting point, efforts should be undertaken to obtain a more complete picture of the available data and the level of protection provided to sawfish in key areas. This will enable comparisons to be made with the distribution of commercial fishing effort and identify shortfalls and information gaps that require further investigation.

3. ***Review handling protocols for sawfish and identify areas to improve current practices across the fishery.***

   Due to the presence of the rostrum, sawfish entanglements represent a considerable risk to the operator and the animal. Depending on the size of the animal and its manoeuvrability, the animal may be injured (inadvertently or on purpose) during the handling and release process. Research is being undertaken in the Gulf of Carpentaria to improve handling and release practices. With this in mind, it is recommended that materials relating to the processing and release of sawfish be reviewed to ensure that they reflect industry best practice.

4.2.5.2 Guitarfish & Wedgefish

Species	Sub-fishery / Apparatus	Risk Rating
Bottlenose wedgefish (*R. australiae*)	Primary risks: N3 fishery Secondary risks: N12/N13 fishery	Precautionary High
Eyebrow wedgefish (*R. palpebratus*)	Primary risks: N3 fishery Secondary risks: N12/N13 fishery	Precautionary High
Giant shovelnose ray (*G. typus*)	Primary risks: N3 fishery Secondary risks: N12/N13 fishery	Precautionary High

Under the current legislation, the bottlenose wedgefish (*Rhynchobatus australiae*), the eyebrow wedgefish (*R. palpebratus*) and the giant shovelnose ray (*Glaucostegus typus*) can be retained for sale in the GOCIF. They are not protected under fisheries legislation and are not classified as either a threatened or migratory species under the EPBC Act (Department of the Environment, 2019b; c). However, the *Family Rhinidae* (wedgefish) and *Family Glaucostegidae* (giant guitarfish) were recently listed under an international convention (CITES) dealing with the sale and trade of threatened species (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2018a; b). This decision has the potential to impact fishing activities in the GOCIF and may have wider implications with respect to their retention and export. Due to this potential, all three were included in the GOCIF SOCC Level 2 ERA.

Wedgefish and giant shovelnose rays are found in inshore waters down to 70–100m (Last *et al.*, 2016) and have habitat preferences that overlap with grounds fished by N3, N12 and N13 operators. As they are benthic species, they are more likely to be caught in gillnet operations fishing in inshore waters and over sandy substrates. In these areas, the likelihood of an interaction occurring increases as there is closer alignment between the drop of the net and the depth of the water being fished. When a guitarfish or wedgefish interacts with a gillnet there is a higher risk of entanglement due to the morphology of their head and rostrum (Last *et al.*, 2016). This increases the *post-interaction mortality* risk (Table 7) which considers both their retention for sale and bycatch mortalities (*in situ* and post release).

Catch data for the fishery shows that guitarfish, wedgefish and shovelnose rays are retained in small amounts in the Gulf of Carpentaria (*average* = 2.4t, *range* = 0.1–14.5t) (Department of Agriculture and Fisheries, 2019b; 2020b).[16] Low retention rates for this subgroup can be attributed to an in-possession limit that restricts commercial fishers to a combined maximum of five guitarfish and/or shovelnose rays.[17] In addition to the retained catch, a proportion of the guitarfish, wedgefish and shovelnose rays caught in gillnets will be discarded as unwanted bycatch. At present, there is limited capacity within the fishery to validate the total guitarfish/wedgefish catch (retained and discarded) or verify the release fates of unwanted product. It is further recognised that a proportion of the rays will be discarded in a dead or moribund state. In the context of this ERA, this is considered to be of

[16] *Catch records available through QFish (https://qfish.fisheries.qld.gov.au/).*

[17] *The Fisheries (General) Regulations 2019 defines Guitarfish as any species from the Family Rhynchobatidae and shovelnose rays as any species from the Family Rhinobatidae. A number of taxonomic reviews re-aligned the batoid families and included the establishment of a separate family of Giant Guitarfish (Family Glaucostegidae) which includes G. typus* and the movement of all *Rhynchobatus species into the Wedgefish family (Family Rhinidae) (Last et al., 2016). As a consequence, names contained within the Fisheries (General) Regulations 2019 are outdates. The intent of the legislation though remains the same.*

notable importance as total mortality will be higher than what is reported through the logbook program.

As noted, the bottlenose wedgefish, eyebrow wedgefish and giant shovelnose ray were included in the Level 2 ERA in response to a recent decision to list the *Rhinidae* and *Glaucostegidae* families on CITES. While acknowledging these developments, it is important to understand the context of their listing and how it relates to species that interact with fisheries on the Queensland east coast. For giant shovelnose rays (*Family Glaucostegidae*), the listing was linked to exploitation concerns surrounding the blackchin guitarfish (*G. cemiculus*) and the sharpnose guitarfish (*G. granulatus*). These two species are not found in the Indo-West Pacific (Last *et al.*, 2016) and they will not interact with commercial fisheries operating in Australian waters. However, listing advice for both species recognised that a) guitarfish can be difficult to differentiate between and b) other species may face similar pressures, including in northern Australia (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2018b; Salini *et al.*, 2007). On the back of this advice, the entire *Glaucostegidae* family was listed on CITES.

The situation surrounding wedgefish differs in that the bottlenose wedgefish was directly nominated for listing along with the whitespotted guitarfish (*R. djiddensis*) (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2018a; Last *et al.*, 2016). The bottlenose wedgefish is found in Australian waters and is retained for sale in the Gulf of Carpentaria. As with the giant guitarfish, this listing was expanded to include the entire *Rhinidae* family which is why a second Queensland species, the eyebrow wedgefish, is now covered under CITES. Listing advice for these species largely focused on areas outside of Australia where fishing activities are less regulated and the risk of over-exploitation is significantly higher *e.g.* South-east Asia, Southern Asia, Northwest Indian Ocean, and East Africa. In Australia, where fisheries operate under a well-established regulatory framework, the majority of the identifiable risks relate to the poor resolution of catch data, bycatch and potential declines in regional populations (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2018a).

The above considerations are important as they provide further context on how fishing-related risks in Queensland compare to global trends. As noted, one of the key threats for this subgroup is unsustainable and unregulated fisheries or trade (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2018a; b; Kyne & Rigby, 2019; Kyne *et al.*, 2019a; Kyne *et al.*, 2019b). This risk is largely mitigated in the GOCIF through the use of input and output controls which include limited licencing, mesh size restrictions, spatial closures and in-possession limits (Department of Agriculture and Fisheries, 2019f). For these reasons, the sustainability risk posed to this subgroup will be lower than in other regions.

At a whole-of-fishery level, the risk posed by gillnet fishing has not been completely mitigated by the current management controls. Guitarfish, wedgefish and shovelnose rays are still caught and retained in the fishery and poor catch data resolution restricts regional sustainability assessments. The challenge being, how best to quantify the level of risk for this subgroup at both a species and regional level? The answer to this question will become clearer with the completion of a CITES-linked Non-Detriment Finding (NDF). A NDF is required for all CITES species that are exported for sale and provides an assessment of the current management arrangements and exploitation status. The primary purpose of the NDF is to determine if the continued exportation of wedgefish and guitarfish will be detrimental to the survival of one or more of the listed species (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2019).

In the interim, it is recommended that measures continue to be undertaken to improve the level of information on species compositions, release fates and, if possible, their stock status. As the taxonomy of guitarfish and wedgefish has changed considerably (Last *et al.*, 2016), it is also recommended that definitions contained within the legislation be reviewed and updated accordingly. This will ensure that the intent of the legislation remains and will help minimise confusion surrounding the level of protection afforded to these species. When compared to other SOCC though, there is less need to mitigate the risk posed to this subgroup through significant reforms or management interventions.

Species-specific recommendations

1. ***Review and update species definitions contained within fisheries legislation to ensure they align with the best available data and maintain relevance.***

   As wedgefish, guitarfish and shovelnose rays are subject to a combined in-possession limit, it is recommended that definitions contained within the regulations be reviewed to ensure they reflect current advice on batoid taxonomy (Last *et al.*, 2016). As part of this process, it is recommended that the CITES listings for the *Family Rhinidae* (wedgefish) and *Family Glaucostegidae* be reviewed to determine if any additional species need to be included in the combined in-possession limit.

2. ***Depending on the outcomes of the NDF, consider assessing the stock status of the bottlenose wedgefish, eyebrow wedgefish and giant shovelnose ray in Queensland waters—noting that these species may be low priorities for assessment when compared to the primary targets.***

   None of the three species have been the subject of a previous stock status evaluation. The NDF assessment (plus supporting material) will provide one of the more comprehensive overviews of the biology of these species, their exploitation status and management in Australian waters. Depending on the outcomes of the NDF, further assessments of their stock status in Queensland waters may be required. If this is a direction that is explored further, current (low) exploitation rates suggest that indicative sustainability evaluations (*e.g.* SAFS) are a more appropriate course of action for these species.

4.2.5.3 Devilrays

Species	Sub-fishery / Apparatus	Risk Rating
Reef manta ray (*M. alfredi*)	N3 & N12/N13 fishery	Precautionary High
Kuhl's devilray (*M. kuhlii*)	N3 & N12/N13 fishery	Precautionary High

In Queensland, only the giant manta ray (*Mobula birostris*) and the reef manta (*M. alfredi*) are afforded full protection from commercial fishing activities. While these protections are not extended to the Kuhl's (*M. kuhlii*), giant (*M. mobular*) and bentfin (*M. thurstoni*) devilray, all three are listed as migratory species under the EPBC Act. Due to this listing, these three species are classified as no-take in the GBRMP. Outside of the GBRMP, operators can still retain Kuhl's, giant and bentfin devilrays providing they are caught in State waters and adhere to provisions governing the take of sharks and rays on the Queensland east coast (Department of Agriculture and Fisheries, 2019b). This includes in the Gulf of Carpentaria.

Global vulnerability assessments consistently identify regional targeted and incidental fishing pressures as two of the more significant risks for this subgroup (Bizzarro *et al.*, 2009; Marshall *et al.*, 2018a; Marshall *et al.*, 2018b; Notarbartolo di Sciara *et al.*, 2015; Pardo *et al.*, 2016; Walls *et al.*, 2016). While devilrays will interact infrequently with gillnet operations, their morphology combined with current mesh-size restrictions minimises the entanglement risk (*pers. comm.* P. Kyne; Appendix D). In the event that a devilray is caught in a gillnet, the majority will be discarded as bycatch due to no-take provisions, poor marketability and likely confusion surrounding the level of protection afforded to a particular species (see above). From an ERA perspective, these factors indicate that risks posed by gillnet fishing in the Gulf of Carpentaria will be lower than what is reported at a global level (Acebes & Tull, 2016; International Union for Conservation of Nature (IUCN), 2017; Marshall *et al.*, 2018a; Marshall *et al.*, 2018b; White *et al.*, 2006).

To date, only one devilray interaction has been reported from the GOCIF; a bentfin devilray caught in an anchored gillnet in 2017 (Department of Agriculture and Fisheries, 2019b). This however is likely to be an underestimate as SOCI logbooks cannot account for contact without capture events *i.e.* interactions that do not result in the animal being captured or landed on the vessel (Jacobsen *et al.*, 2019a). Even so, interaction rates with this complex are expected to be comparatively low. Further consultation on the taxonomy and distribution of devilrays also suggests that the majority of the interactions will involve the Kuhl's devilray[18] (pers. comm. P. Kyne; Bizzarro *et al.*, 2009; Broadhurst *et al.*, 2017; Last *et al.*, 2016; White *et al.*, 2017b). While the reef manta and the giant manta ray occur in the Gulf of Carpentaria, interactions with these species would be limited due to their size and habitat preferences (*pers. comm.* P. Kyne).

Overall, it is likely that the outputs of the Level 2 ERA provide a more cautious assessment of the risk posed by this fishery to the reef manta ray and Kuhl's devilray. As these species are not targeted or retained in the fishery, the GOCIF will be a small contributor of risk for this subgroup. At a regional level, the long-term consequences of these types of interactions will be lower than what is observed for other species included in this assessment. The impacts of the fishery will also be significantly lower when compared to adjacent, international jurisdictions where fisheries management regimes are less developed *e.g.* Indonesia (White *et al.*, 2006).

Going forward, our understanding of how the GOCIF interacts with regional devilray populations will improve with the continued implementation of the *Queensland Sustainable Fisheries Strategy 2017–2027*. Initiatives that will help refine devilray risk profiles include the expansion of *Vessel Tracking,* the establishment of a *Fisheries Data Validation Plan* and ongoing discussions surrounding bycatch minimisation in Queensland's commercial fisheries (Department of Agriculture and Fisheries, 2018g). In the interim, it is recommended that protective descriptions applied in the *Fisheries (General) Regulation 2019* and *Fisheries Declaration 2019* be expanded to all devilray species. This will provide

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[18] *The taxonomy of the Kuhl's devilray (M. Kuhlii) and the longhorn devilray (M. eregoodoo) requires further investigations. Combined morphological and molecular data led Last et al. (2016) and White et al. (2017b) to conclude that M. eregoodootenkee (synonym of M. eregoodoo) is a junior synonym of M. kuhlii. However, Hosegood et al. (2019) suggested these were separate species, which was supported by Notarbartolo di Sciara et al. (2020). The range or both M. kuhlii and M. eregoodoo is poorly defined in Australia due to these taxonomic issues and scientific advice recommended that they be treated the same until their status can be clarified (pers. comm. P. Kyne).*

the subgroup with a consistent level of protection across the state and ensure that all devilray species are being monitored through the SOCI logbooks.

Species-specific recommendations

1. ***Review and update the Species of Conservation Interest (SOCI) logbooks to account for recent taxonomic changes.***

   Batoids which includes devilrays, stingrays, sawfish, stingarees, wedgefish and guitarfish were the subject of a large-scale taxonomic review (Last *et al.*, 2016) and a number of nomenclature (name) changes were made. It is recommended that the SOCI logbooks be reviewed and updated to reflect these changes and any potential legislative changes (see below). This may also require the provision of further educational material/advice to fishers about the changes.

2. ***Expand no-take provisions contained within the fisheries legislation to include all devilray species.***

   The above could be achieved by changing the legislation descriptors from *Manta ray* and *Manta spp.* to *Devilrays* and *Family Mobulidae*. This change will reduce uncertainty surrounding the level of protection afforded to each species across the state and standardise management arrangements for the complex. As devilrays are not targeted in the GOCIF, this change would not have a significant economic impact on the fishery. It is recognised that a change of this magnitude would affect other commercial fisheries. The impact on these fisheries though would be commensurate to the GOCIF.

4. ***Explore avenues to improve the tracking of devilray interactions and mortalities through time.***

   While a number of the devilrays are classified as SOCI, strandings and mortalities are not monitored or tracked in programs like StrandNET. As seen with marine turtles, dugongs and dolphins, cross-comparisons of the SOCI data with information contained in ancillary databases can provide additional context on the number of interactions and mortalities that occur in this fishery. Given this it is recommended that alternate avenues be explored to improve the level of information for this subgroup *e.g.* via closer collaboration with StrandNET and improved collaboration with regional universities and researchers. The viability of this recommendation would need to be considered in consultation with the *Department of Environment and Science* (Queensland) who are the gatekeepers of the StrandNET database.

4.2.5.4 Stingrays

Species	Sub-fishery / Apparatus	Risk Rating
Estuary stingray (*H. fluviorum*)	N3 fishery	Precautionary High

Anecdotal evidence suggests that the distribution of the estuary stingray (*Hemitrygon fluviorum*) has contracted and the species has experienced an overall decline in abundance (Kyne *et al.*, 2016; Pierce & Bennett, 2011). These declines are considered to be most significant in northern New South Wales and in southern Queensland (Kyne *et al.*, 2016). The reasons behind this decline are varied but loss of habitat and their capture in commercial fisheries have been identified as two key contributors. From a fisheries perspective, demersal prawn trawl fisheries are more likely to interact with this species and in higher numbers. Estuary rays though will interact with both of Queensland's inshore net fisheries; GOCIF and ECIF.

While the estuary stingray is not protected under fisheries legislation it is listed as *Near Threatened* in the *Nature Conservation (Wildlife) Regulation 2006* (Qld). This listing was the impetus behind the species' inclusion in the GOCIF SOCC Level 2 ERA. Under this listing, operators are not permitted to target or retain estuary stingrays in any class of protected area outlined in the *Nature Conservation Act 1992* (Queensland Government, 1992). In these areas, any estuary stingray that is caught by a net operator must be discarded irrespective of the life status.

As the estuary stingray is not protected under fisheries legislation, it can be retained for sale in areas not encompassed within the *Nature Conservation Act 1992.* In the GOCIF, estuary ray interactions are more likely to occur in the N3 fishery as the species is often found in mangrove-lined swamps, estuaries and riverine systems (Last *et al.*, 2016). The species though is not classified as a SOCI and operators are less likely to record this catch unless it is retained. At a whole-of-fishery level, stingrays only make up a small proportion of the total GOCIF catch (Department of Agriculture and Fisheries, 2019b; 2020b). Catch data for this complex has poor species resolution and it is difficult to ascertain how many estuary rays (if any) are retained for sale on the Gulf of Carpentaria.

Historical catch data for the fishery shows a number of small peaks, the last of which was 9t in 2003. Since 2003, the reported catch of stingrays has become negligible with most being discarded as unwanted bycatch (Department of Agriculture and Fisheries, 2019b). As net *selectivity* would be high for this species, within net and post-release mortalities arguably present as a greater risk (when compared to their retention for commercial sale). The extent of this risk will be difficult to quantify without additional information on catch rates and discard fates, particularly in the N3 fishery. The fishery though will present as a lower risk when compared to external factors like habitat loss; a key reason for their range contraction (Kyne *et al.*, 2016; Pierce & Bennett, 2011).

When the interaction potential and key drivers of risk are taken into consideration, the final risk rating for this species is viewed as precautionary (Table 7). The fishery will be a contributor of risk and mortalities incurred during a fishing event will exacerbate the impacts of longer-term risks *e.g.* habitat loss and their capture in other commercial fisheries. This places added importance on obtaining accurate information on the number of interactions that are occurring in the fishery and their locations. To address this need, it is recommended that the estuary stingray be classified as a SOCI and monitored accordingly. Due to the status of the species and ongoing sustainability concerns, it is also recommended that the estuary stingray be categorised as a no-take species in order to minimise the number of fishing-related mortalities. As it is not a primary target, this change is not expected to have a significant or detrimental impact on the financial viability of the fishery. This change though would have implications for fisheries outside of the GOCIF, namely the ECIF, the *River & Inshore Beam Trawl Fishery* and the *East Coast Otter Trawl Fishery.*

Species-specific recommendations

1. ***Undertake a review of the spatial closures used in the GOCIF to determine the level of protection afforded to this species under fisheries legislation and ancillary instruments e.g. Nature Conservation (Wildlife) Regulation 2006*** **(Qld).**

While the Gulf of Carpentaria does not have any species-specific measures in place, a number of closures have been established in riverine and estuarine systems. While these protections are primarily linked to other species (*e.g.* dugongs) or resource sharing, the estuary stingray will derive some benefit from these measures. Similarly, the take of the species will be restricted in areas that are covered by the *Nature Conservation (Wildlife) Regulation 2006*.

To help evaluate how precautionary the final risk rating is, it is recommended that a review of these protections be undertaken and the results compared to key habitats for this species. This review will inform discussions on the need for management intervention and, if applicable, the suitability of any management option being proposed.

2. ***Categorise the estuary stingray (H. fluviorum) as a no-take species under fisheries legislation.***

   Categorising the estuary stingray as a no-take species will help to align fisheries legislation with other legislative instruments, namely the *Nature Conservation Act 2006.* It is noted though that this change will have implications for other commercial fisheries operating in Queensland waters.

3. ***Improve the level of information on estuary stingray interactions in the GOCIF including catch rates in critical habitats and locations where the fishery will contribute to regional/cumulative fishing pressures***.

   The above changes could be partly achieved through the listing of the estuary stingray as a SOCI. This change would result in a marginal increase in reporting requirements and should be supported with additional resources on how to identify the species in an active fishing environment. From an ERA perspective, information obtained through the SOCI logbook program would improve the accuracy of the assessment and provide further context on the extent of the risk posed by this fishery. Initiatives instigated as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* will assist in this process including the expanded use of *Vessel Tracking* and the ongoing implementation of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017; 2018b; g).

5 Summary

The Level 2 ERA provides additional depth to the risk profiles of these species and further differentiates between potential and actual risks (Department of Agriculture and Fisheries, 2018c). Outputs from the Level 2 ERA will help inform initiatives instigated under the *Queensland Sustainable Fisheries Strategy 2017–2027* and strengthen linkages between the ERA process and the remaining areas of reform (Department of Agriculture and Fisheries, 2017).

Precautionary elements included in the methodology combined with data deficiencies have contributed to the development of more conservative risk profiles. For some of the species, the final risk ratings were considered precautionary and are unlikely to result in significant species-specific reforms. There were, however, a number of species where the risk requires further attention and the management of the risk is viewed as a higher priority. This will need to occur at both a whole-of-fishery and species-specific level.

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7 Appendices

Appendix A – Species Rationalisation Process Overview.

Appendix B – Species Rationalisation Process: Justifications & Considerations.

Appendix C – Overlap percentages used to calculate scores for the availability attribute .

Appendix D – Residual Risk Analysis.

Appendix E – Supplementary risk assessment: Likelihood & Consequence Analysis.

Appendix F – Summary of the sawfish interactions with nets reported from the Gulf of Carpentaria.

Appendix A—Species Rationalisation Process Overview

1. Overview

The list of *Species of Conservation Interest* was used as the foundation of the *Species of Conservation Concern* (SOCC) Level 2 ERA. *Species of Conservation Interest* or SOCI refers specifically to a limited number of non-target species that are subject to mandatory commercial reporting requirements. The original SOCI list was expanded through a review of Commonwealth and State legislation and international conventions that have the potential to influence fishing activities in Queensland. Key instruments that were reviewed as part of this process included:

- *Fisheries Act 1994* and the subordinate legislation (Qld)*;*
- *Nature Conservation Act 1992* and the subordinate legislation (Qld);
- *Marine Parks (Moreton Bay) Zoning Plan 2008* (Qld);
- *Marine Parks (Great Sandy) Zoning Plan 2017* (Qld);
- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth);
- *Great Barrier Reef Marine Park Regulations 1983* (Commonwealth);
- *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) (International Convention); and
- *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) (International Convention).

The expanded or preliminary list of SOCC was regionally specific and included species that have been listed on international conventions but are subject to national reservations (*e.g.* thresher shark, *Alopias* spp.). Species afforded additional protections under legislation governing the use of resources in State and Commonwealth marine parks were also included in the preliminary list of SOCC. Once established, the preliminary SOCC list was refined and finalised using the following steps:

1. All SOCC subgroups that were not classified as medium/high or high risk in the whole-of-fishery (Level 1) ERA (Jacobsen *et al.*, 2019a) were removed from the analysis.
2. The distributions of the remaining species were then compared with the prescribed area of fishing symbols used in the *Gulf of Carpentaria Fishery* (GOCIF).
3. Species with distributions that had no or low overlap with the fishery, had a low interaction potential or low likelihood of capture within the apparatus were removed. Any species where there was uncertainty surrounding its distribution and interaction potential were retained in the assessment and further advice sought from scientific experts and key stakeholders.
4. A summary of the species rationalisation process was then compiled (Table A1 and A2) and justifications provided as to why a species was included or omitted from the analysis.

Justifications for the inclusion or omission of species in the GOCIF SOCC Level 2 ERA are provided in Appendix B.

2. Summary Tables

- *Table A1—Summary of the species considered for inclusion in the GOCIF SOCC Level 2 ERA.*
- *Table A2—Summary of the species omitted from the analysis whose distribution has no or very low overlap with the GOCIF and/or are highly unlikely to interact with the fishery.*

Table A1*—Summary of the Species of Conservation Concern (SOCC) that were considered for inclusion in the in the GOCIF SOCC Level 2 ERA.*

All species with green squares and a 'Y' were included in the SOCC Level 2 ERA. Red squares with an 'N' are those that were considered for inclusion but omitted from the analysis. '*' Denotes species that were included or omitted in response to advice provided by key stakeholders and members of the scientific community.

Common name	***Species name***	***CAAB***	**N3, N12, N13**
Sharks			
Speartooth shark	*Glyphis glyphis*	37 018041	**Y**
Great hammerhead	*Sphyrna mokarran*	37 019002	**Y**
Scalloped hammerhead	*Sphyrna lewini*	37 019001	**Y**
Winghead shark	*Eusphyra blochii*	37 019003	**Y**
Batoids			
Reef manta ray	*Mobula alfredi*	37 041005	**Y**
Kuhl's devil ray	*Mobula kuhlii (synonym: M. eregoodootenkee)*	37 041001	**Y**
Largetooth sawfish	*Pristis pristis*	37 025003	**Y**
Narrow sawfish	*Anoxypristis cuspidata*	37 025002	**Y**
Green sawfish	*Pristis zijsron*	37 025001	**Y**
Dwarf sawfish	*Pristis clavata*	37 025004	**Y**
Bottlenose wedgefish (synonym - whitespotted guitarfish)	*Rhynchobatus australiae*	37 026005	**Y**
Eyebrow wedgefish	*Rhynchobatus palpebratus*	37 026004	**Y**
Giant shovelnose Ray	*Glaucostegus typus*	37 027010	**Y**
Estuary stingray	*Hemitrygon fluviorum*	37 035008	**Y**
Marine turtles			
Green turtle	*Chelonia mydas*	39 020002	**Y**
Loggerhead turtle	*Caretta caretta*	39 020001	**Y**
Hawksbill turtle	*Eretmochelys imbricata*	39 020003	**Y**
Flatback turtle	*Natator depressus*	39 020005	**Y**
Olive ridley turtle	*Lepidochelys olivacea*	39 020004	**Y**

Common name	***Species name***	***CAAB***	**N3, N12, N13**
Leatherback turtle	*Dermochelys coriacea*	39 021001	**Y**
Dolphins (*Odontocetes*)			
Australian humpback dolphin	*Sousa sahulensis*	41 116014	**Y**
Australian snubfin dolphin	*Orcaella heinsohni*	41 116010	**Y**
Common bottlenose dolphin	*Tursiops truncatus*	41 116019	**Y**
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	41 116020	**Y**
False killer whale	*Pseudorca crassidens*	41 116013	**Y***
Spinner dolphin	*Stenella longirostris*	41 116017	**Y***
Sirenia			
Dugong	*Dugong dugon*	41 206001	**Y**

Table A2*—Summary of the species omitted from the analysis whose distribution has no or very low overlap with the GOCIF and/or are highly unlikely to interact with the fishery. *Denotes species that were included or omitted in response to advice provided by key stakeholders and members of the scientific community.*

Ecological Component & Species	
<u>*Sharks*</u> Whale shark, *Rhincodon typus* (CAAB 37 014001) Great white shark, *Carcharodon carcharias* (CAAB 37 010003) Grey nurse shark, *Carcharias taurus* (CAAB 37 008001) Northern river shark, *Glyphis garricki* (CAAB 37 018042) Porbeagle shark, *Lamna nasus* (CAAB 37 010004) Sandtiger shark, *Odontaspis ferox* (CAAB 37 008003) Shortfin mako shark, *Isurus oxyrinchus* (CAAB 37010001) Longfin mako shark, *Isurus paucus* (CAAB 37 01002) Smooth hammerhead shark, *Sphyrna zygaena* (CAAB 37 019004) Oceanic whitetip shark, *Carcharhinus longimanus* (CAAB 37 018032) Pelagic thresher, *Alopias pelagicus* (CAAB 37 012003) Bigeye thresher, *Alopias superciliosus* (CAAB 37 012002) Thresher shark, *Alopias vulpunus* (CAAB 37 012001) Basking shark *Cetorhinus maximus* (CAAB 37 011001) Harrisson's dogfish, *Centrophorus harrissoni* (CAAB 37 020010) Southern dogfish, *Centrophorus zeehaani* (CAAB 37 020011) Spiny dogfish, *Squalus acanthias* (CAAB 37 020008) Crested hornshark, *Heterodonitidae galeatus* (CAAB 37 007003) <u>*Rays / Batoids*</u> Manta ray, *Mobula birostris* (CAAB 37 041004) Giant devil ray, *Mobula mobula* (CAAB 37 041002) Bentfin devil ray, *Mobula thurstoni* (CAAB 37 041003) Chilean devil ray, *Mobula tarapacana* (CAAB 37 041006) Maugean skate, *Zearaja maugeana* (CAAB 37 031037) <u>*Dolphins (Odontocetes) cont.*</u>	<u>*Dolphins (Odontocetes)*</u> Dusky dolphin, *Lagenorhynchus obscurus* (CAAB 41 116008) Spectacled porpoise, *Phocoena dioptrica* (CAAB 41 117001) Commerson's dolphin. *Cephalorhynchus commersonii* (CAAB N/A) Hourglass dolphin, *Lagenorhynchus cruciger* (CAAB 41 116007) Southern right whale, *Lissodelphis peronii* (CAAB 41 116009) Burrunan dolphin, *Tursiops australis* (CAAB 41 116022) Irrawadddy dolphin, *Orcaella brevirostris*, (CAAB N/A) Indo-Pacific humpback dolphin, *Sousa chinensis* (CAAB N/A) Strap toothed whale, *Mesoplodon layardii* (CAAB 41 120009) Giant beaked whale (aka Arnoux's), *Berardius arnuxii* (CAAB 41 120001) Dwarf sperm whale, *Kogia sima* (CAAB 41 119 002) Southern bottlenose whale, *Hyperoodon planifrons* (CAAB 41 120003) Tropical bottlenose whale (aka Longman's), *Indopacetus pacificus* (CAAB 41 120003) Andrew's beaked whale, *Mesoplodon bowdoini* (CAAB 41 120004) Blainvilles's beaked whale, *Mesoplodon densirostris* (CAAB 41 120005) Ginkgo-toothed beaked whale, *Mesoplodon ginkgodens* (CAAB 41 120006) Gray's beaked whale, *Mesoplodon grayi* (CAAB 41 120007) Hector's beaked whale, *Mesoplodon hectori* (CAAB 41 120008) True's beaked whale, *Mesoplodon mirus* (CAAB 41 120010) Shepard's beaked whale, *Tasmacetus shepherdi* (CAAB 41 120011) Curvier's beaked whale, *Ziphius cavirostris* (CAAB 41 120012)

Ecological Component & Species	
Common dolphin, *Delphinus delphis* (CAAB 41 116001) Fraser's dolphin, *Lagenodelphis hosei* (CAAB 41 116006)* Striped dolphin, *Stenella coeruleoalba* (CAAB 41 116016) Spotted dolphin, *Stenella attemuata* (CAAB 41 116015)* Risso's dolphin, *Grampus griseus* (CAAB 41 116005) Spinner dolphin, *Stenella longirostris* (CAAB 41 116017) Rough toothed-dolphin, *Steno bredanensis* (CAAB 41 116018)* Melon headed whale, *Peponocephala electra* (CAAB 41 116012)* Short-finned pilot whale, *Globicephala macrorhynchus* (CAAB 41 116003)* Killer whale, *Orcinus orca* (CAAB 41 116011) Pygmy killer whale, *Feresa attenuata* (CAAB 41 116002) Pygmy sperm whale, *Kogia breviceps* (CAAB 41 119001) Long-finned pilot whale, *Globicephala melas* (CAAB 41 116004)	*Species of Conservation Concern Subgroups excluded during the Level 1 ERA analysis (Jacobsen et al., 2019a)* - Whales - Sea snakes - Crocodiles - Protected teleosts - Syngnathids - Seabirds - Terrestrial mammals

Appendix B—Species Rationalisation Process: Justifications and Considerations

The following provides a detailed overview of the key justifications and considerations used to omit or include a species in the *GOCIF SOCC* Level 2 ERA. All species with green squares and a 'Y' were included in the SOCC Level 2 ERA. Red squares with an 'N' are those that have been omitted from the analysis. '*' Denotes species that were included or omitted in response to advice provided by key stakeholders and members of the scientific community.

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
Marine turtles					
Green turtle	*Chelonia mydas*	39 020002	**Y**	**Y**	***Included***—Reported effort in the GOCIF overlaps with the known distribution of all six marine turtles. Various turtle interactions have been reported through the SOCI logbooks (Department of Agriculture and Fisheries, 2019f), a previous Fisheries Observer Program and the *Wildlife Stranding and Mortality Database* (Greenland *et al.*, 2002; Meager & Limpus, 2012) The leatherback turtle is sparsely distributed in Queensland waters, and is understood to prefer deeper, pelagic waters along the continental shelf. While this species may be rarer in the shelf waters of the Gulf of Carpentaria, several sightings of leatherback turtle have been recorded in Queensland and the Northern Territory (Atlas of Living Australia, 2020a), along with sporadic nesting activity (Department of the Environment, 2019af). The probability that leatherback turtles will interact with GOCIF nets is lower, but it was included in the PSA as a precautionary measure.
Loggerhead turtle	*Caretta caretta*	39 020001	**Y**	**Y**	
Hawksbill turtle	*Eretmochelys imbricata*	39 020003	**Y**	**Y**	
Flatback turtle	*Natator depressus*	39 020005	**Y**	**Y**	
Olive ridley turtle	*Lepidochelys olivacea*	39 020004	**Y**	**Y**	
Leatherback turtle	*Dermochelys coriacea*	39 021001	**Y**	**N**	
Sirenia					
Dugong	*Dugong dugon*	41 206001	**Y**	**Y**	***Included***—Included in the Level 2 ERA.

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
Dolphins (*Odontocetes*)					
Australian humpback dolphin	*Sousa sahulensis*	41 116014	**Y**	**Y**	***Included***—Included in the Level 2 ERA. Data from the SOCI logbooks, *Wildlife Stranding and Mortality Database* (Meager, 2016a) and a former Fisheries Observer Program indicates that the majority of interactions involve the Australian humpback dolphin (*S. sahulensis*), the Australian snubfin dolphin (*O. heinsohni*), the common bottlenose dolphin (*T. truncates*) and the Indo-Pacific bottlenose dolphin (*T. aduncus*). Based on this data and scientific advice, all four species were included in the Level 2 ERA.
Australian snubfin dolphin	*Orcaella heinsohni*	41 116010	**Y**	**Y**	
Common bottlenose dolphin (Synonym - Offshore or Atlantic bottlenose dolphin)	*Tursiops truncatus*	41 116019	**Y**	**Y**	
Indo-Pacific bottlenose dolphin (Synonyms: Indian, inshore or spotted bottlenose dolphin)	*Tursiops aduncus*	41 116020	**Y**	**Y**	
Common dolphin	*Delphinus delphis*	41 116001	**N**	**N**	***Not Included***—The common dolphin (*D. delphis*) is rarely encountered in northern Australian waters and is unlikely to interact with the GOCIF as they prefer deeper, offshore waters (Department of the Environment, 2019ae). This species was not be included in the Level 2 assessment.

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
False killer whale	*Pseudorca crassidens*	41 116013	**N***	**Y***	***Included***—Advice from the Department of Environment and Energy suggests that the false killer whale (*P. crassidens*) is more likely to interact with fisheries operating in deeper water environments; particularly line-based fisheries (*e.g.* long-line fisheries). Further, there are very few reported cases of the species interacting with commercial fisheries in Queensland. To this extent, the inclusion of *P. crassidens* in the Level 2 ERA is considered precautionary and further assessment will be required as part of the Residual Risk Analysis. It is noted though that two false killer whale interactions were reported from the fishery as recently as 2019. *Additional Consultation—Additional consultation on the scope and extent of the Level 2 ERA indicated that the species has been reported from the Gulf of Carpentaria (pers. comm. J. Meager). The species is expected to have low interaction rates with the GOCIF but was included in the assessment based on expert advice.*
Spinner dolphin	*Stenella longirostris*		**N***	**Y***	***Included***—*Stenella longirostris* has been reported infrequently in StrandNET and records for this species include the Gulf of Carpentaria and the Queensland east coast (Bannister *et al.*, 1996; Department of the Environment, 2019k; Marsh, 1990). The species is primarily viewed as pelagic; although information on their distribution and movements in Australian waters is limited. While fishing activities including netting are identified as a key threat for this species, these threats are largely based in adjacent jurisdictions and outside of Australian waters. The species is not expected to have a high number of interactions with the GOCIF and conservation assessments (*Least concern*, IUCN) suggest that the fishery will have a negligible impact on the long-term sustainability of regional *S. longirostris* populations (Braulik & Reeves, 2018).

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					Additional Consultation—Additional consultation on the scope and extent of the Level 2 ERA indicated that the spinner dolphin has been observed in depths between 50 and 100m (pers. comm. J. Meager). While interactions with the GOCIF are expected to be low, it was recommended that the species be included in the assessment as a precautionary measure (pers. comm. J. Meager).
Fraser's dolphin	*Lagenodelphis hosei*	41 116006	**N***	**N***	***Not Included***—This species is infrequently recorded in StrandNET (Meager, 2016a). However, *L. hosei* prefers waters south of 30° S. It is also considered to be a deeper water species (>1000m) that occupies the outer shelf or continental shelf (Department of the Environment, 2019ad). The species is not expected to interact with the GOCIF or, if applicable, at levels that are not expected to have a long-term or detrimental impact on regional populations. Species was assessed as *Least Concern* by the IUCN (Kiszka & Braulik, 2018). *Additional Consultation—Additional consultation on the scope and extent of the Level 2 ERA indicated that the distribution and depth preferences for this species is less certain. However, the evidence was not considered sufficient to definitively include the species in the Level 2 ERA (pers. comm. J. Meager). If information on the distribution of the species were to improve into the future, consideration should be given to including Fraser's dolphin in subsequent ERAs.*
Striped dolphin	*Stenella coeruleoalba*	41 116016	**N**	**N**	***Not Included***—*Stenella coeruleoalba* strandings are infrequent with only two reported from southern Queensland. It is highly unlikely that this species will interact with the GOCIF although there is limited information on the distribution of this species in Australian waters. The *Species Profile and Threats Database* (SPRAT) suggests that the species is frequently observed in deeper water environments and prefers areas with large seasonal changes in surface temperature and thermocline depth with seasonal upwellings (Au & Perryman, 1985; Department of the

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					Environment, 2019ad). The species was categorised as of *Least Concern* by the IUCN and the key threats for this species largely occur in waters outside of Australia (Braulik, 2019; Reeves *et al.*, 2003).
Spotted dolphin	*Stenella attenuata*	41 116015	**N***	**N***	***Not Included***—Profile for *S. attenuata* is similar to *S. coeruleoalba*. In Australia, Spotted Dolphins have been recorded off the Northern Territory, Western Australia down south to Augusta, Queensland and NSW (Department of the Environment, 2019aa). The species is typically found north of 34° S and in waters generally deeper than 200m on the continental shelf. Spotted dolphins are unlikely to have significant interactions with the GOCIF and/or interact at levels that will be detrimental to regional populations. The species is considered as *Least Concern* by the IUCN (Kiska & Braulik, 2018). *Additional Consultation—Additional consultation on the scope and extent of the Level 2 ERA indicated that the distribution and depth preferences for this species is less certain. However, the evidence was not considered sufficient to definitively include the species in the Level 2 ERA (pers. comm. J. Meager). If information on the distribution of the species were to improve into the future, consideration should be given to including the spotted dolphin in subsequent ERAs*.
Risso's dolphin	*Grampus griseus*	41 116005	**N**	**N**	***Not Included***—Limited reports of the species within the StrandNET data (Meager, 2016a). Dated research indicates that Fraser Island on the Queensland east coast has the only suspected resident population (Corkeron & Bryden, 1992; Department of the Environment, 2019z). DoE considers the species to be potentially abundant in Australian waters. *Grampus griseus* though is associated more with steeper sections of the continental shelf (Department of the Environment, 2019z) and the species is not expected to interact with the GOCIF.

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
Rough-toothed dolphin	*Steno bredanensis*	41 116018	**N***	**N***	***Not Included***—There are infrequent reports of *Steno bredanensis* being stranded in Queensland (Meager, 2016a) and the species is generally considered a deeper-water or oceanic species (Department of the Environment, 2019x). No past threats have been identified, although the *Species Profile and Threats Database* suggests that *S. bredanensis* may be susceptible to pelagic gillnet fishing (Department of the Environment, 2019x). The majority of these threats are likely to occur outside of areas fished in the Gulf of Carpentaria. *Additional Consultation—Additional consultation on the scope and extent of the Level 2 ERA indicated that the distribution and depth preferences for this species is less certain. However, the evidence was not considered sufficient to definitively include the species in the Level 2 ERA (pers. comm. J. Meager). If information on the distribution of the species were to improve into the future, consideration should be given to including the rough-toothed dolphin in subsequent ERAs*.
Melon headed whale	*Peponocephala electra*	41 116012	**N**	**N**	***Not Included***—There have been reports of the species being stranded in Queensland (Meager, 2016a), including one mass stranding (*n* = 53) (Department of the Environment, 2019w). *Peponocephala electra* mainly inhabit equatorial waters that are >25 degrees and most sightings occur from the continental shelf seaward and around oceanic islands (Culik, 2004; Department of the Environment, 2019w). No threats have been identified for *P. electra* (Department of the Environment, 2019w) and the species is unlikely to interact with the GOCIF. In the event that the GOCIF does interact with the fishery, the extent and impact of these interactions are expected to be low to negligible.
Short-finned pilot whale	*Globicephala macrorhynchus*	41 116003	**N***	**N***	***Not Included***—Three *G. macrorhynchus* strandings have been reported from Queensland in StrandNET and the species is associated more with tropical and temperate oceanic waters (Department of the Environment, 2019u; Meager, 2016a; Minton *et al.*, 2018a). Hunting and

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					potential mortalities in longline fisheries and drift gillnet fisheries have been identified as threats for this species (Minton *et al.*, 2018a). These threats largely exist outside of Queensland managed waters and the species is unlikely to interact with the GOCIF in significant numbers. *Additional Consultation—Additional consultation on the scope and extent of the Level 2 ERA indicated that the distribution and depth preferences for this species is less certain. However, the evidence was not considered sufficient to definitively include the species in the Level 2 ERA (pers. comm. J. Meager). If information on the distribution of the species were to improve into the future, consideration should be given to including the short-finned pilot whale in subsequent ERAs.*
Killer whale	*Orcinus orca*	41 116011	**N**	**N**	***Not Included***—Rarely encountered species with a single stranding reported in StrandNET on the Queensland east coast (Meager, 2016a). No known populations/aggregations in Queensland waters and the species is rarely observed. In Australian waters, most observations have been reported in Victoria, South Australia, Tasmania and in Macquarie/Antarctic waters and/or in cold waters near seal colonies (Department of the Environment, 2019t).
Pygmy killer whale	*Feresa attenuata*	41 116002	**N**	**N**	***Not Included***—Limited StrandNET records for this species and there have been few sightings of the species in north-east Australia (Bannister *et al.*, 1996; Bryden, 1976). The species is rarely seen close to shore and not expected to be significantly abundant in Australian waters (Department of the Environment, 2019q; Reeves *et al.*, 2003).
Pygmy sperm whale	*Kogia breviceps*	41 119001	**N**	**N**	***Not Included***—While this species has StrandNET records (Meager, 2016a), it is more frequently found in deeper water environments off the continental shelf. No immediate threats have been reported for this species, although the *Species Profile and Threats Database* suggests that the species may be susceptible to net fishing (Department of the Environment, 2019o). These threats

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					are more prominent in other (international) jurisdictions *e.g.* Indonesia, Sri Lanka (Department of the Environment, 2019o).
Long-finned pilot whale	*Globicephala melas*	41 116004	**N**	**N**	***Not Included***—Species has a mostly southern distribution and it is unlikely to occur in high numbers in Queensland. Only one stranding and four sightings have been recorded from the State (Department of the Environment, 2019n; Minton *et al.*, 2018b).
Dusky dolphin	*Lagenorhynchus obscurus*	41 116008	**N**	**N**	***Not Included***—Northernmost point of the *L. obscurus* Australian distribution lies to the south of Queensland managed waters (Department of the Environment, 2019m).
Spectacled porpoise	*Phocoena dioptrica*	41 117001	**N**	**N**	***Not Included***—Species does not occur and/or is unlikely to occur in waters managed by Queensland (Department of the Environment, 2019l).
Commerson's dolphin	*Cephalorhynchus commersonii*	n/a	**N**	**N**	***Not Included***—Species does not occur in waters managed by Queensland (Crespo *et al.*, 2017).
Hourglass dolphins	*Lagenorhynchus cruciger*	41 116007	**N**	**N**	***Not Included***—Species does not occur and/or is unlikely to occur in waters managed by Queensland (Braulik, 2018b).
Southern right whale dolphin	*Lissodelphis peronii*	41 116009	**N**	**N**	***Not Included***—Species does not occur and/or is unlikely to occur in waters managed by Queensland (Braulik, 2018a).
Burrunan dolphin	*Tursiops australis*	41 116022	**N**	**N**	***Not Included***—Species does not occur in Queensland managed waters (Charlton-Robb *et al.*, 2011).

GOCIF—N3, N12 & N13 fishery symbols					
Common name	**Species name**	**CAAB**	**Inshore (N3)**	**Offshore (N12/N13)**	**Considerations**
Irrawaddy dolphin	*Orcaella brevirostris*	n/a	**N**	**N**	***Not Included***—*Orcaella brevirostris* is now considered to be a south-east Asian species and it is unlikely to interact with commercial fisheries in Australia (Minton *et al.*, 2017).
Indo-Pacific humpback dolphin	*Sousa chinensis*	n/a	**N**	**N**	***Not Included***—Similar profile to the Irrawaddy dolphin (*O. brevirostris*). Taxonomic reviews and further research has identified two distinct species, the Australian humpback dolphin (*Sousa sahulensis*) and the Indo-Pacific humpback dolphin (*S. chinensis*) (Department of the Environment, 2019j).
Strap toothed whale	*Mesoplodon layardii*	41 120009	**N**	**N**	***Not Included***—While this species has StrandNET records (Meager, 2016a) it is more frequently found in deeper water environments and is not expected to interact with GOCIF.
Giant beaked whale (aka Arnoux's)	*Berardius arnuxii*	41 120001	**N**	**N**	***Not Included***—Species does not occur in Queensland managed waters (Department of the Environment, 2019f)**.**
Dwarf sperm whale	*Kogia sima*	41 119002	**N**	**N**	***Not Included***—Dwarf sperm whales (*K. sima*) are not considered to be abundant in Australian waters and sightings/strandings for this species are limited (Department of the Environment, 2019a). In the unlikely event that a *K. sima* interaction does occur in the GOCIF, the extent and impact of these interactions are expected to be low to negligible.
Southern bottlenose whale	*Hyperoodon planifrons*	41 120002	**N**	**N**	***Not Included***—Species does not occur in Queensland managed waters (Department of the Environment, 2019i).
Tropical bottlenose whale (aka Longman's)	*Indopacetus pacificus*	41 120003	**N**	**N**	***Not Included***—Species does not occur in Queensland managed waters (Department of the Environment, 2019h).

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
Andrew's beaked whale	*Mesoplodon bowdoini*	41 120004	**N**	**N**	***Not Included***—Species does not occur in Queensland managed waters (Department of the Environment, 2019g).
Blainville's beaked whale	*Mesoplodon densirostris*	41 120005	**N**	**N**	***Not Included***—A limited number of *M. densirostris* strandings have been reported in Queensland. The species prefers tropical (22–32 °C) to temperate (10–20 °C) oceanic regions and inhabits waters ranging from 700–1000m deep, but often adjacent to much deeper waters of 5000m (Department of the Environment, 2019r).
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	41 120006	**N**	**N**	***Not Included***—*Mesoplodon ginkgodens* are not considered to be abundant and thought to primarily occur in deep, offshore waters (Department of the Environment, 2019s).
Gray's beaked whale	*Mesoplodon grayi*	41 120007	**N**	**N**	***Not Included***—*Mesoplodon grayi* is considered to be a southern species with low potential to interact with fisheries in Queensland (Taylor *et al.*, 2008b).
Hector's beaked whale	*Mesoplodon hectori*	41 120008	**N**	**N**	***Not Included***—*Mesoplodon hectori* is considered to be a southern species with low potential to interact with fisheries in Queensland (Taylor *et al.*, 2008c).
True's beaked whale	*Mesoplodon mirus*	41 120010	**N**	**N**	***Not Included***—Species does not occur in Queensland managed waters (Taylor *et al.*, 2008d).
Shepard's beaked whale	*Tasmacetus shepherdi*	41 120011	**N**	**N**	***Not Included***—Species does not occur in Queensland managed waters (Braulik, 2018c).
Curvier's beaked whale	*Ziphius cavirostris*	41 120012	**N**	**N**	***Not Included***—Species is more commonly found in deeper water environments (>1000m) and is unlikely to interact with the GOCIF (Taylor *et al.*, 2008a).

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
Sharks					
Whale shark	*Rhincodon typus*	37 014001	**N**	**N**	***Not Included***—Whale sharks (*R. typus*) have been reported from the Gulf of Carpentaria and the GOCIF overlaps with their known distribution (Last & Stevens, 2009). However, there have been no reports of the species interacting with net fisheries operating in the Gulf of Carpentaria. Further, commercial fishing has not been identified as a key threat (direct or indirect) to this species in Queensland waters, including in third party assessments (*e.g.* WTO export approvals) and previous whale shark recovery plans. Whale sharks are sighted more frequently on the west coast of Australia where there are known aggregation sites (Department of the Environment and Energy, 2005). While possible, interactions with this species are viewed as highly unlikely in this fishery and the species was excluded from the analysis.
Great white shark	*Carcharodon carcharias*	37 010003	**N***	**N***	***Not Included***—While the white shark's (*C. carcharias*) broader distribution overlaps with the GOCIF (Last & Stevens, 2009), the species has not been reported from the fishery through the logbook program or a previous fisheries observer program. The species has been reported from the shark control program (*n* = 111, 2001–2017 inclusive), although this program only operates on the Queensland east coast (Queensland Government, 2019b). Encounter rates with this species are expected to be lower in the Gulf of Carpentaria (Department of the Environment and Energy, 2013). In Queensland these interactions are more likely to occur on the central and southern coastlines of eastern Queensland. *Additional Consultation—Additional consultation on the scope and structure of the TEP Level 2 for the East Coast Inshore Fishery (ECIF) indicated that white sharks are unlikely to interact with the*

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					Large Mesh Net Fishery with great frequency (Jacobsen et al., 2021; Pidd et al., 2021). Accordingly, it was recommended that the species be omitted from large mesh net ERAs (pes. comm. C. Simpfendorfer). When compared to the ECIF, interactions will be less likely in the GOCIF.
Grey nurse shark	*Carcharias taurus*	37 008001	**N**	**N**	***Not Included***—While the grey nurse shark's (*C. taurus*) broader distribution overlaps with the GOCIF, a number of factors reduce the risk of an interaction occurring in this fishery (Last & Stevens, 2009). Previous research on grey nurse shark movements and migration patterns identified Wolf Rock on the east coast as the most northerly part of the species' known range (Bansemer & Bennett, 2011). A small population of grey nurse sharks have recently been discovered living near the Tiwi islands in the Northern Territory (https://www.abc.net.au/news/2019-04-06/grey-nurse-shark-population-discovered-nt-tiwi-conocophillips/10978352), but there remains very little evidence that this species inhabits Gulf of Carpentaria waters. While noting the potential presence of a grey nurse shark population in Northern Territory, interactions between this species and GOCIF operators are considered to be highly unlikely. Grey nurse shark are typically found close to substrate and at depths where net interactions are less likely to occur.
Speartooth shark	*Glyphis glyphis*	37 018041	**Y**	**Y**	***Included***—The speartooth shark (*G. glyphis*) has experienced significant range and population contractions. Research suggests that the species is extirpated from the majority (if not all) of the Queensland east coast, with the Gulf of Carpentaria being a key stronghold (Compagno *et al.*, 2009; Last & Stevens, 2009; Peverell *et al.*, 2006). The speartooth shark is understood to prefer inshore waters and will be found in waters fished by GOCIF operators (Compagno *et al.*, 2009;

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					Last & Stevens, 2009; Peverell *et al.*, 2006). While there is some uncertainty surrounding the distribution of the species in the Gulf of Carpentaria, these interactions are more likely to occur in and around the Wenlock River region. As the species has already experienced historical population/distributional declines, fishing-related mortalities may have longer term implications. Given the restricted nature of the *G. glyphis* distribution, this could occur at low levels of fishing mortality. The extent of fishing induced mortality may be masked by the infrequent nature of the interactions and a high potential for misidentifications *e.g.* with more common species like bull shark (*C. leucas*).
Northern river shark	*Glyphis garricki*	37 018042	**N**	**N**	***Not Included***—This species shares a number of similarities with the speartooth shark (*G. glyphis*). However, distributional data for *G. garricki* suggests that the species does not occur in Queensland managed waters (Last & Stevens, 2009). Accordingly, *G. garricki* was not included in the Level 2 ERA for the GOCIF.
Porbeagle shark	*Lamna nasus*	37 010004	**N**	**N**	***Not Included***—Interactions with *L. nasus* considered to be unlikely in the GOCIF. *Lamna nasus* prefers more temperate environments and the species is more likely to occur on the continental shelf of the Queensland east coast (Last & Stevens, 2009).
Sandtiger shark	*Odontaspis ferox*	37 008003	**N**	**N**	***Not Included***—Although *O. ferox* is listed as a *Species of Conservation Interest*, it inhabits deeper water environments and is unlikely to interact with the GOCIF (*pers. comm.* D. Bowden; Last & Stevens, 2009).

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
Shortfin mako shark	*Isurus oxyrinchus*	37 010001	**N**	**N**	***Not Included***—The two mako species (*I. oxyrinchus* and *I. paucus*) are afforded full protection in the Great Barrier Reef Marine Park (GBRMP) due to their listing as migratory species under the *Environment Protection and Biodiversity Act 1999* (EPBC Act). The species though can still be retained in Queensland managed waters if a) they are caught as incidental bycatch and b) the animal died as a result of the fisheries interaction. Distribution data for the species does include the Gulf of Carpentaria as part of this species' range (Rigby *et al.*, 2019b) and the species is more likely to be encountered on the Australian east coast and in deeper water environments. Information on the distribution of the longfin mako (*I.* paucus) is limited; although the species is more likely to be encountered in deeper water / oceanic environments and in fisheries managed by the Commonwealth or adjacent jurisdictions *e.g.* Indonesia (Last & Stevens, 2009; White *et al.*, 2006). *Isurus paucus* will have negligible interactions with the GOCIF and does not warrant the inclusion of the species in the Level 2 ERA.
Longfin mako shark	*Isurus paucus*	37 010002	**N**	**N**	
Great hammerhead	*Sphyrna mokarran*	37 019002	**Y**	**Y**	***Included***—Hammerheads form an important component of the GOCIF catch and, while they may not be targeted directly, they will be retained if caught in the net.
Scalloped hammerhead	*Sphyrna lewini*	37 019001	**Y**	**Y**	***Included***—Hammerheads form an important component of the GOCIF catch and, while they may not be targeted directly, they will be retained if caught in the net.
Winghead shark	*Eusphyra blochii*	37 019003	**Y**	**Y**	***Included***—When compared to the scalloped (*S. lewini*) and great hammerhead shark (*S. mokarran*), datasets for the winghead shark (*E. blochii*) are more limited. The distribution of *E. blochii* overlaps with the GOCIF and the species is mainly found in coastal/nearshore waters where net fishing occurs (Last & Stevens, 2009; Smart & Simpfendorfer, 2016). While *E. blochii*

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					has been included in the Level 2 ERA, data deficiencies for this species will need to be given further consideration as part of the Residual Risk Analysis.
Smooth hammerhead	*Sphyrna zygaena*	37 019004	**N**	**N**	***Not included***—The distribution of the smooth hammerhead (*S. zygaena*) is largely confined to temperate waters (Last & Stevens, 2009) and the species is more likely to interact with fisheries in south-east Queensland and New South Wales (Simpfendorfer, 2014). This suggests that the majority of the *S. zygaena* population / stock is found in waters outside of Queensland and that interactions with the GOCIF would be highly unusual.
Oceanic whitetip shark	*Carcharhinus longimanus*	37 018032	**N**	**N**	***Not Included***—Species prefers oceanic/pelagic environments (Last & Stevens, 2009) and it is unlikely to interact with the GOCIF.
Pelagic thresher	*Alopias pelagicus*	37 012003	**N**	**N**	***Not Included***—The pelagic thresher (*A. pelagicus*) is an offshore/pelagic species (Last & Stevens, 2009) and it is more likely to interact with fisheries managed by the Commonwealth. While thresher sharks can be retained for sale in Queensland, none have been reported through the logbook program and/or through a previous Fisheries Observer Program. If *A. pelagicus* were to be caught in the GOCIF the number and frequency of the interactions are not expected to have a long-term or detrimental impact on the health of regional stocks or populations.
Bigeye thresher	*Alopias superciliosus*	37 012002	**N**	**N**	***Not Included***—This species is associated more with pelagic environments and continental shelves; although evidence suggests that the species may come into inshore environments (Amorim *et al.*, 2009). In Australia, the species is more likely to interact with Commonwealth fisheries that operate outside of Queensland's management jurisdiction. This includes the *East Coast Tuna and Billfish Fishery* (*pers. obs.* I. Jacobsen). This inference is partly supported by an absence of thresher interactions in the logbook data and in a previous Fisheries Observer

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					Program. While the species may occur in inshore waters, the number and frequency of GOCIF interactions are not expected to have a long-term or detrimental impact on the health of regional stocks or populations.
Thresher shark	*Alopias vulpinus*	37 012001	**N**	**N**	***Not Included***—The thresher shark (*A. vulpinus*) has a wide/global distribution but is most abundant in waters up to 40 or 50 miles offshore (Goldman *et al.*, 2009). This information suggests that the species is more likely to interact with pelagic long-line fishing operations managed under the Commonwealth framework.
Basking shark	*Cetorhinus maximus*	37 011001	**N**	**N**	***Not Included***—Basking sharks (*C. maximus*) prefers temperate coastal regions and are unlikely to frequent Queensland managed waters (Last & Stevens, 2009). Interactions with the species are highly unlikely in the GOCIF.
Harrisson's dogfish	*Centrophorus harrissoni*	37 020010	**N**	**N**	***Not Included***—A deepwater demersal species found on continental and insular slopes in depths of 220–680m (Last & Stevens, 2009).
Southern dogfish	*Centrophorus zeehaani*	37 020011	**N**	**N**	***Not Included***—The distribution of *C. zeehaani* does not extend into Queensland waters and the species is primarily found on the upper continental slope in depths of 210–700m (Last & Stevens, 2009).
School shark	*Galeorhinus galeus*	37 017008	**N***	**N***	***Not included***—The distribution of *G. galeus* does not extend into the Gulf of Carpentaria (Last & Stevens, 2009).
Spiny dogfish	*Squalus acanthias*	37 020008	**N**	**N**	***Not Included***—Species distribution covers southern waters and *S. acanthias* does not occur in waters managed by Queensland (Last & Stevens, 2009).

<table>
<tr><th colspan="6">GOCIF—N3, N12 & N13 fishery symbols</th></tr>
<tr><th>Common name</th><th>Species name</th><th>CAAB</th><th>Inshore (N3)</th><th>Offshore (N12/N13)</th><th>Considerations</th></tr>
<tr><td>Crested hornshark</td><td>Heterodontus galeatus</td><td>37 007003</td><td>N</td><td>N</td><td>Not Included—The crested hornshark (H. galeatus) was included in the preliminary SOCC list due to it having additional protections in the Moreton Bay Marine Park, south-east Queensland. The distribution of H. galeatus does not extend into the Gulf of Carpentaria (Last & Stevens, 2009).</td></tr>
<tr><td colspan="6">Batoids</td></tr>
<tr><td>Giant manta ray</td><td>Mobula birostris (synonym: Manta birostris)</td><td>37 041004</td><td>N</td><td>N</td><td rowspan="5">Included—M. alfredi & M. kuhlii.

Not Included—M. birostris, M. mobular & M. thurstoni.

The SOCI logbook has a single (SOCI) report of a devilray, the bentfin devilray (M. thurstoni), interacting with the GOCIF (Department of Agriculture and Fisheries, 2019b). However, a previous Fisheries Observer Program indicates that several (n = 15) M. birostris interacted with the fishery between 2000 to 2006 (Note—SOCI logbooks came into effect from 2003 and the level of protection afforded to manta rays / devilrays would vary through time).

While the above information is useful, the Mobulidae complex has undergone a recent taxonomic review and it is likely these species have changed names. The bentfin devilray as it is known today, is only found on the east coast of Queensland (Last et al., 2016). It is therefore likely this SOCI report was a misidentified Kuhl’s devilray (M. kuhlii). At the time the FOP was carried out, Manta birostris was thought to be the only species of manta ray in existence. This species has since been separated into Manta birostris and Manta alfredi, and now the ‘Manta’ genus has been superseded and amalgamated into the Mobulids (Family Mobulidae). Given the type marine</td></tr>
<tr><td>Reef manta ray</td><td>Mobula alfredi</td><td>37 041005</td><td>Y</td><td>Y</td></tr>
<tr><td>Kuhl's devil ray</td><td>Mobula kuhlii (synonym: Manta eregoodootenkee)</td><td>37 041001</td><td>Y</td><td>Y</td></tr>
<tr><td>Giant devil ray (synonym Japanese devil ray)</td><td>Mobula mobular (synonym: M. japanica)</td><td>37 041002</td><td>N</td><td>N</td></tr>
<tr><td>Bentfin devil ray</td><td>Mobula thurstoni</td><td>37 041003</td><td>N</td><td>N</td></tr>
</table>

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					habitat in the Gulf of Carpentaria (limited upwelling, shallower waters, no shelfs or seamounts), it is highly likely that these reports were of *M. alfredi*, not *M. birostris* (Last *et al.*, 2016). *Mobula thurstoni* and *M. Mobula* are not known to inhabit the Gulf of Carpentaria (Last *et al.*, 2016), and will therefore not be included in the Level 2 ERA. *Mobula birostris* does have a distribution that extends into the Gulf of Carpentaria, but upon closer examination of the types of habitats this species prefers, *M. birostris* is less likely to interact with GOCIF (*pers. comm.* K. Townsend; Last *et al.*, 2016). If *M. birostris* were to interact with the GOCIF, it would be infrequent (*pers. comm.* K. Townsend; Armstrong *et al.*, 2020) and not at a level that would impact significantly on the long-term conservation status of the species. *Note—The taxonomy of the Kuhl's devilray (M. Kuhlii) and the longhorn devilray (M. eregoodoo) has some uncertainty. Combined morphological and molecular data led Last et al. (2016) and White et al. (2017b) to conclude that M. eregoodootenkee (synonym of M. eregoodoo) is a junior synonym of M. kuhlii. However, Hosegood et al. (2019) suggested these were separate species, which was supported by Notarbartolo di Sciara et al. (2020). The range or both M. kuhlii and M. eregoodoo is poorly defined in Australia due to these taxonomic issues and scientific advice recommended that they be treated the same until their status and catch ratios can be determined (pers. comm. P. Kyne).*
Chilean devil ray	*Mobula tarapacana*	37 041006	**N**	**N**	***Not Included***—The species was included in the preliminary species list as it has been included the CITES Appendices. The distribution of *M. tarapacana* is expected to be global, however information is fragmented. Species is unlikely to interact with the GOCIF and may not occur in Queensland waters (Last *et. al.,* 2016). Accordingly, it was not included in the Level 2 ERA.

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
Largetooth sawfish (*synonym* - Freshwater sawfish)	*Pristis pristis*	37 025003	**Y**	**Y**	***Included***—This subgroup has experienced notable population declines and their distribution has experienced a significant contraction (Last *et al.*, 2016); particularly on the Queensland east coast where there is a degree of uncertainty surrounding the extent of their distribution (D'Anastasi *et al.*, 2013; Kyne *et al.*, 2013a; Simpfendorfer, 2013). However, all four species are present in the Gulf of Carpentaria and have the potential to interact with the GOCIF. From an ERA perspective, uncertainty surrounding the distribution of *Pristis* species makes it difficult to assess the level of risk. Historical declines and range contractions can amplify the impact of a fishery on regional populations. Depending on the species and the level of population segregation, even low levels of fishing mortality may have a significant and long-term impact on regional populations. As the Gulf of Carpentaria is viewed as a key sawfish population stronghold, all four were included in the Level 2 assessment.
Narrow sawfish	*Anoxypristis cuspidata*	37 025002	**Y**	**Y**	
Green sawfish	*Pristis zijsron*	37 025001	**Y**	**Y**	
Dwarf sawfish	*Pristis clavata*	37 025004	**Y**	**Y**	
Bottlenose wedgefish (synonym - whitespotted guitarfish)	*Rhynchobatus australiae*	37 026005	**Y**	**Y**	***Included***—The listing of wedgefish and guitarfish on CITES and their potential listing on CMS will have implications for commercial fisheries in Queensland. As these species will interact (at various levels) with the GOCIF all three were included in the Level 2 ERA. **A taxonomic review of these species has resulted in a change to the nomenclature. These changes have yet to be reflected in legislation which still refers to the Family Rhynchobatidae. The intent of the legislation though still provides Rhynchobatus species with additional protections.*
Eyebrow wedgefish	*Rhynchobatus palpebratus*	37 026004	**Y**	**Y**	
Giant shovelnose ray	*Glaucostegus typus*	37 027010	**Y**	**Y**	
Estuary stingray	*Hemitrygon fluviorum*	37 035008	**Y**	**Y**	***Included***—The estuary stingray (*H. fluviorum*) was included on the preliminary species list due to its classification as *Near Threatened* under the Queensland *Nature Conservation Act 1992*. However the species is not afforded additional protections under fisheries legislation and is not listed as a threatened or migratory species under the EPBC Act. As a consequence, the species

GOCIF—N3, N12 & N13 fishery symbols					
Common name	***Species name***	***CAAB***	***Inshore (N3)***	***Offshore (N12/N13)***	***Considerations***
					is not classified (internally) as a *Species of Conservation Interest* (SOCI) and it can be retained for sale in the GOCIF if caught in waters not covered under the *Nature Conservation Act 1992*. While the species can be found in a range of environments from mangrove-fringed rivers/estuaries and in offshore waters down to at least 28m deep (Kyne *et al.*, 2016; Last *et al.*, 2016) it is more common in inshore waters. The known distribution of *H. fluviorum* extends along the Queensland east coast and west through the Gulf of Carpentaria and Northern Territory. The species' preference for intertidal, riverine and estuarine waters increases the likelihood of interactions occurring when operators are targeting key inshore species like barramundi. The extent of these interactions are largely unknown as batoid discards are not reported in the fishery and the species is not subject to mandatory reporting requirements as it is not classified as a SOCI.
Maugean skate	*Zearaja maugeana*	37 031037	**N**	**N**	***Not Included***—Species is endemic to Tasmania (Last *et al.*, 2016); therefore it was not included in the Level 2 ERA.

Appendix C—Overlap percentages used to calculate scores for the *availability* attribute

Where available, overlap percentages were based on species distribution maps sourced from the *Commonwealth Scientific and Industrial Research Organisation* (CSIRO) and, where possible, were refined using bathymetry and topographical data (Whiteway, 2009). * Represents species where maps were not initially available and required alternates to be sourced.

Common name	Species	CAAB	2016	2017	2018	Highest %	Highest score of the 3 years
			% Overlap	% Overlap	% Overlap		
Marine Turtles							
Green turtle	*Chelonia mydas*	39 020002	12.3	12.5	10.1	12.5	2
Loggerhead turtle	*Caretta caretta*	39 020001	12.3	12.5	10.1	12.5	2
Hawksbill turtle	*Eretmochelys imbricata*	39 020003	12.3	12.5	10.1	12.5	2
Flatback turtle	*Natator depressus*	39 020005	12.3	12.5	10.1	12.5	2
Olive ridley turtle	*Lepidochelys olivacea*	39 020004	12.3	12.5	10.1	12.5	2
Leatherback turtle	*Dermochelys coriacea*	39 021001	12.3	12.5	10.1	12.5	2
Sirenia							
Dugong	*Dugong dugon*	41 206001	27.3	27.7	22.4	27.7	2
Dolphins							
Australian snubfin dolphin	*Orcaella heinsohni*	41 116010	50.9	53.3	44.9	53.3	3
False killer whale	*Pseudorca crassidens*	41 116013	12.2	12.5	10.0	12.5	2
Australian humpback dolphin	*Sousa sahulensis*	41 116014	33.7	34.0	27.6	34.0	3
Spinner dolphin	*Stenella longirostris*	41 116017	12.2	12.5	10.0	12.5	2
Common bottlenose dolphin*	*Tursiops truncatus*	41 116019	12.2	12.5	10.0	12.5	2
Indo-Pacific bottlenose dolphin*	*Tursiops aduncus*	41 116020	12.2	12.5	10.1	12.5	2
Sharks							
Speartooth shark	*Glyphis glyphis*	37 018041	12.2	12.5	10.1	12.5	2

Common name	Species	CAAB	2016	2017	2018	Highest %	Highest score of the 3 years
			% Overlap	% Overlap	% Overlap		
Scalloped hammerhead	*Sphyrna lewini*	37 019001	12.3	12.5	10.1	12.5	2
Great hammerhead	*Sphyrna mokarran*	37 019002	11.5	11.7	9.3	11.7	2
Winghead shark	*Eusphyra blochii*	37 019003	12.2	12.5	10.1	12.5	2
Batoids							
Green sawfish	*Pristis zijsron*	37 025001	12.2	12.5	10.1	12.5	2
Narrow sawfish	*Anoxypristis cuspidata*	37 025002	12.2	12.5	10.1	12.5	2
Largetooth sawfish	*Pristis pristis*	37 025003	12.2	12.5	10.1	12.5	2
Dwarf sawfish	*Pristis clavata*	37 025004	21.7	22.8	17.8	22.8	2
Eyebrow wedgefish*	*Rhynchobatus palpebratus*	37 026004	14.7	15.8	13.9	15.8	2
Bottlenose wedgefish*	*Rhynchobatus australiae*	37 026005	17.4	19.9	15.5	19.9	2
Giant shovelnose ray	*Glaucostegus typus*	37 027010	11.5	11.7	9.3	11.7	2
Estuary stingray*	*Hemitrygon fluviorum*	37 035008	60.8	62.7	55.0	62.7	3
Kuhl's devil ray*	*Mobula kuhlii*	37 041001	11.5	11.7	9.3	11.7	2
Reef manta ray	*Mobula alfredi*	37 041005	12.2	12.5	10.1	12.5	2

Appendix D—Residual Risk Analysis

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Marine turtles Loggerhead turtle *(C. caretta)* Olive ridley turtle *(L. olivacea)* Leatherback turtle *(D. coriacea)*	*Fecundity (Productivity)*	GOCIF (N3, N12, N13)	3	2	The precautionary nature of the PSA meant that preliminary scores for the *fecundity* attribute were based on the most conservative values published for: number of eggs per year, years between reproductive events and number of batches per reproductive season. For some species, these values were well below the mean and therefore were considered an unrealistic account of the species *fecundity*. The leatherback turtle (*D. coriacea*) provides a good example of this, where the precautionary estimate for number of eggs per year was n = 5, versus n = 237 based on mean values. ***Key changes to the PSA scores*** To address these discrepancies, the number of offspring per year was recalculated using mean values for number of eggs per clutch, number of years between reproductive events, and number of clutches per season. As a result of these amendments, risk ratings assigned to the *fecundity* attribute decreased from high (3) to medium (2) for three species; *C. caretta, L. olivacea and D. coriacea*. These amendments were done in consultation with members from the scientific community (*pers. comm.* C. Limpus & J. Meager) and made in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Marine turtles Loggerhead turtle *(C. caretta)*	*Maximum size (Productivity)*	GOCIF (N3, N12, N13)	1	2	The loggerhead turtle (*C. caretta*) was initially assigned a low (1) risk score for the *maximum size* attribute. During the consultation process, it was advised that this score should be increased (*pers. comm*. C. Limpus). ***Key changes to the PSA scores*** Due to this feedback, the score assigned to this attribute was increased from low (1) to medium (2). This change was done in accordance with *Guideline 1: rating due to*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					missing, incorrect or out of date information and *Guideline 2: additional scientific assessment & consultation.*
<u>Marine turtles</u> Loggerhead turtle *(C. caretta)* Leatherback turtle *(D. coriacea)*	*Encounterability (Susceptibility)*	GOCIF (N3, N12, N13)	3	2	For most species, the *encounterability* attribute was assessed on two key components: 1) the habitat preferences of the species being assessed when it is an adult and 2) its bathymetric preferences. These measures are overridden for air-breathing species which, based on the ERAEF, are assigned a default high-risk score (3) for this attribute (Hobday *et al.*, 2007). Air-breathing animals need to access the surface and therefore have a higher potential of interacting with the gear across the entire fishing event *e.g.* during the net setting, soak and retrieval processes (Hobday *et al.*, 2007). In-line with this methodology, all marine turtles were assigned a preliminary risk score of high risk (3) as part of the PSA. All six marine turtle species have been observed and reported from the Gulf of Carpentaria. Of those assessed, the majority of interactions are expected to be with the green turtle (*C. mydas*), the olive ridley turtle (*L. olivacea*), the flatback turtle (*N. depressus*) and the hawksbill turtle (*E. imbricata*). This assessment is supported by data complied through the StrandNET program. This data (1999–2011 inclusive) showed that 42% of the marine turtle interactions with gillnets / ghost nets were with the olive ridley turtle, followed by the green turtle (18%), hawksbill turtle (16%) and the flatback turtle (8%). Only 2% of the reported interactions were with the loggerhead turtle and the database does not contain any leatherback turtle / net interactions for the Gulf of Carpentaria (Biddle & Limpus, 2011; Department of Environment and Science, 2017; Greenland & Limpus, 2003; 2004; Greenland *et al.*, 2002; Haines *et al.*, 1999; Meager & Limpus, 2012). While it is acknowledged that StrandNET provides an incomplete account of the Gulf of Carpentaria strandings, this data provides an indicative account of the species that might interact with the GOCIF.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Of the species assessed, green, olive ridley and flatback turtles have extensive nesting sites in the Gulf of Carpentaria and a number have been reported within the area fished by GOCIF operators (Department of National Parks Sport and Racing, 2016; Limpus, 2007a; 2008a; b). Nesting sites for the hawksbill turtle have also been reported in higher densities on the eastern and north-eastern coast of the Gulf of Carpentaria (Limpus, 2007b). These preferences increase the probability of the species being encountered by the fishery in key habitats. The loggerhead turtle is not known to nest in the Gulf of Carpentaria and interactions with this species are expected to be less frequent. These interactions are more likely to occur if and when the species migrates through the region utilising subtidal/intertidal seagrass meadows and reefs (Department of National Parks Sport and Racing, 2016; Great Barrier Reef Marine Park Authority, 2018). The leatherback turtle is sparsely distributed in Queensland waters, and is understood to prefer deeper, pelagic waters along the continental shelf. While this species may be rarer in the shelf waters of the Gulf of Carpentaria, several leatherback turtle sightings and sporadic nesting have been recorded in Queensland and the Northern Territory (Atlas of Living Australia, 2020a; Department of the Environment, 2019af). However, the probability of a leatherback turtle interacting with the GOCIF is considered low. ***Key changes to the PSA scores*** The distribution of GOCIF effort and what is known about the distribution and movements of the loggerhead and leatherback turtle indicate that preliminary scores assigned to this attribute are too precautionary. This inference is supported by information contained in StrandNET which shows that the majority of marine turtle-net interactions in the Gulf of Carpentaria involve the green turtle, hawksbill turtle, flatback and olive ridley turtle.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Accordingly, scores assigned to the *encounterability* attribute for loggerhead turtle and leatherback turtle was reduced from high (3) to medium (2).The decision to reduce the scores for this attribute are based on the fact that, while the Gulf of Carpentaria has habitats preferred by the loggerhead and leatherback turtle, they are more likely to be found on the Queensland east coast. The above changes were done in accordance with *Guideline 2: additional scientific assessment & consultation* and further consideration given to *Guideline 3: at risk with spatial assumptions*. Scores assigned to this attribute may still represent a risk overestimate for the leatherback turtle as the species occurs in the Gulf of Carpentaria in relatively low numbers and densities. There is however limited capacity within the current management regime to verify or validate marine turtle interaction rates in the Gulf of Carpentaria. Consequently, a more precautionary approach was taken. With additional information it is anticipated that one or more of the *encounterability* attribute score could be reduced.
<u>Sirenia</u> *Dugong (D. dugong)*	*Encounterability (Susceptibility)*	GOCIF (N3, N12, N13)	3	2	The Gulf of Carpentaria has a notable dugong (*D. dugong*) population and the species inhabits areas that are fished by GOCIF operators. Surveys of the area suggest that the population size is substantial (~12,500) and that the Gulf of Carpentaria is an area of significance in terms of their long-term conservation status (Marsh *et al.*, 2008). There are limited reports of dugongs interacting with commercial net fisheries in the Gulf of Carpentaria including within the *Species of Conservation Concern* (SOCI) logbook (*n* = 1 dead & 1 injured in 2016), in StrandNET or a previous *Fisheries Observer Program* (Biddle *et al.*, 2011; Department of Agriculture and Fisheries, 2019b; Flint & Limpus, 2013; Greenland & Limpus, 2006; Jacobsen *et al.*, 2019a; Meager, 2016b). As GOCIF operations fish in a range of inshore and offshore habitats there is some potential for the fishery to interact with dugongs in their preferred areas. This interaction

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					potential is likely to be higher in inshore waters (N3 fishery) where dugongs tend to be more prevalent (*pers. comm.* A. Grech). At a regional level, research shows that relative dugong densities are higher in the Torres Strait Region, in the Western Gulf of Carpentaria and around Mornington Island (*pers. comm*. A. Grech; Marsh *et al.*, 2008). These areas largely lie outside the prescribed GOCIF fishing area or are afforded additional protections (see below) (Department of Agriculture and Fisheries, 2019b). In inshore environments, dugongs are afforded additional protections from net fishing through a range of measures. These include through the North Marine Parks Network (Director of National Parks, 2018), a prohibition on commercial fishing in some rivers/creeks and the establishment of the *Wellesley Islands Protected Wildlife Area* which prohibits the use of gillnets (apart from barramundi nets) around the islands and adjacent mainland (Marsh, 1990; Department of Agriculture and Fisheries, 2013). As these factors are not easily accounted for in the PSA framework, they were given further consideration as part of the RRA. The above measures are still in effect and continue to afford dugongs with additional protections from net fishing activities in key areas. Located in areas with higher dugong densities, these measures help to reduce the *encounterability* potential for this species. It is recognised though that fishing can still occur in adjacent areas and there is an increased potential for operators to encounter and interact with dugongs in key sectors of the GOCIF. ***Key changes to the PSA scores*** In recognition of the risk management strategies already implemented in the fishery, the score assigned to the *encounterability* attribute was downgraded from high (3) to medium (2). The ability to reduce this score further was limited by an absence of data on interaction rates and a limited capacity to monitor catch rates of non-target species in

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					real or near-real time. The above changes were done in accordance with *Guideline 2: additional scientific assessment & consultation* with additional consideration given to *Guideline 6: Management arrangements to mitigate against the level of bycatch.*
Dolphins *Australian humpback dolphin (S. sahulensis)*	*Age at sexual maturity (Productivity)*	GOCIF (N3, N12, N13)	3	2	Information on the biology and life-history constraints of the Australian humpback dolphin (*S. sahulensis*) is limited and the species was assigned a precautionary high (3) risk score for the *age at sexual maturity* attribute. Subsequent consultation on dolphin species that occur in Queensland waters and their biology indicated that the age at sexual maturity for this species would be less than 15 years (*pers. comm.* J. Meager). ***Key changes to the PSA scores*** Based on the advice provided, the preliminary score assigned to this attribute in the PSA was reduced from high (3) to medium (2). This amendment was done in accordance with *Guideline 2: additional scientific assessment & consultation*.
Dolphins *Australian humpback dolphin (S. sahulensis)*	*Size at sexual maturity (Productivity)*	GOCIF (N3, N12, N13)	3	2	In the PSA, the Australian humpback dolphin (*S. sahulensis*) was assigned a precautionary high (3) risk rating for *size at sexual maturity*. Subsequent consultation on the dolphin species that occur in Queensland waters and their biology indicated that the *size at sexual maturity* for this species would be ≤2 years (*pers. comm.* J. Meager). ***Key changes to the PSA scores*** Based on the advice provided, the preliminary score assigned to this attribute in the PSA was reduced from high (3) to medium (2). This amendment was done in accordance with *Guideline 2: additional scientific assessment & consultation*.
Dolphins	*Availability (Susceptibility)*	GOCIF (N3, N12, N13)	3	2	Distribution maps obtained through the *Species of National Environmental Significance* database (Department of the Environment and Energy, 2019b), did not include the common bottlenose (*T. truncatus*) or the Indo-Pacific bottlenose dolphin (*T. aduncus*).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Common bottlenose dolphin (T. truncatus) *Indo-Pacific dolphin (T. aduncus)*					Accordingly, these two species were assessed under the alternate criteria for the *availability* attribute: *Global distribution & stock proxy considerations*. When the bottlenose dolphins were assessed through these criteria, they were both allocated a precautionary high (3) risk rating for this attribute. While noting the high-risk rating and the justifications used, these values were considered an overestimate. This inference was supported by data on the global distribution and abundance of both species. To address this issue, distribution maps were sourced from the IUCN and the *availability* attribute recalculated for both species. As the IUCN maps are based at a global level, they provide limited information on the distribution of the species in Australian waters (Hammond *et al.*, 2012; Wells *et al.*, 2019). The maps though were considered to be more representative of the current situation (*verse* the alternate criteria). ***Key changes to the PSA scores*** Based on the revised assessments, the preliminary scores assigned to the *availability* attribute were downgraded from a high (3) to a medium (2) for *T. truncates* and *T. aduncus.* The above changes were done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Dolphins</u> *Common bottlenose dolphin (T. truncatus)*	*Encounterability (Susceptibility)*	GOCIF (N3, N12, N13)	3	2	Data on the common bottlenose dolphin (*T. truncatus*) indicates that the species is found in a wide range of environments (Hammond *et al.*, 2012; Wells *et al.*, 2019). From a PSA perspective, this broad habitat profile resulted in the species being assigned a high-risk score for the *encounterability* attribute. In Australia, the common bottlenose dolphin is more frequently observed in deeper water environments (>30m) (Allen *et al.*, 2016; Corkeron & Martin, 2004; Department of the

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Environment, 2019y; Hale *et al.*, 2000). A preference for deeper water environments combined with the estimated depth profile of the fishery (at present) indicates that operators in the GOCIF are more likely to encounter the Indo-Pacific bottlenose dolphin (*T. aduncus*). The Indo-Pacific bottlenose dolphin inhabits shallow coastal waters on the continental shelf, around islands, estuaries and reefs (Department of the Environment, 2019ab; Hale *et al.*, 2000). ***Key changes to the PSA scores*** Based on the available information, the preliminary score assigned to the *encounterability* attribute was reduced from high (3) to medium (2). This decision was largely based on the fact that the species prefers habitats that attract less net effort. It is recognised though that a) the distribution of the common bottlenose dolphin is not exclusively confined to water depths >30m as they can also be found in shallower waters, and b) a proportion of the gillnet effort will occur in environments with deeper water depths. Given these two factors, further reductions in the risk score assigned to this attribute were not considered. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.
Dolphins *False killer whale (P. crassidens)*	*Encounterability (Susceptibility)*	GOCIF (N3, N12, N13)	3	1	The false killer whale (*P. crassidens*) has been reported infrequently in the *Stranding and Mortality Database* and the species was included in the Level 2 ERA as a precautionary measure (*pers. comm.* J. Meager). There has been at least two interactions with this species in the GOCIF; both occurred in 2019 and resulted in the death of the animal. Distribution data for the false killer whale indicates that the species is widespread but occurs in low densities. As the species prefers deep offshore waters, the interaction or *encounterability* potential for this species is considered to be low when compared to

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					other species. It is recognised that false killer whales will occasionally be observed in shallow water environments (Baird, 2018; Baird, 2009; Department of the Environment, 2019v). At whole-of-fishery level, this does not appear to be a regular occurrence and frequent interactions with this species are unlikely in the GOCIF. While noting the two reports in 2019, interactions with this species are more likely to occur on the Queensland east coast. The Queensland east coast supports a much larger net fishery with effort dispersed across a larger section of the coastline. In an analogous ERA for the ECIF, the false killer whale was found to have a low (1) *encounterability* potential. This again was due to their preferred habitats and a low probability of the species encountering a state-based gill net. ***Key changes to the PSA scores*** Based on the known distribution and habitat preferences, encounters with the false killer whale will be low and infrequent. Considering the depth range, habitat preference and behavioural patterns of the species, the preliminary PSA score was considered to be too precautionary. Accordingly, scores assigned to this attribute were reduced from high (3) to low (1) as part of the RRA. Changes made as part of the RRA were done in accordance with *Guideline 3: at risk with spatial assumptions* and *Guideline 5: at risk in regards to level of interaction / capture with a zero or negligible level of susceptibility*.
<u>Dolphins</u> *Spinner dolphin (S. longirostris)*	*Encounterability (Susceptibility)*	GOCIF (N3, N12, N13)	3	1	The spinner dolphin (*S. longirostris*) was included in the Level 2 ERA on the back of advice provided during the species rationalisation process (*pers. comm*. J. Meager). The species has not been reported within the SOCI data or in a now ceased *Fisheries Observer Program*. However the species has been reported in Queensland managed waters of the Gulf of Carpentaria including within the Weipa region (*pers. comm.* J.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Meager). The decision to include the spinner dolphin in the Level 2 ERA was viewed as precautionary. While the spinner dolphin is considered to be a pelagic species, it has been observed in shallow water environments (Braulik & Reeves, 2018; Department of the Environment, 2019k). This was the partial catalyst for the species receiving a preliminary high (3) risk score for *encounterability*. While the species has been observed in shallower waters, estimates provided by the PSA were not commensurate with the current level of risk. The spinner dolphin, for the most part, is a pelagic species and it is more frequently observed in waters exceeding 200m (Department of the Environment, 2019k). The IUCN redlist assessment indicates that the species prefers tropical surface water that is characterised by a shallow mixed layer, a sharp thermocline and relatively small annual variations in surface temperatures (Braulik & Reeves, 2018). They often form large pods with the size of the pod generally increasing as you progress further away from the shoreline. In the Gulf of Carpentaria, the *encounterability* potential for this species is expected to be lower than what is portrayed by the preliminary PSA scores. ***Key changes to the PSA scores*** Based on the known distribution and habitat preferences, it is anticipated that the GOCIF will present as a lower risk with respect to the *encounterability* attribute. While the species has been observed in the Gulf of Carpentaria, habitat preferences suggest that a high proportion of the regional population resides outside of the prescribed fishing grounds. Considering the depth range, habitat preference and behavioural patterns of the species, the score assigned to this attribute in the PSA was considered too precautionary.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Accordingly, scores assigned to this attribute were reduced from high (3) to low (1) as part of the RRA. While noting the magnitude of this change, these amendments are unlikely to contribute to a false-negative result. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation, Guideline 3: at risk with spatial assumptions* and *Guideline 5: at risk in regards to level of interaction/capture with a zero or negligible level of susceptibility*.
Sharks *Speartooth shark (G. glyphis)*	*Age at sexual maturity (Productivity)*	GOCIF (N3, N12, N13)	3	2	There is limited information on the biology of the speartooth shark (*G. glyphis*) (Compagno *et al.*, 2009; Department of the Environment, 2015) and the species was assigned a precautionary high (3) risk score for this attribute. While not universal, research on the growth and development of sharks and rays indicate that a high proportion reach sexual maturity before 15 years (Cortés, 2000; Geraghty *et al.*, 2013; Jacobsen & Bennett, 2011). Based on this research, it is likely that the score assigned to this attribute is an overestimate; particularly since *G. glyphis* is found in the tropics and growth in these regions tends to be faster (when compared to species found in temperate waters). This inference was supported in subsequent discussions on the biology of this species where >5–15 years was nominated as the most likely age at sexual maturity (*pers. comm.* B. Wueringer, *Sharks and Rays Australia Research Organisation*). ***Key changes to the PSA scores*** The preliminary score assigned to the *age at sexual maturity* attribute was reduced from high (3) to medium (2). Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation.*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Sharks *Great hammerhead shark (S. mokarran)*	*Selectivity (Susceptibility)*	GOCIF (N3, N12, N13)	1	3	Criteria used to assign scores for the *selectivity* attribute are based on the size of the animal relative to size of the mesh. As the great hammerhead (*S. mokarran*) has a maximum total length of 6m the species was initially assessed as low risk (1) for this attribute. However, research has shown that morphology of the hammerhead shark cephalofoil makes them highly susceptible to net entanglements across a wide range of size classes (Harry *et al.*, 2011a; Tobin *et al.*, 2010). As a consequence, criteria used to evaluate the *selectivity* risk are less suited to this subgroup of species. ***Key changes to the PSA scores*** The preliminary score assigned to the *selectivity* attribute for the great hammerhead shark was increased from low (1) to high (3). These amendments were done in accordance with *Guideline 2: additional scientific assessment & consultation*.
Batoids *Kuhl's devilray (M. kuhlii*)	*Age at sexual maturity (Productivity)*	GOCIF (N3, N12, N13)	3	2	*Age at sexual maturity* for Kuhl's devilray (*M. kuhlii*) is not known and the species was assigned a precautionary high (3) score for this attribute. Known information on the *age at sexual maturity* for other mobula rays indicates that the complex reaches sexual maturity from 5–15 years. While species-specific data is lacking for the Kuhl's devilray, maturity estimates for other species were considered to be acceptable proxies. ***Key changes to the PSA scores*** The score assigned to this attribute was reduced from high (3) to medium (2). This amendment was primarily done in accordance with *Guideline 2: additional scientific assessment & consultation*.
Batoids	*Encounterability (Susceptibility)*	GOCIF (N3, N12, N13)	3	1–2	Data on the distribution of devilrays across northern Australia is limited and the group (as-a-whole) has some notable data deficiencies (*pers. comm.* P. Kyne).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Reef manta ray (M. alfredi) *Kuhl's devilray (M. kuhlii)*					Research suggests that the reef manta (*R. alfredi*) is more common on the Queensland east coast (Armstrong *et al.*, 2020) with aggregations observed at Lady Elliot Island, North Stradbroke Island, and off Byron Bay (Couturier *et al.*, 2011). In the Gulf of Carpentaria, the species is more likely to occur on eastern coast and in areas north of Weipa. Anecdotal evidence suggests that *M. alfredi*, while present, will have limited interactions with the GOCIF due to the size of the species and the habitat preferences (*pers. comm*. P. Kyne). For this reason, the preliminary score this species was considered an overestimate. Up until recently, the Kuhl's devilray was viewed as a south-east Asian species with a second species (*M. eregoodootenkee)* inhabiting Australian waters. A recent taxonomic review of the *Family Mobulidae* (White *et al.*, 2017b) revealed *M. eregoodootenkee* to be conspecific with *M. kuhlii*. While information on the distribution of *M. kuhlii* is limited, the species (including cf. *M. eregoodootenkee* reports) has been observed in the Gulf of Carpentaria and on the Queensland east coast (Atlas of Living Australia, 2017; 2020b; Broadhurst *et al.*, 2017). When compared to the reef manta, the *encounterability* potential for *M. Kuhlii* is expected to be the same or marginally higher. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute for both species was reduced. For the reef manta, the score was reduced from a high (3) to low (1). The Kuhl's devilray reduction was less with the score downgraded from high (3) to medium (2). These amendments were done in accordance with *Guideline 2: additional scientific assessment & consultation*. Scores assigned to this attribute may still overestimate the level of risk. The extent of any score reductions though was limited by data deficiencies.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Batoids *Reef manta ray (M. alfredi)*	*Post-capture mortality (Susceptibility)*	GOCIF (N3, N12, N13)	3	1	In the PSA, the reef manta (*M. alfredi*) was assigned a high-risk rating for *post-capture mortality* based on the assumption that the species will become entangled in the net. Due to their size, entanglements with the reef manta would be rarer and their morphology (disc widths much larger than their disc length) makes contact without capture events more likely (*pers. comm.* P. Kyne). ***Key Changes to the PSA scores*** Preliminary scores assigned to the *post-capture mortality* attribute for this species was reduced from high (3) to low (1).This change recognises the higher probability of contact without capture events and initiatives that restrict the entanglement potential *e.g.* mesh size restrictions. Both of these factors increase the likelihood of the animal surviving an interaction with a GOCIF net. These amendments were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 6: management arrangements to mitigate against the level of bycatch.*
Batoids *Kuhl's devilray (M. kuhlii)*	*Selectivity (Susceptibility)*	GOCIF (N3, N12, N13)	3	2	In the initial assessment, the Kuhl's devilray (*M. kuhlii*) was assigned a high-risk score (3) for the *selectivity* attribute. While noting this assessment, the risk of entanglement for this species will be lowered by their morphology (disc width approximately twice the size of the disc length) and the current mesh size restrictions (*pers. comm.* P. Kyne). ***Key changes to the PSA scores*** The preliminary score assigned to this attribute in the PSA was reduced from high (3) to medium (2). This amendment was primarily done in accordance with *Guideline 2: additional scientific assessment & consultation* (*pers. comm.* P. Kyne) and *Guideline 6: management arrangements to mitigate against the level of bycatch.* While this score may still represent a risk overestimate, further reductions in the score were not supported by the available information.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
<u>Batoids</u> *Kuhl's devilray (M. kuhlii)*	*Post-capture mortality (Susceptibility)*	GOCIF (N3, N12, N13)	3	2	In the PSA, the Kuhl's devilray (*M. kuhlii*) was assigned a high-risk score (3) for *post-capture mortality* based on the assumption that the species will become entangled in the net. Due to their morphology and mesh size restrictions, the devilray complex are less susceptible to net entanglements. This makes contact without capture events more likely (*pers. comm.* P. Kyne) and will improve post-interaction survival rates. ***Key changes to the PSA scores*** The preliminary score assigned to the *post-capture mortality* attribute was reduced from high (3) to medium (2).These changes were less severe when compared to the reef manta (*M. alfredi*). This differential is due to the fact that the Kuhl's devilray is smaller. These amendments were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 6: management arrangements to mitigate against the level of bycatch.*
<u>Batoids</u> *Largetooth sawfish (P. pristis)* *Green sawfish (P. zijsron)*	*Selectivity (Susceptibility)*	GOCIF (N3, N12, N13)	1	3	Criteria used to assign scores for the *selectivity* attribute are based on the size of the animal relative to size of the mesh. Based on these criteria, the PSA assessed the green (*P. zijsron*) and largetooth sawfish (*P. pristis*) as low (1) risk for this attribute with the narrow (*A. cuspidata*) and dwarf sawfish (*P. clavata*) assessed as high (3) risk. As sawfish poses a large, toothed rostrum, criteria used to assess net *selectivity* are less suited to this complex. The tooth rostrum increases the likelihood of an interaction ending in entanglement. This entanglement risk will apply across a wide range of size classes. ***Key changes to the PSA scores*** Risk scores for the large sawfish and green sawfish were increased from low (1) to high (3). These changes were done in accordance with *Guideline 1: rating due to missing,*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					incorrect or out of date information and *Guideline 2: additional scientific assessment & consultation (bycatch management workshop, Townsville, 14-15 May 2019*).
Batoids *Largetooth sawfish (P. pristis)* *Green sawfish (P. zijsron)* *Narrow sawfish (A. cuspidata)* *Dwarf sawfish (P. clavata)*	*Post-capture mortality (Susceptibility)*	GOCIF (N3, N12, N13)	3	3	There are no published reports on post-release survival rates for sawfish and there is limited information on *in-situ* (within net) survival rates (Ellis *et al.*, 2017). Discussions held at a bycatch management workshop for the *East Coast Inshore Fishery* (Townsville, 14-15 May 2019) suggest that animals will survive the initial enmeshment providing that the gills are not damaged or significantly impeded. Due to the shape and morphology of the rostrum, sawfish pose a potential hazard to the fisher and can be difficult to release. During this process the animal can become stressed and sustain injuries (internal and external) that increase the risk of post-release mortalities (Peverell, 2010). In more extreme events, the animal may be injured or killed in an attempt to preserve the gear or accelerate the extraction process. These factors introduce a degree of uncertainty surrounding the sawfish post-interaction mortality rates and contributed to the complex receiving higher scores for this attribute. Of note, a number of the above risk factors are predicated on the handling practices employed. With good handling practices, there is an increased chance that the animal will survive a fishing event. This inference though can only be confirmed with additional research and/or improved catch monitoring techniques. With additional information on the handling practices and survival success, these scores could be reduced in subsequent ERAs. ***Key changes to the PSA scores*** No change but it is an avenue where risk could be reduced with improved data collection and catch monitoring.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Batoids *Eyebrow wedgefish (R. palpebratus)* *Bottlenose wedgefish (R. australiae)*	*Age at sexual maturity (Productivity)*	GOCIF (N3, N12, N13)	3	2	There is limited information on the age and growth of *R. palpebratus* and *R. australiae* including on their *age at sexual maturity*. This was reflected in the high (3) preliminary scores assigned as part of the PSA. A limited study on the age and growth of a broader *Rhynchobatus* complex indicates that these two species grow to at least 12 years of age with males reaching maturity at an estimated 3–5 year (Rigby, 2019; Simpfendorfer *et al.*, 2019; White *et al.*, 2014). As this estimate is based on a multi-species, single-sex (male) sample, it is difficult to determine how these results translate to either species or to females. With that said, there is considerable evidence that most batoids will reach sexual maturity before 15 years of age; the cut off for a high-risk rating (Jacobsen & Bennett, 2011; Last *et al.*, 2016; Smith *et al.*, 2007; White *et al.*, 2014; White & Dharmadi, 2007; White *et al.*, 2006). ***Key changes to the PSA scores*** PSA scores assigned to the *age at sexual maturity* attribute were downgraded from high (3) to medium (2). Further reductions were not considered to be an option in this ERA given a) uncertainty surrounding the *age at sexual maturity* for females and b) an absence of species-specific data. With additional information the scores assigned to this attribute could be reduced further. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation*.
Batoids *Bottlenose wedgefish (R. australiae)*	*Availability (Susceptibility)*	GOCIF (N3, N12, N13)	3	2	Maps were not available for the eyebrow wedgefish (*R. palpebratus*) and the bottlenose wedgefish (*R. palpebratus*). This resulted in both species receiving high-risk ratings (3) as part of the initial PSA. In the RRA, these scores were refined and recalibrated using an alternate map from the IUCN (Kyne & Rigby, 2019; Kyne *et al.*, 2019b).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Eyebrow wedgefish (R. palpebratus)					***Key changes to the PSA scores*** The preliminary score assigned to this attribute in the PSA was decreased from high (3) to medium (2) based on the revised map assessment. These amendments were done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Batoids</u> *Estuary stingray (H. fluviorum)*	*Availability (Susceptibility)*	GOCIF (N3, N12, N13)	3	3	Distributional data for the estuary stingray (*H. fluviorum*) was incomplete and provided a fragmented account of its range in Australian waters. This resulted in the species being assessed as high risk under the alternate criteria for *availability* (Hobday *et al.*, 2007). In the RRA, *availability* was reassessed using IUCN species distribution maps (Kyne *et al.*, 2016) and the scores assigned to this attribute were revised using the percentage overlap criteria. ***Key changes to the PSA scores*** While use of the IUCN map provides a more accurate account of the *availability* risk, it did not alter the risk rating. As the species is more likely to be encountered in the N3 fishery, scores assigned to the *availability* attribute may still represent a risk overestimation. With additional information on fine-scale effort movements, the *availability* assessment could be refined further and the scores potentially reduced.
<u>Batoids</u> *Estuary stingray (H. fluviorum)*	*Encounterability (Susceptibility)*	GOCIF (N3, N12, N13)	3	2	While the estuary stingray is associated with mangrove swamps, estuarine and riverine systems (Last *et al.*, 2016), the species has been reported down to depths of 20m. This was reflected in the *encounterability* attribute where it was assigned a high (3) risk score. The GOCIF operates in a diverse range of inshore (<2m) and offshore (>2m) environments including in habitats where estuary stingrays are more likely to be encountered. However, the interaction potential for this species will not be uniform and it is unlikely to be encountered in N12 or N13 operations. The species is more likely to be

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					caught by fishers targeting key species in estuaries, riverine systems or nearshore waters with larger mangrove colonies. In the GOCIF, this means that the interaction potential will be higher in the N3 fishery where licence holders target barramundi, threadfin and other shallow-water species. As part of the RRA, consideration was given to a) the type of operations that are more likely to interact with the fishery and b) the prevalence of the estuary stingray interactions across the entire fishery. When these factors were considered in the context of the entire GOCIF, the score assigned this attribute was considered to be an overestimate. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute as part of the PSA was reduced from high (3) to medium (2). Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions.* The revised score may still represent on overestimate for this attribute. The extent of this score reduction though was limited by an absence of information on catch, discard and retention rates.

Appendix E—Supplementary risk assessment: Likelihood & Consequence Analysis

1. Overview & Background

The *Productivity & Susceptibility Analysis* (PSA) includes a number of elements to minimise the risk of a false-negative result or high-risk species being incorrectly assigned a lower risk rating. However, the PSA tends to be more conservative and research has shown that it has a higher potential to produce false positives. That is, low-risk species being assigned a higher risk score due to the conservative nature of the method, data deficiencies *etc*. (Hobday *et al.*, 2011; Hobday *et al.*, 2007; Zhou *et al.*, 2016). In the Level 2 Ecological Risk Assessment (ERA), false-positive results are primarily addressed through the *Residual Risk Analysis* (RRA) and the assignment of *precautionary* risk ratings.

To inform the assignment of *precautionary* risk ratings, each species was subjected to a *Likelihood & Consequence Analysis* (LCA). The LCA, in essence, provides a closer examination of the magnitude of the potential consequence and the probability (likelihood) that those consequences will occur given the current management controls (Fletcher, 2014; Fletcher *et al.*, 2002; Fletcher *et al.*, 2005). A flexible assessment method, the LCA can be used as a screening tool or to undertake more detailed risk assessments (Fletcher, 2014).

In the Level 2 ERA, a simplified version of the LCA was used to provide the risk profiles with further context and evaluate the applicability of the assessment to the current fishing environment. More specifically, the LCA was used to assist in the allocation of *precautionary* risk ratings which are assigned to species with more conservative risk profiles. The benefit of completing a fully qualitative assessment following a more data-intensive semi-quantitative assessment is the reduction of noise in the form of false-positives. This was considered to be of particular importance when identifying priority risks for this fishery.

As the LCA is qualitative and lacks the detail of the PSA, the outputs should not be viewed as an alternate or competing risk assessment. To avoid confusion, the results of the PSA/RRA will take precedence over the LCA. The LCA was only used to evaluate the potential of the risk coming to fruition over the short to medium term.

2. Methods

The LCA was constructed using a simplified version of the *National ESD Reporting Framework for Australian Fisheries* (Fletcher, 2014; Fletcher *et al.*, 2002; Fletcher *et al.*, 2005) and focused specifically on the *Risk Analysis* component. It is recognised that the *National ESD Reporting Framework* incorporates additional steps including ones that establish the context of the assessment and identifies key risks. As these steps were fulfilled with the completion of a Scoping Study (Department of Agriculture and Fisheries, 2019b) and whole-of-fishery (Level 1) assessment (Jacobsen *et al.*, 2019a), they were not replicated for the Level 2 ERA. For a more comprehensive overview of the *National ESD Reporting Framework for Australian Fisheries* consult Fletcher *et al.* (2002) and Fletcher (2014).

Risk Analysis considers a) the potential consequences of an issue, activity or event (Table E1) and b) the likelihood of a particularly adverse consequence occurring due to these activities or events (Table E2). Central to this is the establishment of a Likelihood *x* Consequence matrix that estimates the risk based on scores assigned to each component (Table E3).

Table E1. *Criteria used to assign scores to the Consequence component of the analysis.*

Level	Score	Definition
Negligible	0	Almost zero harvest / mortalities with impact unlikely to be detectable at the scale of the stock or regional population.
Minor	1	Assessed as low risk through the PSA and/or fishing activities will have minimal impact on regional stocks or populations.
Moderate	2	Assessed as a medium risk through the PSA and/or are harvest/mortalities levels at, near or approaching maximum yields.
Severe	3	Species assessed as high risk through the PSA and/or has harvest/mortalities levels that are impacting stocks and/or has high vulnerability and low resilience to harvest.
Major	4	Species assessed as high risk through the PSA and/or harvest levels/mortalities has the potential to cause serious impacts with a long recovery period required to return the stock or population to an acceptable level.

Table E2*. Criteria used to assign indicative scores of the likelihood that fishing activities in the Gulf of Carpentaria Inshore Fishery (GOCIF) will result in or make a significant contribution to a Severe or Major consequence.*

Level	Score	Definition
Likely	5	Expected to occur under the current fishing environment / management regime.
Occasional	4	Will probably occur or has a higher potential to occur under the current fishing environment / management regime.
Possible	3	Evidence to suggest it may occur under the current fishing environment / management regime.
Rare	2	May occur in exceptional circumstances.
Remote	1	Has never occurred but is not impossible.

Table E3*. Likelihood & Consequence Analysis risk matrix used to assign indicative risk ratings to each species: blue = negligible risk, green = low risk, orange = medium risk and red = high risk.*

		Consequence				
Likelihood		**Negligible**	**Minor**	**Moderate**	**Severe**	**Major**
		0	1	2	3	4
Remote	1	0	1	2	3	4
Rare	2	0	2	4	6	8
Possible	3	0	3	6	9	12
Occasional	4	0	4	8	12	16
Likely	5	0	5	10	15	20

For the consequence analysis (Table E2), criteria used to assign scores (0–4) were based on the outputs of the semi-quantitative assessment (*e.g.* PSA/RRA results outlined in section 4, Table 7). In the likelihood assessment (Table E1), scores reflect the likelihood of the fishery causing or making a significant contribution to the occurrence of the most hazardous consequence (Fletcher *et al.* 2002). Once scores are assigned to each aspect of the LCA, they are used to calculate an overall risk value (*Risk = Likelihood x Consequence*) for each species (Table E3).

As the Level 2 ERA uses the LCA as a supplementary assessment, risk scores and ratings were not linked to any operational objective; as per the *National ESD Reporting Framework* (Fletcher, 2014; Fletcher *et al.*, 2005). Instead, these issues are addressed directly as part of the Level 2 ERA through fisheries-specific recommendations. Criteria used to assign scores for likelihood and consequence are outlined in Table E1 and E2 respectively. The Likelihood *x* Consequence matrix used to assign risk ratings is provided as Table E3.

3. Results & Considerations

When compared to the PSA/RRA, the LCA produced lower risk estimates for species included in the Level 2 ERA. This was to be expected as the LCA gives greater consideration and equal weighting to the probability (likelihood) of a fishery contributing to or causing a severe or major event under the current conditions (catch, effort and interaction trends). In a number of instances, the outputs of the Level 2 ERA supported the assignment of *precautionary* risk ratings.

Marine turtles

The LCA assessed all six marine turtles as a medium risk. Scores for the loggerhead turtle (*C. caretta*) and the leatherback turtle (*D. coriacea*) were marginally lower and, based on their interaction potential, support the assignment of a *precautionary* risk rating. The situation surrounding the green (*C. mydas*), hawksbill (*E. imbricata*), flatback (*N. depressus*) and olive ridley (*L. olivacea*) turtle is more complicated as there is an increased potential for these species to interact with the fishery. While these scores may still be conservative, the decision was made to retain the original risk rating. This in part is due to the absence of a mechanism to effectively monitor catch rates in real or near-real time and uncertainty surrounding total interaction rates.

Dugong

The results of the LCA aligned with estimates obtained through the PSA/RRA (Table E4). These outputs suggest that the results are more representative of a real or actual risk *verse* a potential risk.

Cetaceans

The LCA for the cetacean complex largely reflects the population status and interaction potential of the species being assessed. Of the species included in the Level 2 ERA, the LCA supports the assignment of *precautionary* risk ratings to the common bottlenose dolphin (*T. truncatus*), the Indo-Pacific bottlenose dolphin (*T. aduncus*), the false killer whale (*P. crassidens*) and the spinner dolphin (*S. longirostris*). Conversely, the LCA supports retention of the original high-risk rating for the Australian humpback dolphin (*S. sahulensis*) and the Australian snubfin dolphin (*O. heinsohni*); the two species with the greatest population and distribution constraints (Table E4).

Sharks

The shark LCA mirrored that of the marine turtle complex, in that most of the risk estimates were lower than the PSA/RRA (Table E4). The notable difference between these two complexes is that three of the four species (hammerheads) can be retained for sale in the GOCIF.

When compared to the Queensland east coast, Maximum Sustainable Yield (MSY) estimates for the great hammerhead shark (*S. mokarran*), scalloped hammerhead shark (*S. lewini*) and winghead shark (*E. blochii*) are lower in the Gulf of Carpentaria. As these MSY estimates are conservative (Leigh, 2015), it is likely that all three species are being fished below key biomass reference points. There is however a degree of uncertainty surrounding catch compositions in this region and further information is required on individual rates of fishing mortality. Further, there is room within the current management regime for catch to increase for one or more of these species. This was considered to be of particular importance in the GOCIF as the fishery has reported historical catches >40t (Department of Agriculture and Fisheries, 2019b). These factors were reflected in the likelihood scores and contributed to the species receiving higher scores for the consequence component (Table E4).

The LCA for the speartooth shark (*G. glyphis*) aligns with the outputs of the PSA/RRA. The standing population for this species is relatively low and it has a highly contracted and potentially fragmented distribution (Department of the Environment, 2019p). For this species, the likelihood of the fishery contributing to a severe or major event is higher. This could occur at lower levels of fishing mortality.

Outputs of the LCA support the retention of the original risk rating for all three hammerhead sharks and the speartooth shark.

Batoids

The sawfish complex has experienced historic range contractions and the Gulf of Carpentaria is considered a key stronghold for these species. Evidence suggests that the GOCIF will interact with all four species, although the narrow sawfish (*A. cuspidata*) dominates the catch data (Department of Agriculture and Fisheries, 2019b). The conservation status of all four species and their interaction potential were reflected in the LCA with all four scoring high across both components (Table E4). There is a degree of uncertainty surrounding total interaction rates and there is (at present) limited capacity to validate catch data submitted through the logbook program. Due to these factors, the final risk ratings for sawfish were retained.

The LCA of the batoid risk assessment supported the assignment of *precautionary* risk ratings for most of the remaining species (Table E4). For devilrays, these results were intimately linked with the complex having low interaction rates and a smaller entanglement risk. When adopting a weight-of-evidence approach, the LCA lends support to the adoption of a *precautionary* risk rating for these species.

While shovelnose rays and guitarfish can be retained for sale in the GOCIF, the complex is managed under fairly stringent in-possession limits (*n* = 5 combined). These measures prevent the species being targeted in significant quantities or significant levels of effort being directed at the complex *e.g.* due to changing market demand. For this complex, the LCA supports the assignment of a *precautionary* risk rating (Table E4).

Outside of sawfish, the estuary stingray (*H. fluviorum*) was the only species to record an LCA value above low. The elevated score assigned to this species largely reflects data deficiencies and uncertainty surrounding the level of interaction this species has in the GOCIF. The species will interact with operations in the N3 fishery and it may be retained for sale as byproduct. The species though will derive some benefit from provisions that ban the use of commercial nets in key rivers and estuarine systems.

At a whole-of-fishery level, the final risk rating for the estuary risk is more likely to be *precautionary*. While the species has experienced range contractions, anecdotal evidence suggests that the species is more susceptible to external risks including habitat loss/degradation. For these reasons, outputs of the Level 2 ERA are considered to be more representative of the potential risk.

Table E4. *Results of the Likelihood & Consequence Analysis for species assessed as part of the GOCIF Level 2 ERA.*

Common name	Species name	Likelihood	Consequence	Matrix score	Risk category
Marine Turtles					
Green turtle	*Chelonia mydas*	3	3	9	Medium
Loggerhead turtle	*Caretta caretta*	2	3	6	Medium
Hawksbill turtle	*Eretmochelys imbricata*	2	3	9	Medium
Flatback turtle	*Natator depressus*	3	3	9	Medium
Olive ridley turtle	*Lepidochelys olivacea*	3	3	9	Medium
Leatherback turtle	*Dermochelys coriacea*	2	3	6	Medium
Sirenia					
Dugong	*Dugong dugon*	3	4	12	High
Dolphins					
Australian humpback dolphin	*Sousa sahulensis*	3	4	12	High
Australian snubfin dolphin	*Orcaella heinsohni*	3	4	12	High
Common bottlenose dolphin	*Tursiops truncatus*	1	3	3	Low
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	1	3	3	Low
False killer whale	*Pseudorca crassidens*	1	3	3	Low
Spinner dolphin	*Stenella longirostris*	1	3	3	Low
Sharks					
Great hammerhead	*Sphyrna mokarran*	2	3	6	Medium
Scalloped hammerhead	*Sphyrna lewini*	2	3	6	Medium
Winghead shark	*Eusphyra blochii*	2	3	6	Medium
Speartooth shark	*Glyphis glyphis*	4	4	16	High
Batoids					
Narrow sawfish	*Anoxypristis cuspidata*	3	4	12	High
Green sawfish	*Pristis zijsron*	4	4	16	High
Largetooth sawfish	*Pristis pristis*	4	4	16	High
Dwarf sawfish	*Pristis clavata*	4	4	16	High
Bottlenose wedgefish	*Rhynchobatus australiae*	1	3	3	Low
Eyebrow wedgefish	*Rhynchobatus palpebratus*	1	3	3	Low

Common name	Species name	Likelihood	Consequence	Matrix score	Risk category
Giant shovelnose ray	*Glaucostegus typus*	1	3	3	Low
Reef manta ray	*Mobula alfredi*	1	3	3	Low
Kuhl's devilray	*Mobula kuhlii*	2	3	6	Medium
Estuary stingray	*Hemitrygon fluviorum*	3	3	9	Medium

Appendix F—Summary of sawfish interactions with nets reported in the Gulf of Carpentaria

Data compiled through the SOCI logbook program on the number of sawfish interactions with nets used in the Gulf of Carpentaria. Data represents all of the sawfish-net interactions and may include interactions from the N3, N12/13 or N11 fisheries. Reports for the wide/smalltooth sawfish (*P. pectinata*) are likely the result of misidentification and/or the use of outdated taxonomic information. *2020 data incomplete.

Year	Dwarf sawfish (*P. clavata*)				Freshwater / Largetooth sawfish (*P. pristis*)				Green sawfish (*P. zijsron*)				Narrow sawfish (*A. cuspidata*)				Wide / Smalltooth sawfish (*P. pectinata*)				Unknown				Total			
	Total	**Alive**	**Injured**	**Dead**	**Total**	**Alive**	**Injured**	**Dead**	**Total**	**Alive**	**Injured**	**Dead**	**Total**	**Alive**	**Injured**	**Dead**	**Total**	**Alive**	**Injured**	**Dead**	**Total**	**Alive**	**Injured**	**Dead**	**Caught**	**Alive**	**Injured**	**Dead**
2003									4	3		1													4	3	0	1
2004					3	3		0	2	2		0	35	31	1	3									40	36	1	3
2005													23	18	1	4	1	0	0	1					24	18	1	5
2006																									0	0	0	0
2007					21	19		2																	21	19	0	2
2008	3	3			1	1		0					1	1	0	0	10	9	0	1					15	14	0	1
2009	5	5			12	11		1																	17	16	0	1
2010	3	3			11	11		0	2	2		0	2	2	0	0	3	3	0	0	106	106	0	0	127	127	0	0
2011					12	11		1					5	5	0	0									17	16	0	1
2012	19	19			2	2		0																	21	21	0	0
2013									19	19		0													19	19	0	0
2014	1	1			4	4		0																	5	5	0	0
2015	1	1																			6	6	0	0	7	7	0	0
2016									15	15		0	53	18	20	15	1	1	0	0					69	34	20	15
2017	8	8			2	1		1	2	1		1	9	8	1	0									21	18	1	2
2018	6	6			37	34	1	2	57	55	2	0	23	17	0	6									123	112	3	8
2019					11	8		3	44	42		2	56	37	12	7									111	87	12	12
2020*									1	1		0													1	1	0	0
Total	**46**	**46**	**0**	**0**	**116**	**105**	**1**	**10**	**146**	**140**	**2**	**4**	**207**	**137**	**35**	**35**	**15**	**13**	**0**	**2**	**112**	**112**	**0**	**0**	**642**	**553**	**38**	**51**