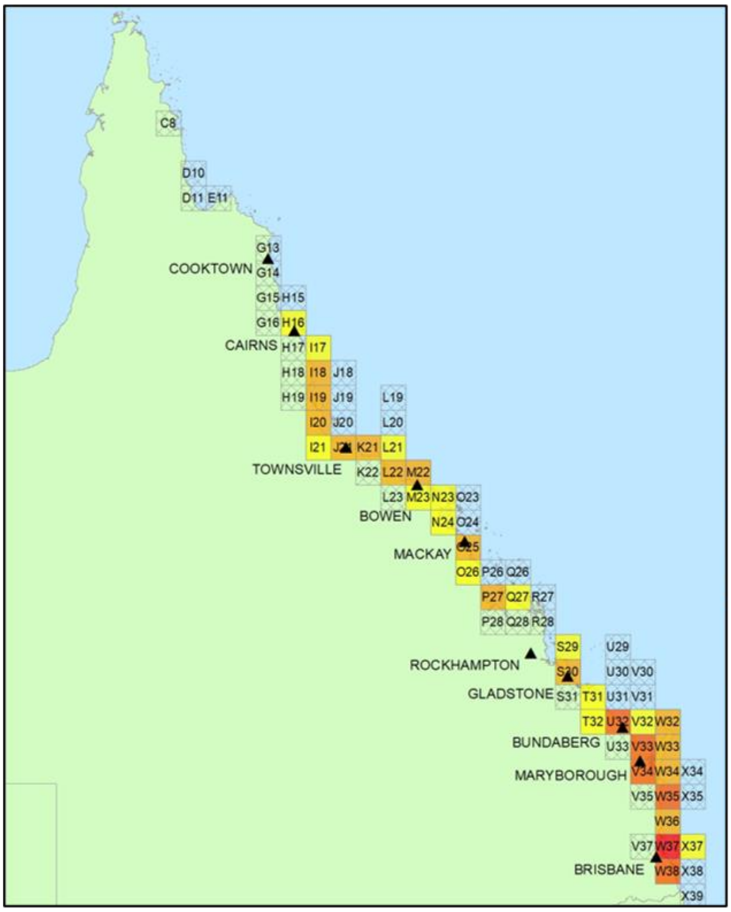
Department of Agriculture and Fisheries

Sustainable Fisheries Strategy
2017–2027

East Coast Inshore Large Mesh Net Fishery

Level 2 Ecological Risk Assessment

Species of Conservation Concern



Queensland Government

East Coast Inshore Fishery – Large Mesh Nets (Gillnets & Ring Nets)

Level 2 Ecological Risk Assessment

Species of Conservation Concern

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Executive Summary

In May 2019, a whole-of-fishery or Level 1 ERA was released for the *East Coast Inshore Fishery* (ECIF; Jacobsen *et al.*, 2019b). The Level 1 ERA provided a broad risk profile for the ECIF, 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 differentiate between low and high-risk elements and established a framework that can be built on 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.*, 2019b). Under the ERA Guidelines (Department of Agriculture and Fisheries, 2018a), 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). As the ECIF incorporates multiple sub-fisheries, this ERA will concentrate on the Large Mesh Net Fishery (gillnets and ring nets) and be followed by assessments involving the Tunnel Net and Ocean Beach Fisheries. While ECIF has a line fishery and a small mesh net (N11) fishery, catch, effort and (overall) risk levels for these sectors are smaller (Department of Agriculture and Fisheries, 2019c; Jacobsen *et al.*, 2019b). Therefore, they will not be assessed as part of the first iteration of the ECIF 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 maturity*, *maximum age*, *fecundity*, *maximum size*, *size at 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 SOCC Level 2 assessment was based on the outputs of the Level 1 ERA (Jacobsen *et al.*, 2019b) and considered the risks posed to marine turtles, dolphins, sharks, rays and dugongs. 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 32 species consisting of six marine turtles, seven dolphins, five sharks, 13 batoids (stingrays, wedgefish, guitarfish) and a single *Sirenia* (the dugong). The remaining 52 species were excluded from the analysis, as their geographical distribution did not overlap with the ECIF, 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 32 species were categorised as being at a medium (*n* = 8 species) or high (*n* = 24 species) risk from large mesh net fishing. 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 interspecies variability, although net *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.

Of the species classified as high risk, 14 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 SOCC Level 2 ERA.

For the remainder of the species (*n* = 10), the final rating is more representative of the risk posed by large mesh nets in the current fishing environment. They are viewed as higher priorities and the management of risk may require more formal arrangements *e.g.* bycatch mitigation strategies for non-target species, harvest strategies for the 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 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 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 the level of information on fine-scale effort movements, with particular emphasis on increasing our understanding of how large mesh nets are used in habitats critical to the survival of key species.*

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

3. *Improve the efficacy of mechanisms used to validate data submitted through the logbook program including information on the dynamics of the fishery (the type of gear being used, soak times etc.) and the number of SOCI interactions. As part of this process, it is recommended that reporting requirements be extended to include information on what fishing symbol is being used.*

4. *Provide a synthesis of habitat data and known distributions of key species in a format that is easily compared/overlayed with the footprint of large mesh net effort.*

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

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

7. *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 Species of Conservation Concern (SOCC) that interact with large mesh nets (gillnets & ring nets) in the East Coast Inshore Fishery.

Common name	**Species name**	**Productivity**	**Susceptibility**	***Risk Rating***
Marine turtles				
Green turtle	*Chelonia mydas*	2.29	2.50	High
Loggerhead turtle	*Caretta caretta*	2.43	2.50	High
Hawksbill turtle	*Eretmochelys imbricata*	2.29	2.50	High
Flatback turtle	*Natator depressus*	2.43	2.00	Medium
Olive Ridley turtle	*Lepidochelys olivacea*	2.14	2.00	Precautionary Medium
Leatherback turtle	*Dermochelys coriacea*	2.43	2.00	Precautionary Medium
Sirenia				
Dugong	*Dugong dugon*	2.71	2.50	High
Dolphins				
Australian humpback dolphin	*Sousa sahulensis*	2.57	2.75	High
Australian snubfin dolphin	*Orcaella heinsohni*	2.57	3.00	High
Common bottlenose dolphin	*Tursiops truncatus*	2.86	2.25	Precautionary High
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	2.71	2.50	Precautionary High
Short-beaked common dolphin	*Delphinus delphis*	2.43	2.00	Precautionary Medium
False killer whale	*Pseudorca crassidens*	2.86	1.50	Precautionary High
Spinner dolphin	*Stenella longirostris*	2.43	2.00	Precautionary Medium
Sharks				
Great hammerhead	*Sphyrna mokarran*	2.86	2.50	High
Scalloped hammerhead	*Sphyrna lewini*	2.86	2.50	High
Winghead shark	*Eusphyra blochii*	2.43	2.50	Precautionary High
Smooth hammerhead	*Sphyrna zygaena*	2.71	2.00	Precautionary High
Speartooth shark	*Glyphis glyphis*	2.43	2.25	Precautionary High
Batoids				
Narrow sawfish	*Anoxypristis cuspidata*	2.57	2.50	High
Green sawfish	*Pristis zijsron*	2.86	2.75	High
Largetooth sawfish	*Pristis pristis*	2.86	2.25	Precautionary High
Dwarf sawfish	*Pristis clavata*	2.86	2.00	Precautionary High
Bottlenose wedgefish	*Rhynchobatus australiae*	2.57	2.75	Precautionary High

Common name	Species name	Productivity	Susceptibility	*Risk Rating*
Eyebrow wedgefish	*Rhynchobatus palpebratus*	2.57	2.75	Precautionary High
Giant shovelnose ray	*Glaucostegus typus*	2.43	2.75	Precautionary High
Giant manta ray	*Mobula birostris*	2.86	1.00	Precautionary Medium
Reef manta ray	*Mobula alfredi*	2.86	1.50	Precautionary High
Kuhl's devilray	*Mobula kuhlii*	2.57	2.25	Precautionary High
Giant devilray	*Mobula mobular*	2.71	1.50	Precautionary Medium
Bentfin devilray	*Mobula thurstoni*	2.43	2.00	Precautionary Medium
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.
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 more of a concern as the impacts/consequences can be more significant.
GBRMP	–	Great Barrier Reef Marine Park.
GBRMPA	–	Great Barrier Reef Marine Park Authority.
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 N1, N2 and N4 fishery symbols including anchored and drifting gillnets. For the purpose of this ERA, the definition of

gillnets does not include ring net operations which are considered as a separate entity, seine nets used in the Ocean Beach Fishery (K1–K8 fishery symbols), the Tunnel Net Fishery (N10 fishery symbol) or small mesh net fishing activities under the N11 fishery symbol.

Large Mesh Nets	–	Nets permitted for use under the N1, N2 and N4 fishery symbol. Does not include small mesh nets permitted for use under the N11 fishing symbol, the Tunnel Net Fishery (N10) and seine nets used in the Ocean Beach Fishery (K1–K8 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.
Ring net	–	Defined in accordance with section 8 of the *Fisheries (General) Regulations 2019* as a large mesh net shot in a way that allows it to encircle the fish being targeted. Ring nets are deployed and retrieved in open water (*i.e.* not from the shore) and does not include seine nets used in the Ocean Beach Fishery which are deployed in an arc from the shoreline.
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 are 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.
SCP	–	Shark Control Program.
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.
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-needs basis and these assessments have often employed alternate methodologies (Department of Agriculture and Fisheries, 2019d). This process has now been formalised as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (the Strategy) and risk assessments are being completed for priority fisheries (Department of Agriculture and Fisheries, 2018a). Once completed, the ERAs will inform a range of Strategy initiatives including the development of harvest strategies, identifying key research needs and implementing detailed bycatch mitigation strategies (Department of Agriculture and Fisheries, 2018a; b; e; 2020b).

In May 2019, a whole-of-fishery or Level 1 ERA was released for the *East Coast Inshore Fishery* (ECIF; Jacobsen *et al.*, 2019b). 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, 2018a).

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, 2018a; 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, 2018a), species with ongoing conservation concerns, including those classified as Threatened, Endangered and Protected (TEP), were prioritised for Level 2 assessment (referred to herein as *Species of Conservation Concern* or SOCC). The primary aim of the Level 2 ERA is to identify the key drivers of risk for individual species and provide further advice on how key aspects of the ECIF may affect their long-term conservation status. In doing so, the Level 2 ERA will inform discussions surrounding the development of harvest strategies for target species and assist in the development of bycatch management plans for non-target species.

In this initial assessment phase, the primary focus will be on the risk posed by large mesh nets. Large mesh nets (gillnets[1] and ring nets) account for most of the reported ECIF catch and effort and they are viewed as the main driver of risk for the SOCC (Department of Agriculture and Fisheries, 2019c;

[1] For the purpose of this ERA, the term gillnet includes general mesh nets, set mesh nets, nets that are not fixed nor hauled including anchored gillnets and drifting gillnets. It does not include tunnel nets (N10 fishery symbol) and/or beach seine nets used in the Ocean Beach Fishery under the K1–K8 fishery symbols.

Jacobsen *et al.*, 2019b). The Large Mesh Net Fishery SOCC Level 2 ERA will be followed by analogous assessments examining the risk posed by operations in the Tunnel Net and Ocean Beach Fisheries. These two sub-fisheries interact with fewer SOCC, utilise different apparatus and operate under different management regimes (Jacobsen *et al.*, 2019b). As a consequence, risk profiles for the Tunnel Net and Ocean Beach Fisheries will be more nuanced and regionally specific. While ECIF has a line fishery and a small mesh net (N11) fishery, catch, effort and (overall) risk levels for these sub-fisheries are smaller. Therefore they will not be assessed as part of the first iteration of the ECIF SOCC Level 2 ERA (Department of Agriculture and Fisheries, 2019c; Jacobsen *et al.*, 2019b).

2 Methods

2.1 The Fishery

The ECIF is one of the more complex commercial fisheries operating on the Queensland east coast. The management system incorporates multiple fishing symbols and the fishery operates across a wide range of habitats and water depths. Despite this variability, the fishery has historically been assessed and monitored as a single entity for *Wildlife Trade Operation* (WTO) approvals, annual fisheries summaries *etc.* (Department of Agriculture and Fisheries, 2018d; 2019c; Department of Environment and Energy, 2019). Even so, the ECIF can be subdivided into a number of informal sub-fisheries based on the apparatus being used: large mesh nets (general purpose mesh nets, set mesh nets and ring nets), tunnel nets, the ocean beach fishery, small mesh nets and a line fishery (Department of Agriculture and Fisheries, 2019c).

In Queensland, large mesh nets are mostly used by fishers operating under the N1,[2] N2 or N4 fishery symbols (Department of Agriculture and Fisheries, 2019c). Management of these fishing activities include a mixture of input and output controls; although the majority of species are not subject to species-specific quotas or Total Allowable Commercial Catch (TACC) limits. Some of the more notable exceptions being black jewfish (*Protonibea diacanthus*), grey mackerel (*Scomberomorus semifasciatus*), spotted mackerel (*S. munroi*), tailor (*Pomatomus saltatrix*) and the shark complex (Department of Agriculture and Fisheries, 2019c).

The management regime for the entire ECIF 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 establishing an *East Coast Inshore Protected Species Management Strategy* (Department of Agriculture and Fisheries, 2019a). This review is ongoing and a number of the alternative strategies are still in development, have yet to be adopted and/or fully implemented. For these reasons, the Large Mesh Net 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 and, when and where appropriate, will be given further consideration as part of this assessment. It is noted though that these

[2] While they are separate symbols with their own regulations, fishers with a N2 or K1–K8 symbol are permitted use of any net described under the N1 fishery symbol. These provision also apply to the N4 symbol but exclude set pock nets, prawn seine nets and Noosa Lakes mesh nets (Department of Agriculture and Fisheries, 2019c).

impacts or cumulative risks involve a wider range of stakeholders and are difficult to address through a fisheries management framework. Accordingly, cumulative risk comparisons will only be used to provide further context on the extent of the risk posed by commercial fishing activities to key species or species complexes.[3]

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 *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 *Fisheries Monitoring Program* (FMP)[4] and the *Statewide Recreational Fishing Survey* (Department of Agriculture and Fisheries, 2020a; 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 *Large Mesh Net SOCC Level 2 ERA* was determined by the outcomes of the whole-of-fishery (Level 1) assessment (Jacobsen *et al.*, 2019b). 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 SOCC Level 2 ERA. The remaining ecological components (target & byproduct species and bycatch) will be assessed in subsequent ERAs.

In Queensland, the list of *Species of Conservation Interest* formed the basis of the 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*

[3] *A number of the species caught in the ECIF 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 consideration as part of the ECIF Target & Byproduct Species Level 2 ERA.*

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

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 was collectively referred to as the *Species of Conservation Concern* or SOCC. This classification aligns with the Level 1 ERA (Jacobsen *et al.*, 2019b) 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 ECIF, a final review was undertaken to ensure that all SOCC included in the analysis were relevant to this fishery. Where possible, the species rationalisation process was done in consultation with key stakeholders including Fisheries Working Groups established under the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017).

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 East Coast Inshore Fishery.*

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 ECIF, a number of shark species will be assessed as part of the ECIF 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 ECIF, the ability to determine the gear-affected area is limited by the complexity of the fishery. Unlike other commercial fisheries, operators can access the ECIF using a variety of net fishing symbols (Department of Agriculture and Fisheries, 2019c). While legislative provisions governing the use of the net symbols are similar, there are key differences in terms of the maximum net length permitted for use under each symbol and the minimum or maximum mesh size (Department of Agriculture and Fisheries, 2019c). Net operators on the Queensland east coast are also permitted to use more than one net provided that the total net length does not exceed that permitted under each symbol or within a particular region (Department of Agriculture and Fisheries, 2019c). This is considered to be of some importance as the number of nets being used, their configuration, the use of a back-net, the distance between each net and the extent of any overlap will all influence the gear-affected area.

In addition to the management nuances, there is a degree of uncertainty surrounding the type and configuration of nets used in the fishery. In the ECIF, commercial fishers are only required to submit information on the mesh size, total net length (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. Consequently, there is limited information on the configurations used by individual operators, how this effects the probability of an animal encountering the net (Zhou *et al.*, 2008) and how it might vary across the fishery. This complexity introduces a level of uncertainty surrounding the gear-affected area and makes it difficult to assess the accuracy of any estimate.

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 Large Mesh Net SOCC Level 2 ERA. This decision aligns with a corresponding assessment involving key target and byproduct species (Pidd *et al.*, 2021); meaning the entire Large Mesh Net Fishery will be assessed under a single methodology. 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 assessed using the 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 Large Mesh Net 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 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 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 initially 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 ECIF is comparable to a Commonwealth managed shark gillnet fishery (Australian Fisheries Management Authority, 2018a), the same criteria were applied to large mesh net operations in the ECIF (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.

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: < than 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.

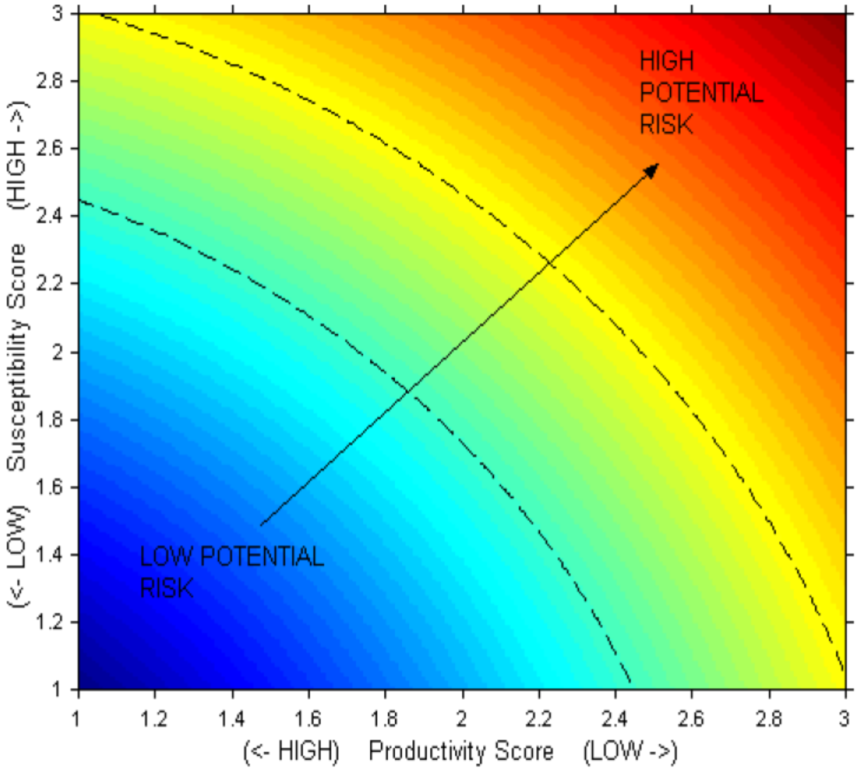

Figure 1. *PSA plot demonstrating the two-dimensional space which species units are plotted. PSA scores for species units represent the Euclidean distance or the distance between the origin and the productivity (x axis), susceptibility (y axis) intercept (excerpt from Hobday. et al., 2007).*

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, 2018e).

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 subjected 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, 2018a) 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, 2018a).

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 *Queensland Sustainable Fisheries Strategy 2017–2027* including *Fisheries Working Groups* and the *Sustainable Fisheries Expert Panel*.
Guideline 3*: At risk with spatial assumptions.*	Provides further consideration to the spatial distribution data, habitat data and any assumptions underpinning the assessment.

Guidelines	Summary
***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.

2.5 Consultation & Review

The Level 2 ERA framework includes a number of feedback loops that are used to refine the scope of the assessment and the accuracy of species-specific risk profiles. This includes *Fisheries Working Groups* established as part of the *Queensland Sustainable Fisheries Strategy 2017–2027*, *East Coast Inshore Bycatch Management Strategy Workshops,* the *Sustainable Fisheries Expert Panel* and (when and where appropriate) targeted consultation with key stakeholders. All consultation is done in accordance with the *Queensland Ecological Risk Assessment Guidelines* (Department of Agriculture and Fisheries, 2018a).

3 Results

3.1 PSA

Cross-referencing the expanded SOCC list (*n* = 84 species) with the ECIF effort footprint produced a list of 32 species with the potential to interact with large mesh nets. Of those species identified for inclusion in the Large Mesh Net Fishery SOCC Level 2 ERA, batoids (stingrays, devilrays, guitarfish etc.) had the highest representation with 13 species, followed by dolphins (*n* = 7 species), marine turtles (*n* = 6 species), sharks (*n* = 5 species) and dugong (Appendix A).

Based on the prescribed criteria, all of the SOCC had *productivity* scores higher than 2.00 (*average* = 2.63; *range* = 2.14–2.86). The estuary stingray (2.14) had the lowest *productivity* score and 10 species registered an assessment-high score of 2.86 (Table 5). Of the six *productivity* attributes assessed, *fecundity* (*average* =3.00) and *reproductive strategy* (*average* = 2.81) were assigned the highest overall scores. Conversely, *age at maturity* and *size at maturity* had the lowest average *productivity* score at 2.19 and 2.25 respectively (Table 5).

In the *susceptibility* analysis, all of the SOCC registered scores of between 2.00 and 3.00 at an average of 2.56 (Table 5). Six species, three dolphins and three batoids, were assigned the maximum score for all four *susceptibility* attributes. Two attributes, *encounterability* and *post-capture mortality* had an average score of 3.00. *Availability* showed the highest degree of variability, registering an average score of 1.65 across all of the species assessed (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 maturity**	**Maximum age**	**Fecundity**	**Maximum size**	**Size at 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	1	3	3	3	2.50	**3.39**
Loggerhead turtle	*Caretta caretta*	3	3	3	1	2	2	3	2.43	1	3	3	3	2.50	**3.49**
Hawksbill turtle	*Eretmochelys imbricata*	3	3	3	1	2	2	2	2.29	1	3	3	3	2.50	**3.39**
Flatback turtle	*Natator depressus*	3	3	3	1	2	2	3	2.43	1	3	3	3	2.50	**3.49**
Olive Ridley turtle	*Lepidochelys olivacea*	2	3	3	1	2	2	3	2.29	1	3	3	3	2.50	**3.39**
Leatherback turtle	*Dermochelys coriacea*	3	3	3	2	2	2	3	2.57	1	3	3	3	2.50	**3.59**
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	2	3	3	3	2.75	**3.97**
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**

Common name	Species name	Age at maturity	Maximum age	Fecundity	Maximum size	Size at 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	3*	3	3	3	3.00	**4.05**
Short-beaked common dolphin	*Delphinus delphis*	2	2	3	2	2	3	3	2.43	1	3	3	3	2.50	**3.49**
False killer whale	*Pseudorca crassidens*	2	3	3*	3	3	3	3	2.86	1	3	1	3	2.00	**3.49**
Spinner dolphin	*Stenella longirostris*	2	2	3	2	2	3	3	2.43	1	3	3	3	2.50	**3.49**
Sharks															
Speartooth shark	*Glyphis glyphis*	3*	3*	3*	2	2	3	2	2.57	1	3	3	3*	2.50	**3.59**
Great hammerhead	*Sphyrna mokarran*	2	3	3	3	3	3	3	2.86	1	3	1	3	2.00	**3.49**
Scalloped hammerhead	*Sphyrna lewini*	2	3	3	3	3	3	3	2.86	1	3	3	3	2.50	**3.80**
Winghead shark	*Eusphyra blochii*	2	2	3	2	2	3	3	2.43	2	3	3	3	2.75	**3.67**
Smooth hammerhead	*Sphyrna zygaena*	2	2	3	3	3	3	3	2.71	1	3	3	3	2.50	**3.69**
Batoids															
Giant manta ray	*Mobula birostris*	2	3*	3	3	3	3	3	2.86	1	3	1	3*	2.00	**3.49**
Reef manta ray	*Mobula alfredi*	2	3*	3	3	3	3	3*	2.86	2	3	1	3*	2.25	**3.64**
Kuhl's devilray	*Mobula kuhlii* (synonym, *M. eregoodootenkee* or *eregoodoo*)[5]	3*	3*	3	2	2	3	3	2.71	2	3	3	3*	2.75	**3.86**

[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)*

Common name	Species name	Age at maturity	Maximum age	Fecundity	Maximum size	Size at maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Susceptibility	*PSA score*
Giant devilray	*Mobula mobular* (synonym, *M. japanica*)	2	2	3	3	3	3	3	2.71	2	3	1	3*	2.25	**3.53**
Bentfin devilray	*Mobula thurstoni*	3*	3*	3	2	2	3	2	2.57	1	3	3	3*	2.50	**3.59**
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	1	3	3	3*	2.50	**3.59**
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	1	3	3	3*	2.50	**3.80**
Bottlenose wedgefish	*Rhynchobatus australiae*	3*	3*	3*	2	2	3	3	2.71	2	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	3*	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**

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).

When the *productivity* and *susceptibility* scores were taken into consideration, dugongs were assigned the highest preliminary risk score (3.86), followed by dolphins (*average* = 3.79), batoids (*average* = 3.71) and sharks (*average* = 3.65). Based on these results all 32 species were assigned preliminary PSA scores in the high-risk category (Table 5).

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 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 maturity* attributes (Table 6). While the *fecundity* attribute had the largest number of precautionary high (3) scores, all but one 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 maturity* and *maximum age* had a larger influence on the preliminary risk scores (Table 6). This was particularly evident in assessments involving the shark and ray species. 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, wedgefish and the estuary stingray where *availability* was assessed using the alternate criteria (Table 3). *Post-capture mortality* estimates were available for the four hammerhead shark species (*Sphyrna* spp. & *E. blochii*) and there was sufficient evidence to support the allocation of a high (3) risk rating for all air breathing species. The remaining 12 species were assigned a precautionary risk rating in the absence of additional information (Table 5 & 6).

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 maturity**	**Reproductive strategy**	**Trophic level**	**Availability**	**Encounterability**	**Selectivity**	**Post-capture mortality**
Species with data	26	25	23	32	30	32	28	27	32	32	20
Species with missing attribute data	6	7	9	0	2	0	4	5	0	0	12
% Unknown Information	19%	22%	28%	0%	6%	0%	13%	16%	0%	0%	38%

3.3 Residual Risk Analysis

The Large Mesh Net 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 account for 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.

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.

All changes to the *susceptibility* component of the marine turtle PSA were confined to the *encounterability* attribute (Table 7). Research indicates that flatback, olive ridley and leatherback turtles prefer deeper waters and, based on the current distribution of net effort, will be less frequently encountered in this sector of the ECIF (pers. comm. C. Limpus; Department of Agriculture and Fisheries, 2019c; Department of the Environment, 2019ab; c; d). Accordingly, scores assigned to the *encounterability* attribute were reduced from a 3 to a 1 (Appendix D). Green, loggerhead and hawksbill turtles make up the majority of interactions reported with nets and the *susceptibility* scores for these three species were retained (Table 7; Appendix E).

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 maturity	Maximum age	Fecundity	Maximum size	Size at 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	1	3	3	3	2.50	**3.39**
Loggerhead turtle	*Caretta caretta*	3	3	2	2	2	2	3	2.43	1	3	3	3	2.50	**3.49**
Hawksbill turtle	*Eretmochelys imbricata*	3	3	3	1	2	2	2	2.29	1	3	3	3	2.50	**3.39**
Flatback turtle	*Natator depressus*	3	3	3	1	2	2	3	2.43	1	1	3	3	2.00	**3.15**
Olive Ridley turtle	*Lepidochelys olivacea*	2	3	2	1	2	2	3	2.14	1	1	3	3	2.00	**2.93**
Leatherback turtle	*Dermochelys coriacea*	3	3	2	2	2	2	3	2.43	1	1	3	3	2.00	**3.15**
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	2.57	2	3	3	3	2.75	**3.76**
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	1	2	3	3	2.25	**3.64**
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	2	3	3	2	3	3	3	2.71	1	3	3	3	2.50	**3.69**
Short-beaked common dolphin	*Delphinus delphis*	2	2	3	2	2	3	3	2.43	1	1	3	3	2.00	**3.15**

Common name	Species name	Age at maturity	Maximum age	Fecundity	Maximum size	Size at maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Susceptibility	*PSA score*
False killer whale	*Pseudorca crassidens*	2	3	3	3	3	3	3	2.86	1	1	1	3	1.50	**3.23**
Spinner dolphin	*Stenella longirostris*	2	2	3	2	2	3	3	2.43	1	1	3	3	2.00	**3.15**
Sharks															
Speartooth shark	*Glyphis glyphis*	2	3	3	2	2	3	2	2.43	1	2	3	3	2.25	**3.31**
Great hammerhead	*Sphyrna mokarran*	2	3	3	3	3	3	3	2.86	1	3	3	3	2.50	**3.80**
Scalloped hammerhead	*Sphyrna lewini*	2	3	3	3	3	3	3	2.86	1	3	3	3	2.50	**3.80**
Winghead shark	*Eusphyra blochii*	2	2	3	2	2	3	3	2.43	1	3	3	3	2.50	**3.49**
Smooth hammerhead	*Sphyrna zygaena*	2	2	3	3	3	3	3	2.71	1	1	3	3	2.00	**3.37**
Batoids															
Giant manta ray	*Mobula birostris*	2	3	3	3	3	3	3	2.86	1	1	1	1	1.00	**3.10**
Reef manta ray	*Mobula alfredi*	2	3	3	3	3	3	3	2.86	2	2	1	1	1.50	**3.23**
Kuhl's devilray	*Mobula kuhlii* (synonym, *M. eregoodootenkee* or *eregoodoo*)[6]	2	3	3	2	2	3	3	2.57	2	3	2	2	2.25	**3.42**
Giant devilray	*Mobula mobular* (synonym, *M. japanica*)	2	2	3	3	3	3	3	2.71	2	2	1	1	1.50	**3.10**

[6] *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 maturity	Maximum age	Fecundity	Maximum size	Size at maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Susceptibility	*PSA score*
Bentfin devilray	*Mobula thurstoni*	2	3	3	2	2	3	2	2.43	1	3	2	2	2.00	**3.15**
Largetooth sawfish	*Pristis pristis*	2	3	3	3	3	3	3	2.86	2	1	3	3	2.25	**3.64**
Narrow sawfish	*Anoxypristis cuspidata*	1	2	3	3	3	3	3	2.57	1	3	3	3	2.50	**3.59**
Green sawfish	*Pristis zijsron*	2	3	3	3	3	3	3	2.86	2	3	3	3	2.75	**3.97**
Dwarf sawfish	*Pristis clavata*	2	3	3	3	3	3	3	2.86	1	1	3	3	2.00	**3.49**
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**

As a result of the above changes, the risk profiles of the flatback turtle, olive ridley turtle and leatherback turtle were reduced from high to medium risk (Table 7).

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, 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 seven of the eight 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 viewed as 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 *availability* attribute for each species (Table 7; Appendix D).

With dolphins being observed across a wide range of habitats and bathymetries, the majority were assigned the highest score for *encounterability* (Table 5). Further consultation and review of the available data revealed that the false killer whale, the short-beaked common dolphin, and the spinner dolphin are found more readily in pelagic environments and in some instances are considered to be 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).

The *encounterability* score for a fourth species, the common bottlenose dolphin, was reduced under similar circumstances. In Australia, the common bottlenose dolphin is more frequently observed in deeper water environments (>30 m) (Allen *et al.*, 2016; Corkeron & Martin, 2004; Department of the Environment, 2019ae; Hale *et al.*, 2000) where effort levels tend to be lower.[7] When compared, the fishery is more likely to encounter the Indo-Pacific bottlenose dolphin and interact with this species across a wider section of the ECIF. It is recognised though that the common bottlenose dolphin is found in waters <30m deep and the interaction potential for this species is higher than the false killer whale, short-beaked common dolphin, and the spinner dolphin. This limited the extent of the reductions applied to this species as part of the RRA (Appendix D).

The RRA resulted in changes to the preliminary risk ratings of two species: the short-beaked common dolphin (high to medium) and the spinner dolphin (high to medium). In the remaining species, risk score reductions were not sufficient to drop the species below the threshold for a high-risk rating. At 3.23, the false killer whale had the closest risk score to 3.18 threshold required for a medium-risk

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[7] *Qfish: http://qfish.fisheries.qld.gov.au/query/19a9bfad-0d3b-4313-924d-49a8faf818d3/map*

rating (Table 7). With improved information on interaction rates, the false killer whale will more than likely fall within the medium-risk category (Fig. 1).

3.3.3 Dugongs

Large mesh nets operate in a wide range of habitats and water depths including those preferred by dugongs. In the PSA, this was reflected in the score assigned to the *encounterability* attribute (Table 5). While noting this assessment, there are a number of management arrangements already in place on the Queensland east coast that provide dugongs with additional protection from net fishing activities. Examples of which include the use of Dugong Protection Areas (DPAs) and a prohibition on commercial net fishing within sections of the Great Barrier Reef, Moreton Bay and Great Sandy marine parks. As these factors are not easily accounted for in the PSA, 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 two amendments being made to the preliminary risk scores for the speartooth shark. In the PSA, the *age at maturity* attribute was assigned a precautionary high (3) risk rating due to data deficiencies. This score was downgraded to medium (2) on the back of further scientific advice (Appendix D). The second amendment involved the *encounterability* attribute and a risk score reduction from high (3) to medium (2) (Table 7). This amendment recognised that while the ECIF operates in habitats and bathymetries preferred by this species, effort within the confirmed geographical range is limited. This combined with the rareness of the species on the Queensland east coast reduces the risk of an operator encountering this species (Appendix D). These two changes facilitated a downgrading of the overall risk score but did not alter the final risk rating (Table 7).

Outside of the speartooth shark, one amendment was made to the risk profiles of both the great hammerhead shark, the smooth hammerhead shark and the winghead shark (Table 7). In the PSA, body size was used as the primary determinant for scores assigned to the *selectivity* attribute (Table 3). 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.*, 2011b). Due to this increased *susceptibility*, the *selectivity* score for the great hammerhead shark was increased from low to high (Appendix D). For the smooth hammerhead shark, the *encounterability* score was reduced as the frequency and extent of interactions with this species will be lower than the three remaining species (Appendix D). In the winghead shark risk profile, improved data on the distribution of this species in Queensland allowed for refinements to be made to the *availability* attribute (Table 7, Appendix D). In all three instances, changes made as part of the RRA did not alter the final risk ratings (Table 7).

3.3.5 Batoids

All amendments to the *productivity* scores for batoids involved the *age at 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.

When compared to the *productivity* assessment, the RRA of the *susceptibility* component was more complex. In the devilray complex, the changes involved the giant manta ray, reef manta ray and the giant devilray. All three species have broad habitat descriptors and received higher risk scores for the *encounterability* attribute (Table 5). However, evidence suggests that giant manta ray is a deeper water species (*pers. comm*. C. Simpfendorfer, P. Kyne) with behavioural and migration analyses indicating that the reef manta aggregates in areas less conducive to net fishing activities. While these factors will not prevent the species from being caught in the fishery, they reduce the *encounterability* risk (Table 7, Appendix D). Outside of the *encounterability* attribute, *availability* scores for the Kuhl's devilray were revised with additional information on their distribution in Australian waters. Preliminary scores for the *post-capture mortality* and *selectivity* attribute were also lowered to account for the fact that entanglements are less likely in this subgroup due to a) their morphology and b) maximum mesh size restrictions imposed on the fishery (Table 7).

In addition to the devilrays, two susceptibility scores for the estuary stingray were reviewed as part of the RRA. Distributional data for the estuary stingray was incomplete and provided a fragmented account of its range and distribution (see Atlas of Living Australia, 2019; Ellis *et al.*, 2017). In the RRA, the *availability* attribute was reassessed using the IUCN species distribution map (Kyne *et al.*, 2016) and the score recalibrated to better reflect what is known about this species' distribution (Appendix D). In addition to the *availability* attribute, the *encounterability* scores were downgraded from a high (3) to medium (2). This amendment recognises that a) smaller amounts of effort are reported from the fishery in habitats preferred by this species and b) the preliminary score is likely to be an overestimate for the entire Large Mesh Net Fishery (Appendix D). This reduction was not sufficient to move the species into a lower risk category (Table 7).

While sawfish had information gaps that impacted both aspects of the PSA, only the *susceptibility* attributes could be refined as part of the RRA. As the maximum total length for largetooth sawfish and the green sawfish exceeds 5m (Last *et al.*, 2016) both were assigned a low (1) risk score in the PSA for *selectivity* (Table 5). Criteria used to assess the *selectivity* risk 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).

Of the four species assessed as part of the Level 2 ERA, research suggests that the largetooth sawfish and the dwarf sawfish are less likely to be encountered in the ECIF. There is a high degree of uncertainty surrounding their distribution on the Queensland east coast and the two species may now be extirpated in the region. If the species are still present on the Queensland east coast, their distribution would be confined to waters north of Cairns (Department of the Environment, 2019ag; h; Last *et al.*, 2016; Last & Stevens, 2009). These areas attract smaller amounts of effort and, when combined with rareness of the species, reduces the *encounterability* risk for these two species (Table 7; Appendix D). *Encounterability* scores for the narrow sawfish and the green sawfish were retained as the distribution of both species extends further south (D'Anastasi *et al.*, 2013; Last *et al.*, 2016; Simpfendorfer, 2013). These amendments did not alter the overall risk rating assigned to either species.

Of the remaining batoids, the eyebrow wedgefish and the bottlenose wedgefish were the only other species to have amendments made to the preliminary scores. In these instances, the *availability* attribute score was decreased from a precautionary high (3) to a medium (2) on the back of more detailed distributional data (Table 7; Appendix D).

4 Risk Evaluation

4.1 Large Mesh Nets

When the results of the PSA and RRA were taken into consideration, the Level 2 ERA indicates that fishing activities in the Large Mesh Net Fishery presents a high risk to the majority of the SOCC (Table 7). Biological and life-history constraints were a key driver of risk for most species and, in some instances, were the main contributors of risk. If for example, all of *susceptibility* attributes were assigned the lowest value possible (1), around 60% of the species (n = 19 out of 32) would still register a medium-risk rating. 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/or the level of uncertainty. These include the increased risk of drowning for air breathing species (marine turtles, dugongs, and cetaceans), the absence of an effective mechanism to monitor fishing interactions or validate catch compositions, underreporting of interactions with non-target species, and poor species resolution in the retained catch data (Jacobsen *et al.*, 2019b). In these instances, the risk will need to be managed across the entire ECIF and through the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017).

At the whole-of-fishery level, the SOCC ERA identified 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 SOCC Level 2 ERA. In the context of this ERA, the following is recommended to assist in the long-term management of risk in the Large Mesh Net Fishery and improve the accuracy of future risk assessments:

General recommendations

1. *Improve the level of information on fine-scale movement of effort, with particular emphasis on increasing our understanding of how large mesh nets are used in habitats critical to the survival of key species.*

2. *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.*

3. *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.*

4. *Provide a synthesis of habitat data and known distributions of key species in a format that can be easily compared and overlayed with the footprint of large mesh net effort.*

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

6. *Review nomenclature used in fisheries legislation to ensure that it reflects the best available data with consideration given to expanding the definition for hammerhead sharks and devil rays.*

7. *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 bSAFE.*

A number of the above recommendations are already being implemented as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* including the mandatory 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; e; g). In the ECIF, many of the proposed changes represent a significant step forward in terms of the long-term management of both target and non-target species.

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 Large Mesh Net Fishery. They have however been observed in habitats and water depths where gillnets and ring nets are used and they may still interact with this sector of the 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 (Department of Agriculture and Fisheries, 2019c). 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 F).[8] With improved information, a number of the species with *precautionary* risk ratings could be excluded from future iterations of the Large Mesh Net Fishery SOCC Level 2 ERA.

[8] *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 F). 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.*

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 been identified.

4.2.1 Marine Turtles

Species	Sub-fishery / Apparatus	Risk Rating
Green turtle *(C. mydas)*	Large Mesh Net: Gillnets & Ring nets	**High**
Loggerhead turtle *(C. caretta)*	Large Mesh Net: Gillnets & Ring nets	**High**
Hawksbill turtle *(E. imbricata)*	Large Mesh Net: Gillnets & Ring nets	**High**
Flatback turtle *(N. depressus)*	Large Mesh Net: Gillnets & Ring nets	**Medium**
Olive ridley turtle *(L. olivacea)*	Large Mesh Net: Gillnets & Ring nets	**Precautionary Medium**
Leatherback turtle *(D. coriacea)*	Large Mesh Net: Gillnets & Ring nets	**Precautionary Medium**

Final risk ratings for this complex align well with catch composition data for marine turtles on the Queensland east coast (Appendix E). This data shows that the majority of net interactions involve the green turtle (*Chelonia mydas*), loggerhead turtle (*Caretta caretta*) and hawksbill turtle (*Eretmochelys imbricata*) (Biddle *et al.*, 2011; Department of Agriculture and Fisheries, 2019c; Department of Environment and Science, 2017; Greenland *et al.*, 2002; Haines *et al.*, 1999; Meager & Limpus, 2012). Of those three, green turtles are the most abundant species reported through the SOCI logbook, and it has the largest representation in the StrandNET data. In the SOCI data (2003 to 2017 inclusive), around 2000 green turtle interactions were reported from large mesh net operations (gillnets and ring nets), followed by loggerhead turtles (*n* = 124 interactions) and hawksbill turtles (*n* = 41 interactions). This contrasts with the flatback turtle (*Natator depressus*), olive ridley turtle (*Lepidochelys olivacea*), and leatherback turtle (*Dermochelys coriacea*) which had a combined total of 12 reported interactions (Appendix E; Department of Agriculture and Fisheries, 2019c).

Of the marine turtle species included in the Level 2 ERA, research indicates that the green turtle has the largest population on the Queensland east coast (Department of the Environment, 2019a). This partly explains why green turtles are well represented in data compiled through the SOCI logbooks and StrandNET (Biddle *et al.*, 2011; Department of Agriculture and Fisheries, 2019c; Greenland & Limpus, 2004; Meager & Limpus, 2012). The size of the green turtle population indicates that this species is in a better position (compared to the other marine turtle species) to absorb mortalities incurred from net fishing activities. Accordingly, the final risk rating for this species may be more precautionary as it potentially reflects population differences *versus* a higher *susceptibility* to capture. With that said, it is recognised that marine turtle populations have declined through time (*pers. comm*. C. Limpus) and concerns still remain about the long-term sustainability of this complex. Consequently, mortalities incurred due to net fishing activities may have longer-term implications for regional marine turtle populations; particularly the hawksbill turtle (Mortimer & Donnelly, 2008).

While all six species were assessed as either a medium or high risk (Table 7), the risk posed by large mesh nets along the Queensland east coast is not uniform. The three species at high risk are not evenly distributed across the area affected by net fishing and they will be observed in higher densities at key times, locations and/or habitats along the Queensland coastline (*pers. comm.* C. Limpus). Accordingly, the risk posed by large mesh nets will be lower in some regions than what is presented in the Level 2 ERA. In the risk profiles of the flatback, olive ridley and leatherback turtles, this variability was partly addressed through the RRA (Appendix D). In the three remaining species, the extent of these refinements was restricted by an absence of data on fine-scale effort movements in key habits and a limited understanding of how the fishery operates in areas with higher turtle densities. Going forward, the risk profiles of all three high-risk species would benefit from an improved synthesis of the available information on the distribution of large mesh 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 ECIF.

As marine turtles are air-breathers, there are significant post-interaction risks for individuals that encounter a large mesh net. A marine turtle caught in large mesh 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. Despite this risk, SOCI reports indicate that only 24 marine turtles died during a fishing event in the 2003–2017 period: 14 loggerhead turtles, six green turtles, three hawksbill turtles, and one unspecified (Appendix E). In comparison, StrandNET attributes at least 20 marine turtle mortalities and seven entanglements to netting activities and on deck damage.[9] A further 33 entanglements with ghost nets were recorded over the same period, resulting in the deaths of an additional 24 animals (Biddle *et al.*, 2011; Department of Environment and Science, 2017; Greenland & Limpus, 2003; 2004; Greenland *et al.*, 2002; Meager & Limpus, 2012). As the origin and legality of ghost nets cannot be confirmed, it is unclear how many (if any) of the additional 24 mortalities were due to fishing activities in the ECIF.

On numbers alone, data submitted as part of the SOCI logbook program are comparable to that compiled through StrandNET. There are however a number of caveats that need to be taken into consideration when reviewing StrandNET data in the context of fisheries-based risk management. While StrandNET data is collected across the state, the program relies heavily on reports from the general public. As a consequence, datasets from remote areas or areas with smaller populations are less comprehensive (Department of Environment and Science, 2017). Similarly, the majority of reports will come from inshore or near-shore waters with improved accessibility. Outside of these areas, the database relies more heavily on mandatory reporting requirements and dead or moribund animals washing onto shore or into areas where they are more likely to be detected (*e.g.* due to currents and tidal flows). For these reasons, StrandNET provides an incomplete account of the number of marine turtles that die due to net fishing activities on the Queensland east coast (Department of Environment and Science, 2017).

The above considerations suggest that the number of marine turtle interactions are underreported in the Large Mesh Net Fishery (Appendix E; Department of Agriculture and Fisheries, 2019c). The level of underreporting will be difficult to quantify but can be partly attributed to contact without capture events and post-release mortalities. Both types of interactions are difficult to quantify in a marine

[9] *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, gillnets; ghost net entanglement) and provided greater avenues for direct comparison with the SOCI data.*

environment and are viewed as an inadvertent or unintentional from of underreporting. In other instances, the underreporting of marine turtle interactions will be due to non-compliance, inaccurate reporting of release fates and the concealment or attempted concealment of an interaction *e.g.* weighting the carcass down (Greenland & Limpus, 2004). These instances contribute to the level of uncertainty surrounding the accuracy of the SOCI data and are compounded by management's inability to monitor the capture of non-target species in real or near-real time. Similarly, there is limited capacity within the current management regime to document release fates, validate the accuracy of the SOCI data, or assess the level of non-compliance with mandatory reporting requirements (Jacobsen *et al.*, 2019b).

SOCI data for the ECIF indicates that anchored gillnets and drifting gillnets were responsible for most of the marine turtle interactions reported between 2003 and 2011 (inclusive). This dynamic shifted in the post-2011 period with ring net fishing accounting for the majority of reported interactions (Appendix E). As SOCI reporting requirements have not changed substantially over this period, the reasons behind this change are unclear. Factors that may have contributed to the observed shift include changing fishing behaviours or patterns, the removal of operations as part of management reforms (*e.g.* buybacks linked to the establishment of net free areas), inaccurate reporting of the gear type being used, the use of generic gear identifiers (*e.g. net fishing, nets*)[10] and the potential under-reporting of marine turtle interactions with gillnets.

Obtaining accurate information on the type of nets (gillnets or ring nets) marine turtles interact with, the frequency of interactions, and locations, are all of notable importance to the ERA process. In the Level 2 ERA, gillnets and ring nets were assessed as a single entity as they operate under similar management constraints (mesh size and net length restrictions *etc*.) and have a degree of spatial overlap (Department of Agriculture and Fisheries, 2019c). Despite this, there will be subtle differences in the risk profiles of both gear types including in their potential to interact with marine turtles and the longer-term consequences. For example, ring netting is viewed as a more active form of fishing as the net is towed around a suitable shoal or school of fish before it is retrieved for processing. This contrasts with gillnet operations where the net is left at the desired location (fixed or drifting) and allowed to soak or fish for an extended period of time. Due to these differences, the length of a fishing event in the gillnet fishery (*average* = ~6hrs) is almost double that of a ring net (*average* = ~3hrs). When viewed in the context of this ERA, the extended soak time means that the *encounterability* and *post-capture mortality* risk will be higher for gillnets.

The resolution of the logbook data is not sufficient to establish long-term datasets for each apparatus or examine risk level variations. With improved information on the use of gillnets and ring nets, the risk profiles of all six marine turtles could be refined. This will be of particular relevance to the *availability* and *encounterability* attributes where risk values are based on the effort footprint, the distribution of the species, and their habitat preferences (Table 3). In the current ERA, these attributes could not be refined as part of the RRA due to perceived inconsistencies in the SOCI data (Appendix E). If for example the logbook data is taken at face value, ring net fishing is responsible for the majority of marine turtle interactions in the post-2011 period. As ring net fishing makes a smaller contribution to the total ECIF effort and has a smaller footprint, this suggests that the apparatus is more selective for marine turtles and/or is being used in areas where there is a higher probability of

[10] *SOCI reports registered with generic identifiers such as 'net fishing' or 'nets' will, by default, be attributed to gillnet fishing (anchored or drifting gillnets). This factor would more than likely have contributed to an apparent under-representation of marine turtle / ring net interactions during the 2003 to 2011 (inclusive) period.*

encountering a marine turtle. The difficulty with this assessment is that this scenario is the opposite of what occurred in the pre-2012 period where gillnets dominated the marine turtle SOCI catch (Appendix E).

Risk profiles developed for the marine turtle complex are more representative of the actual risk *verse* the potential risk. With that said, the precautionary nature of the methodology combined with data deficiencies have contributed to the production of more conservative assessments (Table 7). Outputs of the Level 2 ERA demonstrate that net fishing presents a comparatively high risk to any marine turtle that interacts with the fishery. What is less certain is how these interactions will impact on the long-term conservation of the species or the resilience of regional populations.

Going forward, 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). While the green, loggerhead and hawksbill turtle should be prioritised in this process, this data could be used to refine the assessments of all six marine turtle species. More importantly, it will provide further context on how large mesh net fishing impacts regional marine turtle populations and how this compares to other risk factors (*e.g.* boat strike, interactions with other fisheries or sectors, disease).[11]

Species-specific recommendations

1. ***Provide a synthesis of regional distribution data for green, loggerhead and hawksbill turtles to a) evaluate the level of overlap with large mesh net effort, 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 the species through marine park reserves, fisheries closures etc.***

   Distribution maps for the green, loggerhead and hawksbill turtle provided little insight into regional movements, abundance, and habitat usage. If it is determined that some form of management intervention is required, discussions would benefit from a more detailed account of where these species are found in higher densities, the distribution of habitats critical to their survival, and areas where this risk is already being managed effectively. Ideally, this information would be provided in a shapefile that could be overlayed with a map depicting the distribution of net effort along the Queensland coastline. This would facilitate easier and more accurate comparisons of how this sector of the ECIF interacts with this subgroup across and within fishing years.

2. ***Depending on the outcomes of recommendation 1, identify high-risk areas where fishing-related risks may be reduced or mitigated through a bycatch management strategy including areas where the cumulative impacts are likely to be higher e.g. commercial fishing plus Shark Control Program nets, high risk of boat strike mortalities etc.***

   While commercial net fishing presents as a high risk for the green, loggerhead and hawksbill turtle, regional marine turtle populations will be impacted on by a range of factors including boat strike, urban development, and disease. When compared to boat strike (60–116 turtle mortalities each year), the risk posed by commercial net fishing will be lower. However, commercial netting

[11] *Additional information on the cumulative risks has been provided in the whole-of-fishery (Level 1) Ecological Risk Assessment (Department of Agriculture and Fisheries, 2019c).*

activities will contribute to the cumulative risk and, in some areas, may exacerbate mortalities incurred due to other marine-based activity. Depending on the location and the species, consideration may need to be given to these cumulative risks when determining the need undertake additional management reforms.

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

   Unless an interaction is reported through both programs, SOCI data are 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, 2019e).

   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.*, 2019b).

4.2.2 Sirenia

Species	Sub-fishery	Risk Rating
Dugong (*D. dugon*)	Large Mesh Net: Gillnets	**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 in not been for the *trophic level* attribute which was assigned the lowest possible value (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 on the Queensland east coast (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.

Unlike turtles, the main driver of risk for this species will be gillnets. While there is the potential for ring nets to encircle a dugong, this risk is relatively low given the areas being fished, the teleosts being targeted, and habitats preferred by dugongs. For these reasons, the greatest risks to dugongs relate to an animal swimming into a gillnet undetected and becoming entangled to the point where it cannot access the surface to breath. This is supported by SOCI data and information collated through StrandNET which shows that all but one of the dugong interactions involved gillnets, anchored gillnets, and drifting gillnets. The other interaction was with a tunnel net in 2005 (Flint & Limpus, 2013).[12]

Interactions between large mesh net operations (including the Shark Control Program) and dugongs are well documented (Department of the Environment, 2018; Marsh, 2009; Marsh *et al.*, 2005; Meager, 2016b; Meager *et al.*, 2013). The potential consequences of these types of interactions have also been explored in detail and, in a number of instances, resulted in increased protections. On 14th August 1997, the Federal and Queensland Governments announced additional protection measures for dugongs in the southern Great Barrier Reef and Hervey Bay regions. Central to this were the establishment of a two-tiered Dugong Protection Area (DPA) system—Zone A DPAs and Zone B DPAs (Meager *et al.*, 2013; Queensland Government, 2002). Zone A DPAs afford additional protections to significant dugong habitats and prohibit the use of foreshore set nets and offshore set and drift nets.[13] While mesh netting is still permitted in Zone B DPAs, operators are restricted in terms of the type, size and location of the net and in attendance provisions (Meager *et al.*, 2013; Queensland Government, 2002). These measures are mirrored in legislation governing the use of marine resources in the *Great Barrier Reef Marine Park,* referred to within as *Special Management Areas* (Great Barrier Reef Marine Park Authority, Undated).

The above measures are still in effect and provide dugongs with additional protections from net fishing activities. The introduction of the DPAs has been recognised as a highly effective measure for reducing the number of fishing-related mortalities in the prescribed areas (refer to dugong annual stranding reports; Department of Environment and Science, 2017). Outside of the DPAs, dugongs are protected from net fishing activities through a range of State and Commonwealth Marine Parks *i.e. Great Barrier Reef Marine Park*, *Moreton Bay Marine Park* and *Great Sandy Marine Park*. In these areas, commercial netting is prohibited in key areas including within sections of Moreton Bay; one of the key strongholds for the southernmost dugong population and among the top 10 habitats for this species (Department of National Parks Sport and Racing, 2015). When all of these provisions are taken into consideration, dugongs arguably have one of the more advanced species-specific strategies for managing fishing related risks.

While dugongs are afforded considerable protections from commercial fishing, interactions still occur in the ECIF. Once trapped within the net, the risk of the interaction ending in a mortality is considered high; even with the use of net-attendance provisions. Data submitted as part of the SOCI logbook program documents 37 dugong interactions between 2003 to 2017 (inclusive) and include 16 mortalities (43%) (Department of Agriculture and Fisheries, 2019c; Jacobsen *et al.*, 2019b). This number is smaller than the figures reported in StrandNET which attributes at least 19 dugong deaths to commercial netting activities on the Queensland east coast over the same period (Biddle *et al.*, 2011; Department of Environment and Science, 2017; Flint & Limpus, 2013; Greenland & Limpus, 2006; Meager, 2016b). A further five dugong mortalities were linked to netting activities but could not be confirmed definitively through the available evidence.

[12] *Timescale for both datasets do not show complete alignment. SOCI logbooks were introduced in 2003 and included data up to and including 2017. Data available through the Marine Wildlife Stranding and Mortality and Stranding Database covers the 2000 to 2015 period.*

[13] *Excludes in the Hervey Bay – Great Sandy Strait Protection Area, where specialised fish netting practises are allowed to continue with modifications.*

While the number of dugong–net interactions reported in the SOCI logbook and StrandNET are similar, accepting the accuracy of this comparison assumes that a) the StrandNET dataset is complete, b) all dugong–net interactions are reported through the SOCI logbooks, and c) the two are closely correlated in terms of dates, locations, and release fates. In reality, the situation surrounding the reporting of dugong–net interactions on the Queensland east coast is more complicated. As noted in the marine turtle assessment, a heavy reliance on public reports limits StrandNET's coverage in sparsely populated areas and in regions where regular patrols are not undertaken (Meager, 2016b). Further, StrandNET mostly compiles information on injured, dead, or moribund animals that have washed up on shore or into an area where they are more likely to be observed. This however may not always be the case as currents, wind, buoyancy, and predation/scavengers all have a bearing on whether or not a carcass or debilitated animal reaches the shoreline (Meager, 2016b). For these reasons, StrandNET is unlikely to provide a complete overview of dugong–net interactions on the Queensland east coast.

While ECIF operators are required to record all dugong interactions in the SOCI logbook, it is difficult to assess how compliant the fishery is with this requirement as there is no on-water monitoring of fishing activities. This increases the risk of underreporting and inaccurate reporting of release fates *e.g.* recording a dugong as released alive when it was dead. This inference is supported by comparisons with ancillary datasets like StrandNET which demonstrates that a degree of underreporting does occur in this fishery. In some instances, this includes attempts to actively conceal a dugong entanglement or mortality *e.g.* reducing the buoyancy of a carcass by cutting it open or attaching weights (Biddle *et al.*, 2011; Flint & Limpus, 2013; Greenland & Limpus, 2006).

Despite the potential for underreporting, data compiled through the SOCI logbooks and StrandNET indicates that dugongs interact with the Large Mesh Net Fishery in (comparatively) low numbers. This is partly attributed to measures already implemented along the Queensland east coast to protect key habitats and minimise the risk from commercial fishing. In the Large Mesh Net Fishery, the effectiveness of the DPA has seen a notable reduction in the number of mortalities being reported from these areas. Outside of the DPAs, the impact of the fishery on regional dugong populations may be more significant. Given the conservative life-history of the species, these risks will still be present even at low levels of fishing mortality. This places added importance on collating information on the location and extent of dugong habitats outside the DPAs and the extent of the overlap with effort in the Large Mesh Net Fishery. In terms of the Level 2 ERA, this information will help refine the *susceptibility* assessment, provide more context on the impact of the fishery at a regional level and assist in identifying areas where further management of this risk may be required.

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 Large Mesh Net Fishery.***

   This recommendation is best addressed through the *Monitoring & Research Plan* as it largely requires a review of the available data on dugong populations and habitats. The challenge being how best to consolidate this information into something that can be readily used to inform the broader review process *e.g.* shapefiles that can be easily overlayed with a map depicting the distribution of net effort along the Queensland coastline. 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.

2. ***Undertake a review of all dugong-specific closures implemented on the Queensland east coast through State and Commonwealth legislation to evaluate the current level of protection and the intensity of net fishing effort in adjacent areas.***

   In addition to the distribution maps, it is recommended that a review of dugong spatial closures and protections be undertaken. This information will provide insight into the amount of critical habitat that is already protected from commercial fishing and (if applicable) areas where the risk posed to this species requires further monitoring or management. The mapping of these closures will allow for fine-scale assessments of fishing intensities in adjacent areas and provide regional context on the interaction potential.

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

   Unless an interaction is reported through both programs, SOCI data are 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, 2019e).

   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 provide greater insight into the cumulative pressures being exerted on a species and allow for direct comparisons with other risk factors such as boat strike, pollution, discarded equipment and disease. 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.*, 2019b).

4.2.3 Cetaceans

The cetacean subgroup registered one of the highest average scores for the *productivity* component of the PSA (Table 5). All seven 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 encounters a large mesh net, the risk of the interaction ending in a mortality will increase with the length of the interaction. This risk will be higher for gillnet operations which account for a larger proportion of the ECIF effort and have longer soak times (~6hrs *vs.* ~3hrs for ring nets). This inference is supported by data submitted through the SOCI logbook program that shows all of the dolphin interactions were with gillnets, anchored gillnets or drifting gillnets (2003–2018 inclusive; Department of Agriculture and Fisheries, 2019c; e). In these instances, any attempt by the animal to extricate themselves from the net may exasperate the extent of the initial entanglements. This in turn will reduce the period of time an operator has to release the animal and rectify the situation.

As with the marine turtle complex, the risk of non-compliance and non-reporting is elevated by the absence of an effective mechanism to monitor fishing activities. Data obtained through the SOCI logbooks (2003–2017) contains six dolphin interactions including two snubfin dolphins (*Orcaella heinsohni*), two offshore or common bottlenose dolphins (*Tursiops truncatus*) and two unidentified specimens (Department of Agriculture and Fisheries, 2019c; e). This contrasts with the StrandNET program which links at least 11 dolphin mortalities to commercial net fishing operations over the 2003–2015 period: three bottlenose dolphins, one humpback dolphin (*Sousa* spp.), five snubfin dolphins, one short-beaked common dolphin (*Delphinus delphis*) and one unknown specimen (Department of Environment and Science, 2017; Meager, 2013; 2016a; Meager *et al.*, 2012).[14]

Cross-comparisons of the StrandNET and SOCI data support hypotheses that the number of dolphin interactions are underreported in this sector of the ECIF. This uncertainty makes it difficult to quantify species-specific rates of fishing mortality or assess the longer-term risks and consequences. However, the available data also suggests that dolphin interaction rates are comparatively low in this fishery. Based on the available data, interaction rates for this subgroup are well below that reported for marine turtles and through the SCP (n = ~300 dolphin interactions between 2001 and 2021; Department of Agriculture and Fisheries, 2020a; Queensland Government, 2019a). For some species, current interaction rates and mortality levels could be tolerated or sustained by regional populations. Other species including the snubfin and Australian humpback dolphin will find it more difficult to sustain even very low levels of fishing mortality.

In the Level 2 ERA, the above factors were considered for three groups a) snubfin and humpback dolphins, b) bottlenose and common 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.

4.2.3.1 Snubfin & Humpback Dolphin

Species	Sub-fishery / Apparatus	Risk Rating
Australian snubfin dolphin (*O. heinsohni*)	Large Mesh Net: Gillnets & Ring nets	**High**
Australian humpback dolphin (*S. sahulensis*)	Large Mesh Net: Gillnets & Ring nets	**High**

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

[14] StrandNET data for the post-2015 period yet to be made publicly available (Department of Environment and Science, 2017). It is anticipated that StrandNET data for the post-2015 period will include additional dolphin–net interactions including the two snubfin mortalities reported through the SOCI logbook in 2017 (Department of Agriculture and Fisheries, 2019c).

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, 2018a; 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 Queensland coastline (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 fishery and their potential to interact with a gillnet or ring net. These uncertainties reflect a broader deficiency in the amount of information that is available on the ecology and biology of these species (Allen *et al.*, 2012; Cagnazzi, 2017; Parra *et al.*, 2006b). At a whole-of-fishery level, this risk is unlikely to be uniform and will be more significant in central and north Queensland. Within these areas, 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 their depth profiles with both species occupying shallow water environments (<20 m); often in close proximity to river mouths and estuaries (Parra *et al.*, 2006b). Based on these preferences, snubfin and humpback dolphins are more likely to be encountered by gillnets and ring nets operating in the GBRMP or along the adjacent coastline. South of the GBRMP, fishers are more likely to encounter and interact with the humpback dolphin including in and around the *Great Sandy* and *Moreton Bay Marine Parks* (Department of Environment and Science, 2018a; b).

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, 2019c; e). While the origin and legality of the apparatus cannot be verified, StrandNET identifies net fishing as a contributing factor in at least one other snubfin dolphin mortality (Meager, 2013; 2016a; Meager *et al.*, 2012). As SOCI 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. As the fishery currently operates without an effective mechanism to monitor catch compositions in real or near-real time, non-compliance, or the underreporting of interactions will be an additional risk factor for this subgroup.

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 east coast populations. These risks increase when cumulative fishing pressures are taken into consideration *e.g.* their capture in the SCP (Department of Agriculture and Fisheries, 2020a; Department of Environment and Science, 2017; Queensland Government, 2019a).

Species-specific recommendations

1. ***Provide a synthesis of regional distribution data for snubfin and humpback dolphins to a) evaluate the level of overlap with large mesh net effort and b) the level of protection already afforded to the species through marine park reserves, fisheries closures etc.***

   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 along the Queensland coastline.

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

   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.

   The species distribution and habitat preference 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. This may include areas where the cumulative risk posed to these species are higher *e.g.* commercial fishing plus the SCP. If this review determines that intervention is required, management of this risk will arguably be most effective at a regional level (*versus* across the entire state).

   Given the ongoing success of Dugong Protection Areas (DPAs), some consideration could be given to replicating this program (or something similar) in key snubfin and humpback dolphin habitats. It is recognised that the mobility of these species combined with spatially fragmented pods may reduce the effectiveness of regional or fine-scale spatial/temporal closures. Similarly, this strategy may be less suited for netting operations that occur in these areas. However, research has shown that a) these species exhibit greater site fidelity tendencies and b) form isolated populations. This suggests that a risk management strategy of this nature may be more effective when compared to other cetaceans.

   As the geographical range of the snubfin dolphin appears to be more restrictive, this species may derive greater benefit from this type of approach. The extent of this benefit would be highly dependent of the size of regional populations, the strength of any site fidelity and the temporal scale of any closure *e.g.* throughout the year or during key seasons etc.

4.2.3.2 Bottlenose & Short-Beaked Common Dolphin

Species	Sub-fishery / Apparatus	Risk Rating
Indo-Pacific bottlenose dolphin (*T. aduncus*)	Large Mesh Net: Gillnets & Ring nets	**Precautionary High**
Common bottlenose dolphin (*T. truncatus*)	Large Mesh Net: Gillnets & Ring nets	**Precautionary High**
Short-beaked common dolphin (*D. delphis*)	Large Mesh Net: Gillnets & Ring nets	**Precautionary Medium**

When compared to the snubfin and humpback dolphin, there are fewer concerns surrounding the conservation status of the common bottlenose dolphin (*Tursiops truncatus*), the Indo-Pacific bottlenose dolphin (*T. aduncus*), and the short-beaked common dolphin (*Delphinus delphis*). Population estimates for the common bottlenose dolphin and the short-beaked common dolphin indicate that these two species are relatively abundant throughout their range (Hammond *et al.*, 2008; Wells *et al.*, 2019). This has contributed to the species receiving an IUCN redlist classification of *Least Concern* (Hammond *et al.*, 2008; 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 the species has a comparatively high aggregate abundance in coastal waters (Hammond *et al.*, 2012).

All three species have distributions that extend well beyond the Australian Exclusive Economic Zone (Department of the Environment, 2019n; 2019ae; Hammond *et al.*, 2012; Hammond *et al.*, 2008; Wells *et al.*, 2019). On the Queensland east coast, the distribution of the two bottlenose dolphins extends along the entire Queensland coastline and both species will interact with large mesh net 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. The situation surrounding the short-beaked common dolphin differs in that their distribution on the Australian east coast only extends as far north as the Sunshine Coast (Hammond *et al.*, 2008; Queensland Government, 2019a). The species is considered to be more prevalent in southern Australia and it occurs in two main locations, one cluster in the southern / south-eastern Indian Ocean and another in the Tasman Sea (Department of the Environment, 2019o).

Catch records for all three species are limited with only four interactions reported though the SOCI logbooks since 2003; two common bottlenose dolphins (identified by their synonym: offshore bottlenose dolphin) and two unidentified dolphins (Department of Agriculture and Fisheries, 2019c). These figures were lower than what was reported through the StrandNET program where commercial net fishing was linked to at least seven bottlenose dolphin interactions (mortalities plus releases) during the 2003 to 2015 period (Department of Environment and Science, 2017). As with snubfin and humpback dolphins, this suggests that data compiled through the SOCI logbook program underestimates the number of interactions that occur in this fishery. The total number of interactions are expected to increase once post-interaction mortalities and contact without captures are taken into consideration (Jacobsen *et al.*, 2019b).

While the short-beaked common dolphin has not been reported through the SOCI logbooks, the species is encountered in comparatively high numbers in the SCP. 201 short-beaked common dolphins have been recorded from the SCP across south-east Queensland since 2001 (Department of Agriculture and Fisheries, 2020a; Queensland Government, 2019a). In contrast, 58 bottlenose dolphins, 25 humpback dolphins and 4 snubfin dolphins were caught in the program over the same period (Department of Agriculture and Fisheries, 2020a). The reasons behind the absence of the short-beaked common dolphin in large mesh net data are unclear. However, misidentifications for other species, a smaller overlap with the ECIF effort footprint, their habitat preferences, and lower (dolphin) interaction rates will all be contributing factors.

Of the three, the two bottlenose dolphins have depth profiles and habitat preferences that align more closely with the ECIF 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; Fury & Harrison, 2008; Lukoschek & Chilvers, 2008). While common bottlenose dolphins also inhabit inshore waters, they are regularly observed in larger groups or 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.

The prominence of the short-beaked common dolphin in the SCP data is evidence that the species, at the very least, overlaps with sections of the ECIF. On the strength of this data, the species has the potential to interact with large mesh nets used in and around south-east Queensland (Department of Agriculture and Fisheries, 2019c). While noting this potential, the short-beaked common dolphin is often referred to as an offshore species and it has a preference for modified waters, areas with steep sea floor relief and extensive shelf areas (Department of the Environment, 2019o; Hammond *et al.*, 2008). These preferences combined with their increased abundance in southern Australia suggests that interactions with large mesh nets, while possible, will be confined to a small section of the ECIF. This limits the *encounterability* risk for this species (Appendix D) and by extension the frequency of net entanglements.

When a bottlenose or common dolphin interacts with a large mesh net, the risk of entanglement and mortality is arguably greater for gillnets. The reasons behind this will be similar to that observed for marine turtles and be addressed through identical measures. In the ring net fishery, dolphins are more likely to be encountered when they become encircled in the net whilst feeding on the target species. In these instances, the increased mobility of the species (*vs.* marine turtles) may allow them to escape under the net or avoid entanglement until they can be released or extracted from the net. The ability of the animal to escape the net will be highly dependent on the depth of water being fished, the drop of the net, and the time taken to detect the presence of the animal and/or the entanglement.

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. Interaction rates in the Large Mesh Net Fishery though are unlikely to lead to a decline in the long-term conservation status of these three species. Population numbers for the common bottlenose dolphin, Indo-Pacific bottlenose dolphin and short-beaked common dolphin are seemingly robust (Hammond *et al.*, 2012; Hammond *et al.*, 2008; Wells *et al.*, 2019) and there is little evidence to suggest that they form sub-populations on the Queensland east coast 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 with these species at a whole-of-fishery or regional level.

Species-Specific Recommendations

No species-specific recommendations for the two bottlenose dolphins and the short-beaked common dolphin. However improved information on interaction rates (or lack thereof) may allow for further refinement of the cetacean Level 2 ERA and the removal of low-risk species from subsequent ERAs involving the Large Mesh Net Fishery.

4.2.3.3 False Killer Whale & Spinner Dolphin

Species	Sub-fishery / Apparatus	Risk Rating
False killer whale (*P. crassidens*)	Large Mesh Net: Gillnets	**Precautionary High**
Spinner dolphin (*S. longirostris*).	Large Mesh Net: Gillnets & Ring nets	**Precautionary Medium**

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. 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 (Table 5). In the false killer whale assessment, biological constraints were identified as 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.

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 ECIF; hence their inclusion in the Level 2 ERA. In reality, the overlap between net effort and the preferred habitats and bathymetric ranges is 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, 2019u). The spinner dolphin is found more readily in inshore waters but is commonly observed around oceanic islands or forming large groups hundreds of kilometres offshore (Braulik & Reeves, 2018; Department of the Environment, 2019w). 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 likelihood of these species interacting with large mesh nets in higher numbers or with increased frequency.

Due to the above considerations, risk ratings for the false killer whale and spinner dolphin are considered precautionary and do not warrant further management reforms. This situation may change if the dynamics of the fishery change significantly, or the footprint of the fishery extends further into deeper water environments (Department of Agriculture and Fisheries, 2019c). Alternatively, improved information of vessel movements and fine-scale effort usage may facilitate the removal of these species from subsequent ERAs.

Species-Specific Recommendations

No species-specific recommendations for the false killer whale and the spinner dolphin. However improved information on interaction rates (or lack thereof) may allow for further refinement of the cetacean Level 2 ERA and the removal of low-risk species from subsequent ERAs involving the Large Mesh Net 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 Large Mesh Net Fishery and how best to manage this risk through the reform process. The fishery is more likely to interact with hammerhead sharks as they are targeted in this sector of the ECIF (Department of Agriculture and Fisheries, 2019c; 2020a). The risk posed to this subgroup will be more immediate and will need to be considered in the context of the broader fisheries reform framework (Department of Agriculture and Fisheries, 2017). 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*)	Large Mesh Net: Gillnets & Ring nets	**High**
Great hammerhead (*S. mokarran*)	Large Mesh Net: Gillnets & Ring nets	**High**
Winghead shark (*E. blochii*)	Large Mesh Net: Gillnets & Ring nets	**Precautionary High**
Smooth hammerhead (*S. zygaena*)	Large Mesh Net: Gillnets & Ring nets	**Precautionary High**

If criteria used to construct the species list was strictly adhered to (Appendix A), only the scalloped hammerhead shark (*S. 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, 2019b). 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 all four hammerhead sharks (*Sphyrna* spp. & *Eusphyra blochii*) in the Level 2 ERA and assess risk across the entire complex. 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 four hammerhead sharks as being at high risk from gillnets and ring-net operations (Table 7). While acknowledging these results, the risk posed to this subgroup is not expected to be as uniform. This variability was partly addressed through the RRA (Appendix D); although the extent of these refinements were limited by data deficiencies and uncertainty surrounding total interaction rates (retained plus discards). Of the species assessed, the preferred habitats of the smooth hammerhead shark (*S. zygaena*) had the lowest overlap with the ECIF effort footprint. This species prefers temperate waters, and it is more likely to interact with gillnets located in south-east Queensland. While the species has been observed north of these areas, they occur in lower numbers and in smaller densities (*pers. comm.* C. Simpfendorfer). For these reasons, the high-risk rating is viewed as more precautionary and direct management of this risk is seen as less of a priority. This risk is arguably greater in New South Wales where the species occurs in larger numbers and interacts more regularly with commercial and recreational fishers.

Of the three remaining species, the more immediate risks and sustainability concerns involve the scalloped hammerhead shark and the great hammerhead shark (*S. mokarran*). These two have widespread distributions and, as migratory species, have sustainability concerns that extend beyond Australian waters (Rigby *et al.*, 2019a; Rigby *et al.*, 2019b). Evidently, the targeting of scalloped and great hammerhead sharks across jurisdictions (cumulative fishing pressures) was the catalyst for their inclusion on 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 fisheries operating in Queensland and their management will be considered as part of third-party assessments *e.g.* threatened species assessments conducted under the EPBC Act, *Wildlife Trade Operation* (WTO) approvals.

Datasets for the winghead shark (*Eusphyra blochii*) are less complete but research suggests that the species has a patchy localised distribution (Smart & Simpfendorfer, 2016). Accordingly, the risk profile of the winghead shark may be of more value when considering regional fishing pressures. 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). Even so, winghead shark interactions are expected to be higher than the smooth hammerhead shark and the species will be encountered across a wider stretch of the Queensland coastline.

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 if 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 ECIF and can be actively targeted by operators with a shark (S) fishing symbol (Department of Agriculture and Fisheries, 2019c). This introduces a degree of complexity not found in the risk profiles of most other SOCC. In the Large Mesh Net Fishery, the take of hammerhead sharks is managed through a combined 100t TACC limit. This limit applies to all *Sphyrna* species including the scalloped, great, and smooth hammerhead shark.[15] As the winghead shark belongs to a different genus (*Eusphyra*); the take of this species is recorded

[15] *Catch reported as 'Hammerhead shark—unspecified' is accounted for in the annual hammerhead shark TACC.*

against a more generic 600t shark TACC limit.[16,17] This difference is important as it (theoretically) allows the retained winghead shark catch to increase to levels not permitted under the hammerhead shark TACC. While this is unlikely in the current fishing environment (Department of Agriculture and Fisheries, 2019c), it is a risk that can actively 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 these species on the Queensland east coast. 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 considered biological reference points contained within a multi-species shark stock assessment (Leigh, 2015). The TACC limit is currently applied at a higher taxonomic level and is based on the retained hammerhead shark catch (excluding wingheads). While data is being collected on hammerhead shark discards, this data is reported by number and lacks the information required to calculate an accurate weight estimate. Without a weight estimate, hammerhead shark discards cannot be accounted for in the TACC limit.

Multi-species TACCs are useful for groups like hammerheads 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. In the Large Mesh Net Fishery, 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. Of the species included in this assessment, this risk is most applicable to the great hammerhead shark as research indicates that the maximum sustainable yield (MSY) for this species is below the scalloped hammerhead and much smaller than the 100t TACC limit (Leigh, 2015).

Depending on the catch compositions, the use of a multi-species TACC could lead to a scenario where the fishery is operating within the prescribed catch limits but still overfishing a regional stock. This risk will increase as annual catch levels approach and reach the TACC limit. As the TACC only accounts for retained catch, this situation will 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 as total catch, effort, and fishing mortality (the commercial catch, non-commercial catch plus discards) will be higher than what is reported through the logbook program. While noting these risks, the best available data indicates that this is not currently occurring on the Queensland east coast (Department of Agriculture and Fisheries, 2018f; Department of the Environment and Energy, 2014; Leigh, 2015).

Catch data for the Large Mesh Net Fishery (gillnets and ring nets) is dominated by scalloped hammerheads and interaction rates for this species are expected to be higher than for the other three (Department of Agriculture and Fisheries, 2019c; Department of the Environment and Energy, 2014). The remainder of the identified catch consists of great hammerhead sharks and smaller amounts of winghead shark. It is noted though that historical data for this complex has poor species resolution and a high proportion of the reported catch has been classified as *Hammerhead—unspecified*

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[16] *This 600t TACC limit incorporates the 100t hammerhead shark TACC. If for example, the 100t hammerhead shark TACC was exhausted, only 500t of other shark species could be retained.*

[17] *TACC limits applied to the entire shark complex and hammerhead sharks are being reviewed as part of the Queensland Sustainable Fisheries Strategy 2017–2027 and the harvest strategy development process (Department of Agriculture and Fisheries, 2020b).*

(Department of Agriculture and Fisheries, 2019c)**.** The *unspecified hammerhead* catch category will include multiple species and records from south-east Queensland may incorporate unidentified smooth hammerhead sharks.

Uncertainties in the catch data makes it difficult to quantify fishing mortality rates and assess the likelihood that one or more of the hammerhead sharks are being fished beyond sustainability reference points (Leigh, 2015). These risks are being actively addressed through the management framework and fishers are now required to report all retained hammerhead shark catch to species level as well as discards (Department of Agriculture and Fisheries, 2018c). 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 mandatory 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 and reporting of target and non-target catch (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. On this basis, the Level 2 ERA should represent a worst-case scenario in terms of the risk posed to this subgroup by large mesh nets used in Queensland waters. 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 inform decisions on where to set mortality rate limits.

Risk profiles for the four hammerhead sharks reflect their status as a target species in the ECIF, their low biological *productivity* and high *susceptibility* to net entanglements. This risk has been well documented and resulted in additional protections for at least one of the species, the scalloped hammerhead. As both target species and a complex that attracts a high level of conservation interest, fishing-related risks posed to this subgroup will be discussed and scrutinised as part of the harvest strategy development process (Department of Agriculture and Fisheries, 2020b). From an ERA perspective, there are a number of areas where data improvements would improve the accuracy of the risk profiles and areas where risk could potentially be reduced for this subgroup.

Species-specific recommendations

1. ***Include the winghead shark in management arrangements targeted specifically at hammerhead sharks such as the 100t 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 100t TACC is exhausted, it would also remove a (potential) compliance risk *e.g.* operators retaining more hammerhead sharks than was permitted under the regulations but reporting them as the winghead shark.

2. ***Implement measures that a) improve the effectiveness of the hammerhead shark catch reporting program and b) assist 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, 2018c). 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/or 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. A 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 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*)	Large Mesh Net: Gillnets	**Precautionary High**

The geographical distribution of the speartooth shark (*Glyphis glyphis*) is highly contracted and the species is known from a few scattered locations in northern Australia and New Guinea (Compagno *et al.*, 2009; Department of the Environment, 2019e; Last *et al.*, 2016; White *et al.*, 2017a). On the Queensland east coast, the reported distribution of the speartooth shark is largely restricted to rivers north of Cairns and Cape Tribulation (Last & Stevens, 2009). This information may now be outdated with regional surveys failing to detect or observe the species across their preferred habitats. This absence of reports has led to suggestions that the species may now be extirpated from the Queensland east coast (Pillans *et al.*, 2009).

In the Large Mesh Net Fishery, a lack of confirmed reports combined with low levels of effort in far north Queensland reduces the likelihood of a speartooth shark interaction. Due to these reasons, some consideration was given to excluding the speartooth shark from the analysis as part of the species rationalisation process (Appendix B). The species was ultimately included in the Level 2 ERA as a precautionary measure and the interaction potential was addressed as part of the RRA (Appendix D). This decision was based on the fact that the sustainability of regional populations, if still present on the Queensland east coast, could be compromised by fishing activities. As the species is known to occur in low densities (Department of the Environment, 2019e), this risk will be present at low levels of fishing mortality. In terms of the Large Mesh Net Fishery, this risk (if applicable) will be confined to gillnet operations targeting species like barramundi and threadfin in inshore waters, estuaries, and rivers.

The risk profile compiled for the speartooth shark is precautionary and key risks for this species are being addressed at a whole-of-fishery level *e.g.* improved catch monitoring and validation, *Vessel Tracking etc*. While the species has been assessed as high risk, additional information is required on the probability of the species being encountered in the Large Mesh Net Fishery and shark catch compositions in areas where it has previously been observed. In the interim, the *productivity* component of the PSA (Table 7) should be updated when new information becomes available on the biology and life-history of the species.

Species-specific recommendations

1. ***Provide a synthesis of regional distribution data on areas where the speartooth shark are more likely to be encountered in the ECIF.***

   It is recommended that the available data on the historic and potential distribution of the speartooth shark be consolidated for comparison with the effort footprint of the entire ECIF. This information will be of value when identifying priority areas for monitoring, assessment and (if applicable) management intervention.

2. ***Identify priority areas for the collection of fine-scale data on effort movement and shark species compositions in key speartooth shark habitats.***

   This recommendation is largely predicated on the completion of the first recommendation and is designed to improve the level of information on (potential) speartooth shark interactions and misidentifications. This recommendation is best addressed through the *Monitoring & Research Plan* and can utilise data obtained through initiatives instigated under the Strategy.

3. ***Explore alternate venues to improve the level of information on speartooth shark distributions and track interactions (commercial and recreational) through time.***

As noted, the SOCI logbooks are the primary source of information in terms of interaction rates and mortalities. With the continued implementation of the *Queensland Sustainable Fisheries Strategy 2017–2027*, there will be greater capacity to monitor and validate catch rates for these species. 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. This recommendation though may present as more of a challenge when compared to other SOCC as speartooth shark interactions are not currently tracked through StrandNET.

4.2.5 Batoids

The batoid ecological subcomponent is one of the more diverse complexes assessed in the 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)*	Large Mesh Net: Gillnets	**High**
Green sawfish *(P. zijsron)*	Large Mesh Net: Gillnets	**High**
Largetooth sawfish *(P. pristis)*	Large Mesh Net: Gillnets	**Precautionary High**
Dwarf sawfish *(P. clavata)*	Large Mesh Net: Gillnets	**Precautionary High**

Risk profiles for the sawfish complex are more conservative and, for at least two of the species, represent the potential risk *vs.* an actual or real risk (Department of Agriculture and Fisheries, 2018a). 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 regionally extirpated (*pers. comm.* B. Wueringer, C. Simpfendorfer). In the event that the largetooth and dwarf sawfish still inhabit areas of the Queensland east coast, they are more likely to be found in areas north of Cairns where net effort levels are lower and less concentrated (Department of Agriculture and Fisheries, 2019c).

When compared to the largetooth and dwarf sawfish, the situation surrounding the two remaining species is more complex. The green sawfish (*P. zijsron*), has been reported from the ECIF and it will interact with large mesh nets (Department of Agriculture and Fisheries, 2019c). However, the green sawfish distribution has contracted and it is now considered more abundant in north Australian waters (Department of the Environment, 2019ah; Harry *et al.*, 2011b; Simpfendorfer, 2013). Based on the current distribution of effort, the Large Mesh Net Fishery may interact with this species in areas north of the Whitsundays (Harry *et al.*, 2011b). In areas south of the Whitsundays, where the majority of the net effort is reported, research indicates that the species is less abundant or regionally extirpated (Department of the Environment, 2019ah). For example, the last reported record of a green sawfish being caught in Moreton Bay was back in the 1960s (Johnson, 1999; Simpfendorfer, 2013).

While the distribution of the narrow sawfish (*Anoxypristis cuspidata*) has contracted, its range extends further south along the Queensland east coast (D'Anastasi *et al.*, 2013; Last *et al.*, 2016). The risk profile for this species also differs with research suggesting that narrow sawfish are more abundant, have higher fecundity, and are faster growing (Table 7; *pers. comm.* B. Wueringer, C. Simpfendorfer; *ECIFFF Bycatch Management Workshop, Townsville, 14–15 May 2019*). This combined with the distribution of ECIF effort suggests that large mesh nets are more likely to encounter this species. This inference is supported by data submitted through the SOCI logbooks which show that over half of the reported sawfish interactions are with *A. cuspidata* (Department of Agriculture and Fisheries, 2019c).

At a species-specific level, sawfish risk profiles were heavily influenced by their biological constraints. 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 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 (medium risk).[18] This meant that the green, largetooth and dwarf sawfish would all be classified as high risk if a) at least one the *susceptibility* attributes were assigned the maximum score of 3 or b) at least two of the attributes were assessed as medium risk (2). The threshold for a high-risk rating was 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 (*risk score* = >3.18).

One of the fundamental challenges of addressing the risk posed to sawfish is that the morphology of their rostrum makes them highly susceptible to net entanglements. 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 3 or high risk (Appendix D). In the ECIF, this risk will be highest for operations using gillnets in inshore, riverine, and estuarine waters. 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 or swim under it. This risk will lower in fishing operations that target fish in deeper water environments.

Data submitted as part of the SOCI logbook program indicates that the majority (86%) of the reported 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 (2003–2017 inclusive; Department of Agriculture and Fisheries, 2019c). While the accuracy of this data is difficult to verify, discussions held at a dedicated *ECIF bycatch management workshop* (Townsville, 14–15 May 2019) suggest that sawfish can survive an entanglement providing that the gills are not damaged or significantly impeded. The fact that sawfish do not rely on ram ventilation, would assist in this process. In the Large Mesh Net Fishery, the ability of the animal to survive a fishing event would be dependent on a range of factors including the size of the animal, the extent of the entanglement and a number of confounding factors such as the extent of any injuries, handling procedures and the presence of larger predators.

[18] *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.*

At a whole-of-fishery level, the total number of sawfish mortalities (*in-situ*, post-release and unreported) may 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 overrides 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 and there is limited scope to draw on information from ancillary databases. This leaves the SOCI logbook as the primary source of information on sawfish interactions.

Based on the available data and the outputs of the Level 2 ERA, large mesh nets present a higher risk for at least two of the species: the green sawfish and the narrow sawfish. While the fishery could (theoretically) interact with the largetooth and dwarf sawfish, evidence suggests that these species are more readily encountered in the Gulf of Carpentaria. Without additional information on interaction and mortality rates, it is difficult to ascertain how vulnerable regional sawfish populations are to large mesh nets. Verifying catch composition, release fates, types of injuries, and locations would assist in this process. As anecdotal evidence suggests that sawfish can survive the initial entanglement, improving handling and release strategies is another mechanism that could be used to reduce the risk posed to this subgroup.

Species-specific recommendations

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

   Due to the presence of the rostrum, sawfish entangled in a net represent a considerable risk in terms of workplace health and safety. Depending on the size of the animal and its manoeuvrability, the animal may be injured (inadvertently or intentionally) 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 practise.

2. ***Explore alternate avenues to improve the level of information on sawfish biology, fishing interactions and mortalities.***

   As noted, the SOCI logbooks are the primary source of information in terms of interaction rates and mortalities. With the continued implementation of the *Queensland Sustainable Fisheries Strategy 2017–2027*, there will be greater capacity to monitor and validate catch rates for these species. 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. 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.

4.2.5.2 Guitarfish & Wedgefish

Species	Sub-fishery / Apparatus	Risk Rating
Bottlenose wedgefish (*R. australiae*)	Large Mesh Net: Gillnets	**Precautionary High**
Eyebrow wedgefish (*R. palpebratus*)	Large Mesh Net: Gillnets	**Precautionary High**
Giant shovelnose ray (*G. typus*)	Large Mesh Net: Gillnets	**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 ECIF. 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, 2019c; d). 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 ECIF and may have wider implications with respect to their retention and export. Due to this potential, all three were included in the 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 ECIF fishing grounds. 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 large mesh net there is a higher risk of entanglement due to the morphology of their head and rostrum (Last *et al.*, 2016). This by extension increases the *post-interaction mortality* risk (Table 7) which considers both their retention for sale and bycatch mortalities (within net and post release).

Catch data for the fishery shows that guitarfish, wedgefish, and shovelnose rays are retained in small amounts on the Queensland east coast; *average* = 4.8t, *range* = 0.2–12.2t.[19] 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.[20] In addition to the retained catch, guitarfish, wedgefish, and shovelnose rays caught in large mesh nets will be discarded as unwanted bycatch. At present, there is limited capacity within the fishery to validate the total guitarfish/wedgefish catch (retained plus discarded) or verify the release fates of unwanted product. It is further recognised that a portion of the rays will be discarded in a dead or moribund state. In the context of this ERA, this is of notable importance as total mortality will be higher than what is reported through the logbook program.

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

[20] *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 outdated. The intent of the legislation though remains the same.*

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 slightly 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 by large mesh net fishers. 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 Large Mesh Net Fishery through input and output controls including limited licencing, mesh size restrictions, spatial closures, and in-possession limits (Department of Agriculture and Fisheries, 2019c). For these reasons, the sustainability risk posed to this subgroup on the Queensland east coast will be lower than in other regions.

At a whole-of-fishery level, the risk posed by large mesh net fishing has not been mitigated completely. 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 further 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 rays in Queensland waters—noting that these species may be low priorities for assessment when compared to 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*)	Large Mesh Net: Gillnets & Ring nets	**Precautionary High**
Kuhl's devilray (*M. kuhlii*)	Large Mesh Net: Gillnets & Ring nets	**Precautionary High**
Giant manta ray (*M. birostris*)	Large Mesh Net: Gillnets & Ring nets	**Precautionary Medium**
Giant devilray *(M. mobular)*	Large Mesh Net: Gillnets & Ring nets	**Precautionary Medium**
Bentfin devilray (*M. thurstoni*)	Large Mesh Net: Gillnets & Ring nets	**Precautionary Medium**

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, 2019c).

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). On the Queensland east coast, devilrays will interact infrequently with large mesh nets and their size and morphology minimises the entanglement risk (*pers. comm.* P. Kyne). In the event that a devil ray is caught in a gillnet or ring net, 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 the risk posed by this sector of the ECIF is 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).

Devilrays and manta rays were merged into a single genus (*Mobula*) as part of a broader investigation into batoid taxonomy (Last *et al.*, 2016; White *et al.*, 2017b).[21] This review also resulted in the reclassification of regional conspecifics or the merging of previously distinct species (White *et al.*, 2017b). These changes introduce a degree of uncertainty in terms of the species that interact with the ECIF and the composition of data submitted through the SOCI logbook program (Jacobsen *et al.*, 2019b). This uncertainty will reduce through time with improved information on the distribution of each species under the new taxonomic structure.

Data compiled through the SOCI logbooks document interactions with four devilray categories: manta rays (unspecified), the bentfin devilray, the pygmy devilray (*M. munkiana*) and the Japanese devilray (*M. japonica*) (Department of Agriculture and Fisheries, 2019c; e).[22] The veracity of these records have yet to be fully tested and, in some instances, may be the result of misidentifications. For example, research on mobulid taxonomy has revealed that the Japanese devilray and the giant devilray are conspecifics *i.e.* they are the same species. In addition, the distribution of the pygmy devilray has now been revised to the west coast of North, Central and South America (Last *et al.*, 2016). Given this, SOCI reports for the pygmy devilray are likely to be the Kuhl's devilray or the bentfin devilray (Last *et al.*, 2016). Based on their known distribution and habitat preference, the Kuhl's devilray is considered the species most likely to interact with the ECIF (*pers. comm.* P. Kyne).

When compared, interactions with the giant manta ray, reef manta ray and the giant devilray are less likely (*pers. comm.* P. Kyne). The giant manta ray is considered to be a pelagic/oceanic species and it is commonly associated with coastlines with regular upwellings, oceanic island groups, and offshore pinnacles or seamounts (Couturier *et al.*, 2011; Marshall *et al.*, 2018a; Marshall *et al.*, 2009). As giant manta rays inhabit areas with less net effort, interactions with this species will be less frequent (*pers.*

[21] *A review of devilray (Family Mobulidae) taxonomy identified Manta as a synonym of Mobula and therefore reclassified the devilrays as a single genus family (Fricke et al., 2019; Last et al., 2016; White et al., 2017b). The intent of the legislation though remains the same and the giant manta ray (M. birostris) and the reef manta (M. alfredi) are still afforded full protection from fishing activities in Queensland waters.*

[22] *The increased number of SOCI reports for devilrays in the post-2015 period is a result of the reef manta (M. alfredi), Kuhl's devilray (M. kuhlii), the Japanese devilray (M. japonica) and the bentfin devilray (M. thurstoni) being listed as migratory species in the EPBC Act 1999 and becoming no-take in the GBRMP.*

comm. C. Simpfendorfer). The reef manta is found more commonly in inshore waters (Couturier *et al.*, 2014; Couturier *et al.*, 2011; Couturier *et al.*, 2018) and there is an increased potential for this species to interact with the ECIF. If and when these species interact with large mesh nets, their size and morphology make contact without capture events more likely (Jacobsen *et al.*, 2019b; Last *et al.*, 2016). *Mobula birostris*, *M. alfredi* and *M. mobular* are three of the largest species in the complex and their morphology (disc widths much larger than their disc length) reduces both the entanglement potential and the risk of mortality. This factor was taken into consideration as part of the RRA and contributed to two of the species receiving lower risk ratings (Table 7; Appendix D).

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 five devilray species. As devilrays are not targeted in the fishery and are not retained, large mesh nets are more likely to be a contributor of risk *verse* the main driver of risk. At a regional level, the long-term consequences of these types of interactions will be lower than what is observed in other regions. In this context, it is less likely that the ECIF will have a significant or long-term detrimental impact on regional devilray populations. The fishery though will contribute to the cumulative fishing pressures exerted on some species. To determine the extent of this risk, further information is required on the species that interact with this fishery, catch rates, and release fates.

Our understanding of how the ECIF interacts with 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 mandating the use of *Vessel Tracking,* the establishment of a *Data Validation Plan,* and ongoing discussions surrounding bycatch minimisation in the ECIF (Department of Agriculture and Fisheries, 2018b). With improved information, it is conceivable that a number of these species will be excluded from subsequent ERAs involving the Large Mesh Net Fishery. In the interim, it is recommended that protective descriptions applied in the *Fisheries (General) Regulation 2019* and *Fisheries Declaration 2019* be expanded to include all devilray species. This will provide the subgroup with a consistent level of protection across Queensland and ensure that all devilray species are being monitored through the SOCI logbooks.

Species-specific recommendations

1. ***Increase the level of information on devilray interactions, catch compositions and review catch data from ancillary projects to identify what species are more likely to interact with this fishery.***

   Catch data for devilrays has a high level of uncertainty and further information is required on the species that will interact with this aspect of the ECIF. As the taxonomy of this group has shifted, it is less clear how many of the five species will regularly interact with the fishery. The SCP uses mesh sizes more than double that permitted in the ECIF, and mobulid entanglements are documented with more regularity. This data could be used to inform management on what species are more likely to interact with nets on the Queensland east coast.

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 target species, this change will not have a significant economic impact on commercial fisheries operating in Queensland waters.

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

   Batoids which include 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. This may also require the provision of further educational material/advice to fishers about the changes.

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 through 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*)	Large Mesh Net: Gillnets	**Precautionary High**

While the estuary stingray (*Hemitrygon fluviorum*) 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 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, this species can be retained in areas not encompassed within the *Nature Conservation Act 1992.* As the species is primarily associated with mangrove swamps, estuaries and riverine systems (Last *et al.*, 2016), interactions with this species will be largely confined to gillnets. 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 ECIF catch (Department of Agriculture and Fisheries, 2019c). 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 Queensland east coast.

Anecdotal evidence suggests that the distribution of the estuary stingray has contracted and the species has experienced on overall decline in abundance (Kyne *et al.*, 2016; Pierce & Bennett, 2011).

These declines are 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. When compared, large mesh nets will be a contributor of risk for this species *verse* the main driver of risk.

When the interaction potential and key drivers of risk are taken into consideration, the final risk rating for the estuary stingray is viewed as precautionary (Table 7). The fishery will be a contributor of risk for this species 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 further 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 this fishery (Department of Agriculture and Fisheries, 2019c). This change though would have implications for fisheries outside of the ECIF, namely the *Gulf of Carpentaria Inshore Fishery,* the *River & Inshore Beam Trawl Fishery,* and the *East Coast Otter Trawl Fishery.*

Species-specific recommendations

1. ***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 align fisheries legislation with other legislative instruments, namely the *Nature Conservation Act 2006.* Noting that this change will have implications for other commercial fisheries in Queensland and would require some form of broad-scale education / species identification program.

2. ***Improve the level of information on estuary stingray interactions in the ECIF including on catch rates in critical habitats and locations where the fishery contributes to regional/cumulative fishing pressures***.

   The above changes could be 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 context on the extent of the risk posed by this fishery.

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, 2018a). 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 dolphin, shark and ray species the final risk ratings were considered precautionary and are unlikely to require or 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.

6 References

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7 Appendices

Appendix A	–	*Summary of the Species Rationalisation Process (Protocols & Assessment).*
Appendix B	–	*Species Rationalisation Process: Justifications & Considerations.*
Appendix C	–	*Overlap percentages used to calculate scores for the availability attribute.*
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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 though 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 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.*, 2019b) were removed from the analysis.
2. The distribution of the remaining species were compared with the prescribed area of fishing symbols used in the *East Coast Inshore Fishery* (ECIF).
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 the 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 Level 2 ERA for the Large Mesh Net Fishery are provided in Appendix B.

2. Summary Tables

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

Table A1—*Summary of the Species of Conservation Concern (SOCC) that were considered for inclusion in the in the Large Mesh Net 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 stakeholders and members of the scientific community.

Common name	***Species name***	***CAAB***	***Included***
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**
Leatherback turtle	*Dermochelys coriacea*	39 021001	**Y**
Sirenia			
Dugong	*Dugong dugon*	41 06001	**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**
Short-beaked common dolphin	*Delphinus delphis*	41 116001	**Y**
False killer whale	*Pseudorca crassidens*	41 116013	**Y***
Spinner dolphin	*Stenella longirostris*	41 116017	**Y***
Sharks			
Great white shark	*Carcharodon carcharias*	37 010003	**N***
Speartooth shark	*Glyphis glyphis*	37 018041	**Y**
Shortfin mako shark	*Isurus oxyrinchus*	37 010001	**N***
Great hammerhead	*Sphyrna mokarran*	37 019002	**Y**
Scalloped hammerhead	*Sphyrna lewini*	37 019001	**Y**
Winghead shark	*Eusphyra blochii*	37 019003	**Y**
Smooth hammerhead	*Sphyrna zygaena*	37 019004	**Y***

Common name	***Species name***	***CAAB***	***Included***
School shark	*Galeorhinus galeus*	37 017008	**N***
Batoids			
Giant manta ray	*Mobula birostris* (synonym: *Manta birostris*)	37 041004	**Y***
Reef manta ray	*Mobula alfredi*	37 041005	**Y**
Kuhl's devilray	*Mobula kuhlii* (synonym: *Manta eregoodootenkee)*	37 041001	**Y**
Giant devilray (synonym Japanese devilray)	*Mobula mobular* (synonym: *M. japanica*)	37 041002	**Y**
Bentfin devilray	*Mobula thurstoni*	37 041003	***Y***
Largetooth sawfish (*synonym*—Freshwater 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**

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

Ecological Component & Species	
<u>Dolphins (Odontocetes)</u> 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) 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) 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)	***<u>Dolphins (Odontocetes) cont.</u>*** 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) ***<u>Sharks</u>*** Whale shark, *Rhincodon typus* (CAAB 37 014001) 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) Longfin mako shark, *Isurus paucus* (CAAB 37 01002 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)

Ecological Component & Species	
Sharks continued Harrisson's dogfish, *Centrophorus harrissoni* (CAAB 37 020010) Southern dogfish, *Centrophorus zeehaani* (CAAB 37 020011) Spiny dogfish, *Squalus acanthias* (CAAB 37 020008) Crested hornshark, *Heterodontus galeatus* (CAAB 37 007003) ***Rays/Batoids*** Chilean devilray, *Mobula tarapacana* (CAAB 37 041006)	***SOCC subgroups excluded during the Level 1 ERA analysis (Jacobsen et al., 2019b)*** - Whales - Sea snakes - Crocodiles - Protected teleosts - Syngnathids - Seabirds - Terrestrial mammals

Appendix B—Species Rationalisation Process: Key Justifications and Considerations

The following provides a detailed overview of the key justifications and considerations used to omit or include a species in the *Large Mesh Net 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 stakeholders and members of the scientific community.

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
Marine turtles				
Green turtle	*Chelonia mydas*	39 020002	**Y**	***Notes***—Included in the Level 2 ERA. Reported effort in the ECIF 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, 2019c), a previous *Fisheries Observer Program* and the *Wildlife Stranding and Mortality Database* (Greenland *et al.*, 2002; Meager & Limpus, 2012)
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**	
Leatherback turtle	*Dermochelys coriacea*	39 021001	**Y**	
Sirenia				
Dugong	*Dugong dugon*	41 206001	**Y**	***Notes***—Included in the Level 2 ERA.

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
Dolphins (Odontocetes)				
Australian humpback dolphin	*Sousa sahulensis*	41 116014	**Y**	***Notes***—Included in the Level 2 ERA. A review of distributional data and information collated through the SOCI logbooks, *Wildlife Stranding and Mortality Database* (Meager, 2016a) and a former *Fisheries Observer Program* suggest that the majority of interactions will involve the Australian humpback dolphin (*Sousa sahulensis*), the Australian snubfin dolphin (*Orcaella heinsohni*), the common bottlenose dolphin (*Tursiops truncatus*), the Indo-Pacific bottlenose dolphin (*T. aduncus*) and the common dolphin (*D. delphis*). Based on this data and advice provided as part of the *East Coast Inshore Fishery Bycatch Management Strategy Workshop* (Townsville, 14–15 May), all five species were included in the Level 2 ERA. *Note—the Australian humpback dolphin (S. sahulensis) is a relatively new species that was historically considered conspecific with the Indo-Pacific humpback (S. chinensis*). *Sousa chinensis is listed as a migratory species under CMS and the EPBC Act and the intent of this legislation will (more than likely) apply to S. sahulensis. It is also noted that all cetaceans are protected under the EPBC Act.*
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**	
Common dolphin	*Delphinus delphis*	41 116001	**Y**	
False killer whale	*Pseudorca crassidens*	41 116013	**Y***	***Notes***—Included in the Level 2 ERA based on recommendations from experts attending the *East Coast Inshore Fishery Bycatch Management Strategy Workshop* (Townsville, 14–15 May). The species has been reported in StrandNET and strands infrequently. Information on the species is limited and there is no information on population numbers in Australian waters (Reeves *et al.*, 2003); although species is likely to occur in low abundance (Department of the Environment, 2019u). Advice from the Department of Environment and Energy suggests that the species in more likely to interact with fisheries operating in deeper water environments; particularly line-based fisheries including long-line fisheries. Further, there are no reported cases of the species interacting with commercial fisheries in

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				Queensland. To this extent, the inclusion of *P. crassidens* in the Level 2 ERA is considered precautionary and may need further assessment as part of the Residual Risk Analysis. *Additional Consultation*—Additional consultation on the scope and extent of the Level 2 ERA indicated that the species has been reported from the Queensland east coast and forms groups often along the outer Great Barrier Reef (*pers. comm.* J. Meager). The species is expected to have very low interaction rates with the ECIF but was included in the assessment based on expert advice. The decision to include the species in the Level 2 ERA is considered precautionary.
Fraser's dolphin	*Lagenodelphis hosei*	41 116006	**N***	***Not Included***—Species is infrequently recorded in StrandNET (Meager, 2016a). However, *L. hosei* prefers waters south of 30 S. It is also viewed as a deeper water species (>1000m) that occupies the outer shelf or continental shelf (Department of the Environment, 2019aj). Species is not expected to interact with the ECIF or, if applicable, at levels that are not expected to have a long-term or detrimental impact on regional populations. Species is considered 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**	***Not Included***—*Stenella coeruleoalba* strandings are infrequent with only two reported from southern Queensland. The species Is unlikely to interact with the ECIF although there is limited information on the distribution of this species in Australian waters. The Species Profile and Threats Database (SPRAT) suggests that this 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 Environment, 2019af). More broadly, the species was categorised as of *Least*

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				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***	***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, 2019v). The species is typically found north of 34° S and in waters generally deeper than 200m including on the continental shelf. Species is unlikely to have significant interactions with the ECIF (if applicable) and/or at levels that will have detrimental impact on regional populations. Species is also 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**	***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, 2019t). The Department of Environment and Energy 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, 2019t) and the species is not expected to interact with the ECIF.
Spinner dolphin	*Stenella longirostris*	41 116017	**Y**	***Included***—*Stenella longirostris* has been reported infrequently in StrandNET and records for this species incorporate the Gulf of Carpentaria, the Queensland east coast (inc. the Great Barrier Reef) and New South Wales (Bannister *et al.*, 1996; Department of the Environment, 2019w; Marsh, 1990).

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				The species in 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 jurisdictions that are adjacent to and outside of Australian waters. The species is not expected to have a high number of interactions with the ECIF 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). *Additional Consultation*—Additional consultation on the scope and extent of the Level 2 ERA indicated that the spinner dolphin has been observed in the Great Barrier Reef and at water depths between 50 and 100m (*pers. comm*. J. Meager). While interactions with the ECIF are expected to be low, it was recommended that the species be included in the assessment as a precautionary measure (*pers. comm*. J. Meager).
Rough-toothed dolphin	*Steno bredanensis*	41 116018	**N***	***Not Included***—Infrequent reports of the species being stranded in Queensland (Meager, 2016a) and is generally considered to be a deeper-water or oceanic species (Department of the Environment, 2019s). No past threats have been identified for this species, although the Species Profile and Threats Database suggests that *S. bredanensis* may be susceptible to pelagic gillnet fishing (Department of the Environment, 2019s). The majority of these threats are likely to occur outside of key fishing areas in the Queensland. *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***	***Not Included***—Reports of the species being stranded in Queensland (Meager, 2016a) including one mass stranding (*n* = 53) (Department of the Environment, 2019r). *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, 2019r).

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				No threats have been identified for *P. electra* (Department of the Environment, 2019r) and the species is unlikely to interact with the ECIF. In the event that the ECIF does interact with the fishery, the extent and impact of these interactions are expected to be low to negligible. *Additional Consultation*—Additional consultation on the scope and extent of the Level 2 ERA indicated that the species is frequently recorded in StrandNET and that it forms larger groups in pelagic waters / on the continental shelf (*pers. comm.* J. Meager). 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 melon headed whale in subsequent ERAs.
Short-finned pilot whale	*Globicephala macrorhynchus*	41 116003	**N***	***Not Included***—Three *G. macrorhynchus* strandings have been reported from Queensland and the species is more associated with tropical and temperate oceanic waters the species has been reported in StrandNET (Department of the Environment, 2019q; Meager, 2016a; Minton *et al.*, 2018a). Hunting and 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 ECIF 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 rough short-finned pilot whale in subsequent ERAs.
Killer whale	*Orcinus orca*	41 116011	**N**	***Not Included***—Rarely encountered species with a single stranding reported in StrandNET (Meager, 2016a). No known populations/aggregations in Queensland waters, rarely observed. In Australian waters. Most observations have been reported in Victoria, South Australian, Tasmania and in Macquarie/Antarctic waters and/or in cold waters near seal colonies (Department of the Environment, 2019p; Reeves *et al.*, 2003).

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
Pygmy killer whale	*Feresa attenuata*	41 116002	**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). Species rarely seen close to shore and not expected to be significantly abundant in Australian waters (Department of the Environment, 2019m).
Pygmy sperm whale	*Kogia breviceps*	41 119001	**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* suggest that the species may be susceptible to net fishing (Department of the Environment, 2019l). These threats are more prominent in other (international) jurisdictions *e.g.* Indonesia, Sri Lanka (Department of the Environment, 2019l).
Long-finned pilot whale	*Globicephala melas*	41 116004	**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, 2019k; Minton *et al.*, 2018b).
Dusky dolphin	*Lagenorhynchus obscurus*	41 116008	**N**	***Not Included***—The northernmost point of the *L. obscurus* Australian distribution lies to the south of Queensland managed waters (Department of the Environment, 2019j)
Spectacled porpoise	*Phocoena dioptrica*	41 117001	**N**	***Not Included***—Species does not occur and/or is unlikely to occur in waters managed by Queensland (Department of the Environment, 2019i).
Commerson's dolphin	*Cephalorhynchus commersonii*	N/A	**N**	***Not Included***—Species does not occur in waters managed by Queensland (Crespo *et al.*, 2017).
Hourglass dolphins	*Lagenorhynchus cruciger*	41 116007	**N**	***Not Included***—Species does not occur and/or is unlikely to occur in waters managed by Queensland (Braulik, 2018a).

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
Southern right whale dolphin	*Lissodelphis peronii*	41 116009	**N**	***Not Included***—Species does not occur and/or is unlikely to occur in waters managed by Queensland (Braulik, 2018b).
Burrunan dolphin	*Tursiops australis*	41 116022	**N**	***Not Included***—Species does not occur in Queensland managed waters (Charlton-Robb *et al.*, 2011)
Irrawaddy dolphin	*Orcaella brevirostris*	N/A	**N**	***Not Included***—*Orcaella brevirostris* is now considered 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**	***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, 2019b).
Strap toothed whale	*Mesoplodon layardii*	41 120009	**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 this sector of the ECIF.
Giant beaked whale (aka Arnoux's)	*Berardius arnuxii*	41 120001	**N**	***Not Included***—Species does not occur in Queensland managed waters (Department of the Environment, 2019h).
Dwarf sperm whale	*Kogia sima*	41 119002	**N**	***Not Included***—Dwarf sperm whales (*K. sima*) are not considered abundant in Australian waters and sightings/strandings for this species are limited (Department of the Environment, 2019g). In the unlikely event that a *K. sima* interaction does occur in the ECIF, the extent and impact of these interactions are expected to be low to negligible.
Southern bottlenose whale	*Hyperoodon planifrons*	41 120002	**N**	***Not Included***—Species does not occur in Queensland managed waters (Department of the Environment, 2019f).

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
Tropical bottlenose whale (aka Longman's)	*Indopacetus pacificus*	41 120003	**N**	***Not Included***—Species does not occur in Queensland managed waters (Department of the Environment, 2019x).
Andrew's beaked whale	*Mesoplodon bowdoini*	41 120004	**N**	***Not Included***—Species does not occur in Queensland managed waters (Department of the Environment, 2019y).
Blainville's beaked whale	*Mesoplodon densirostris*	41 120005	**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, often adjacent to much deeper waters (Department of the Environment, 2019z).
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	41 120006	**N**	***Not Included***—*Mesoplodon ginkgodens* are not considered abundant and thought to primarily occur in deep, offshore waters (Department of the Environment, 2019aa).
Gray's beaked whale	*Mesoplodon grayi*	41 120007	**N**	***Not Included***—*Mesoplodon grayi* is considered a southern species with low potential to interact with fisheries in Queensland (Taylor *et al.*, 2008d).
Hector's beaked whale	*Mesoplodon hectori*	41 120008	**N**	***Not Included***—*Mesoplodon hectori* is considered a southern species with low potential to interact with fisheries in Queensland (Taylor *et al.*, 2008a).
True's beaked whale	*Mesoplodon mirus*	41 120010	**N**	***Not Included***—Species does not occur in Queensland managed waters (Taylor *et al.*, 2008b).
Shepard's beaked whale	*Tasmacetus shepherdi*	41 120011	**N**	***Not Included***—Species does not occur in Queensland managed waters (Braulik, 2018c).

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
Curvier's beaked whale	*Ziphius cavirostris*	41 120012	**N**	***Not Included***—Species is more commonly found in deeper water environments (>1000m) and is unlikely to interact with the tunnel net fishery (Taylor *et al.*, 2008c).
Sharks				
Whale shark	*Rhincodon typus*	37 014001	**N**	***Not Included***—Whale sharks have been reported from the Queensland east coast and the ECIF overlaps with their known distribution (Last & Stevens, 2009). However, there have been no reports of the species interacting with net or line fisheries operating on the Queensland east coast. 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 like 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). In the unlikely event that a whale shark were to interact with a large mesh net, there is a low probability of enmeshment given the size of the animal and current gear restrictions.
Great white shark	*Carcharodon carcharias*	37 010003	**N***	***Notes***—While the white shark (*C. carcharias*) overlaps with the ECIF (Last & Stevens, 2009), the species has not been reported from the fishery through either the logbook program or a previous *Fisheries Observer Program*. It has however been reported from the shark control program (*n* = 111, 2001–2017 inclusive); primarily in waters south of Bundaberg (Queensland Government, 2019b). Encounter rates with this species tend to be lower (Department of the Environment and Energy, 2013) and misidentifications may have contributed to absence of catch data from the ECIF. If interactions were to occur in the fishery, they would be more likely in the southern half of Queensland. This inference is supported by data obtained through the Shark Control Program. Even so, interaction rates with this species are expected to be low. *Additional Consultation*—Additional consultation on the scope and structure of the TEP Level 2 ERA indicated that white sharks are unlikely to interact with the gillnet fishery with great frequency. Accordingly, it

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				was recommended that the species be omitted from the large mesh net (gillnet and ring net) ERA (*pes. comm.* C. Simpfendorfer).
Grey nurse shark	*Carcharias taurus*	37 008001	**N**	***Not Included***—While the grey nurse shark (*C. taurus*) distribution overlaps with the ECIF, a number of factors reduce the risk of an interaction occurring in this fishery. Previous research on grey nurse shark movements and migration patterns identified Wolf Rock as the most northerly part of the species known range (Bansemer & Bennett, 2011). As Wolf Rock is located south of Fraser Island, a high proportion of the ECIF effort would occur outside their known geographical range. Within Queensland, grey nurse sharks aggregate in and around rocky reef systems that are often afforded additional protections from commercial and recreational fishing (Last & Stevens, 2009). Grey nurse shark is typically found close to substrate and at depths where net interactions are less likely to occur. While the species does undertake southern migrations, there is little evidence to suggest that these migrations are impacted by the ECIF. Research has shown that grey nurse sharks will take baited hooks / lures and evidence suggests that some animals will experience multiple hooking events (Bansemer & Bennett, 2010). While the ECIF does have a line sector, it makes up a small component of the catch/effort and operators target finfish outside the rocky reef complex. It is for this reason that the *Rocky Reef Fishery* (RRF) and the recreational fishing sector are more likely to interact with this species (Department of Agriculture and Fisheries, 2019b).
Speartooth shark	*Glyphis glyphis*	37 018041	**Y**	***Notes***—The distribution of *Glyphis glyphis* remains uncertain with research suggesting that speartooth sharks are extirpated from the majority (if not all) of the Queensland east coast (Compagno *et al.*, 2009; Last & Stevens, 2009; Peverell *et al.*, 2006). If *G. glyphis* had viable east coast populations, it would more likely occur in far north Queensland where there are smaller amounts of ECIF effort (Department of Agriculture and Fisheries, 2019c; Peverell *et al.*, 2006). 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. In the event that *G. glyphis* does occur on the Queensland east

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				coast, the ECIF would be more likely to interact with the species in estuarine and riverine systems. The extent of these (potential) interactions though may be masked by the infrequent nature of the interactions and a high potential for misidentifications with to more common species like the pigeye (*Carcharhinus amboinensis*) and the bull shark (*C. leucas*). As evidence suggests that the species may be extirpated on the Queensland east coast, some consideration was given to excluding the species from the Level 2 ERA. The premise being that there is limited need to manage or mitigate risk for species that do not interact with the fishery. Uncertainty surrounding the distribution of *G. glyphis* and the potential for the species to interact with ECIF also makes it difficult to quantify the level of risk. These types of data deficiencies increase the likelihood that the PSA will produce a highly conservative risk rating for *G. glyphis*. Accordingly, results obtained from the PSA will be more representative of the 'potential' risk *verse* the actual or real risk (Department of Agriculture and Fisheries, 2018a). While recognising the above considerations, the species was included in the *Large Mesh Net SOCC Level 2 ERA* as any interactions (real or potential) may have long-term implications for this species. The decisions to include the species in the assessment is considered precautionary and data deficiencies will need to be considered as part of the Residual Risk Assessment. Due to these uncertainties, it is recommended that the potential for the ECIF to impact *G. glyphis* be explored further as part of the *Queensland Monitoring and Research Plan*.
Northern river shark	*Glyphis garricki*	37 018042	**N**	***Not Included***—Distribution does not extend into Queensland managed waters with the species primarily found in north-west Australia (Last & Stevens, 2009). *Glyphis garricki* was not included in the Level 2 ERA.
Porbeagle shark	*Lamna nasus*	37 010004	**N**	***Not Included***—Interactions with *L. nasus* considered unlikely in the ECIF. *Lamna nasus* prefers more temperate environments and the species is more likely to occur on the continental shelf (Last & Stevens, 2009). This species, if encountered, will most likely interact with Commonwealth managed fisheries *e.g.* the East Coast Tuna & Billfish Fishery.

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
Sandtiger shark	*Odontaspis ferox*	37 008003	**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 ECIF (*pers. comm.* D. Bowden; Last & Stevens, 2009).
Shortfin mako shark	*Isurus oxyrinchus*	37 010001	**N***	***Not Included***—Mako sharks make up a small component of the ECIF catch (<1t) and the two 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 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. Catch data for the species though suggests that it is taken infrequently in the fishery with distributional data indicating that the species prefers oceanic and pelagic environments (Last & Stevens, 2009) *Additional Consultation*—Additional consultation on the scope and structure of the TEP Level 2 ERA indicated that the shortfin mako species would be a lower-priority species for assessment (*pes. comm.* C. Simpfendorfer).
Longfin mako shark	*Isurus paucus*	37 010002	**N**	***Not Included***—Mako sharks make up a small component of the ECIF catch (<1t) and the two 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 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. Catch information for mako sharks retained for sale in Queensland has limited species resolution. However, the majority of the mako sharks retained for sale are expected to be shortfin makos (*I. oxyrinchus*). While information on the distribution of the longfin mako (*I.* paucus) is more limited, the species is more likely to be encountered in deeper water / oceanic environments and in fisheries managed by the Commonwealth (*e.g.* the *East Coast Tuna and Billfish Longline Fishery*) or adjacent jurisdictions (*e.g.* Indonesia) (Last & Stevens, 2009; White *et al.*, 2006).

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				Isurus paucus is not expected to interact with the ECIF with great regularity, particularly in inshore and nearshore environments. The extent of these interactions and therefore the risk posed by the ECIF were not considered sufficient to include this species in the Level 2 ERA for TEP species.
Great hammerhead	*Sphyrna mokarran*	37 019002	**Y**	***Notes***—Included in the Level 2 ERA.
Scalloped hammerhead	*Sphyrna lewini*	37 019001	**Y**	***Notes***—Included in the Level 2 ERA.
Winghead shark	*Eusphyra blochii*	37 019003	**Y**	***Included***—When compared to the scalloped, great, and smooth hammerhead shark, datasets for the winghead shark (*Eusphyra blochii*) are more limited. The distribution of *E. blochii* does overlap with the ECIF and the species is mainly found in coastal/nearshore waters where net fishing occurs (Last & Stevens, 2009; Smart & Simpfendorfer, 2016). While *E. blochii* 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	**Y***	***Included***—Distribution of the smooth hammerhead is largely confined to temperate waters (Last & Stevens, 2009) and the species is more likely to interact with commercial and recreational fishers in New South Wales. In Queensland, any interactions with the smooth hammerhead shark will be confined to waters in, around south east Queensland (Simpfendorfer, 2014). This suggests that the majority of the *S. zygaena* population/stock is found in waters outside of Queensland and that the ECIF poses a more limited risk when compared to the other species. This inference is partially supported by a non-detriment finding where the key discussions involving Queensland revolved around the scalloped hammerhead (*S. lewini*) and the great hammerhead (*S. mokarran*). Both of these species are being assessed as part of the Level 2 ERA. *Additional Consultation*—Additional consultation on the scope and structure of the TEP Level 2 ERA recommended that the smooth hammerhead shark be included as they will interact with the large mesh net (gillnets) fishers in south east Queensland (*pes. comm.* C. Simpfendorfer). Based on this recommendation,

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				the species was included in the Level 2 ERA. The decision to include the species in the assessment is considered precautionary.
Oceanic whitetip shark	*Carcharhinus longimanus*	37 018032	**N**	***Not Included***—The oceanic whitetip shark (*C. longimanus*) is largely associated with oceanic environments (Department of the Environment and Energy, 2014; Last & Stevens, 2009) and interactions with the ECIF are considered unlikely.
Pelagic thresher	*Alopias pelagicus*	37 012003	**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 the ECIF, 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 ECIF the number and frequency of the interactions are not expected to have a long-term or detrimental impact on the health of regional stocks/populations.
Bigeye thresher	*Alopias superciliosus*	37 012002	**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 supported by an absence of thresher interactions in the logbook data and in a previous *Fisheries Observer Program*. While the species may occur in inshore waters, the number and frequency of ECIF interactions are not expected to have a long-term or detrimental impact on the health of regional stocks/populations.
Thresher shark	*Alopias vulpinus*	37 012001	**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 longline fishing operations managed under the Commonwealth framework.

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
Basking shark	*Cetorhinus maximus*	37 011001	**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 ECIF and therefore it was not included in the Level 2 ERA.
Harrisson's dogfish	*Centrophorus harrissoni*	37 020010	**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**	***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***	***Not included***—The distribution of *G. galeus* has overlaps with the ECIF and the species has been reported as far north as Moreton Bay in south-east Queensland. Based on the available information the species prefers continental and insular shelves and inhabits water depths down to 600m (Last & Stevens, 2009). School sharks have been reported from the ECIF with around 83t retained in the fishery since 1993. The overwhelming majority of this catch (78t) was retained before the introduction of the shark (S) fishery symbol with 2004 accounting for more than half of the total reported catch. Since the introduction of the S fishery symbol, the reported catch for *G. galeus* has dropped with less than 2t reported from the ECIF since 2009. While noting these figures, DAF recognises that the species may still be caught in the fishery but discarded. School sharks are retained in the *Southern and Eastern Scalefish and Shark Fishery* and in state managed fisheries across Tasmania, Victoria and South Australia (Australian Fisheries Management Authority, 2019) and the stocks in these regions have been classified as depleted (Woodhams *et al.*, 2018). When compared to the ECIF, these fisheries retain higher amounts of *G. galeus* with annual catch rates fluctuating between 191 and 212t (2013 –2017 inclusive) (Woodhams *et al.*, 2018). At a species level, *G. galeus* has a number of the *k*-selected life history traits reaching sexual maturity at 12–16 years and having *maximum age* estimates of >50 years (Australian Fisheries Management Authority,

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				2019; Last & Stevens, 2009; Woodhams *et al.*, 2018). These characteristics make the species more vulnerable to sustained fishing pressures like those observed in southern Australia. *Additional Consultation*—Additional consultation indicated that the Queensland presents the upper limits of the school shark distribution. Due to this reason, it is recommended the species be removed from the assessment as there is a lower probability of it being caught in the ECIF (*pes. comm.* C. Simpfendorfer). In the event that it is caught by gillnet operators, the extent of these interactions is not expected to have a longer-term impact on the conservation status of this species.
Spiny dogfish	*Squalus acanthias*	37 020008	**N**	***Not Included***—Species distribution covers southern waters and *S. acanthias* does not occur in waters managed by Queensland (Last & Stevens, 2009).
Crested hornshark	*Heterodontus galeatus*	37 007003	**N**	***Not Included***—The crested hornshark (*H. galeatus*) was included on the preliminary list as it is afforded additional protections in Moreton Bay under the *Marine Parks (Moreton Bay) Zoning Plan 2008*. The majority of this species distribution occurs outside of Queensland; although the species can be found as far north as Cape Moreton (Bray, 2019; Kyne & Bennett, 2016; Last & Stevens, 2009). The species is commonly associated with rocky reef systems, among large macroalgae and on seagrass beds. The species is classified as '*Least Concern*' under the IUCN (Kyne & Bennett, 2016) and it is not afforded any additional protections in Fisheries legislation and/or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In the ECIF there is limited evidence to suggest that *H. galeatus* interacts with the fishery and/or that regional populations are experiencing significant levels of fishing mortality. Due to these reasons *H. galeatus* was excluded from the Level 2 ERA.

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
Batoids				
Giant manta ray	*Mobula birostris* (synonym: *Manta birostris*)	37 041004	**Y***	***Notes***—Included in the Level 2 ERA ***Considerations***—There have been limited reports of manta rays and devilrays (*Family Mobulidae*) interacting with the ECIF (*n* = 19). All of these interactions were reported in 2015 (*n* = 1), 2016 (*n* = 8) and 2017 (*n* = 10) and the increase in reporting can be partly explained by the listing of *M. alfredi*, *M. kuhlii* and *M. mobular* on the *Convention on the Conservation of Migratory Species* and their subsequent classification as migratory species under the EPBC Act. Prior to 2014 *M. birostris* was the only species of *Mobulidae* included on the SOCI list. Data collected through the SOCI logbooks has poor species resolution and provides limited insight into the size or sex of the animal that interacted with the apparatus. This data though suggests that all of the animals were released alive with one sustaining an injury during the fishing event. The Queensland shark control program (SCP) has a higher number of Devilray (*Family Mobulidae*) interactions with 190 manta rays and 65 devilrays caught in the program between 2001 and 2017 inclusive (Queensland Government, 2019a). While this data shows that this complex is susceptible to net fishing, nets used in the shark control program have a larger mesh size (500mm *verse* 165mm max; Department of Agriculture and Fisheries, 2016) and manta rays would be more susceptible to entanglement in this program. As a consequence, it would not be appropriate to draw parallels between the number of manta rays / devilrays reported in the SCP and the ECIF. The complex has been subject to a relatively recent taxonomic review and the distributions of some mobula species are less defined. To this extent, the ECIF may only interact with some of the more common species. Even so, there is some potential for these species to interact with the fishery and they were all included in the Level 2 assessment.
Reef manta ray	*Mobula alfredi*	37 041005	**Y**	
Kuhl's devilray	*Mobula kuhlii* (synonym: *Manta eregoodootenke e)*	37 041001	**Y**	
Giant devilray (synonym Japanese devilray)	*Mobula mobular* (synonym: *M. japanica*)	37 041002	**Y**	
Bentfin devilray	*Mobula thurstoni*	37 041003	**Y**	

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				Additional Consultation—Additional consultation on the scope and structure of the TEP Level 2 ERA indicated that the giant manta ray (*M. birostris*) is less likely to be found in areas where gillnet fishing occurs (*pes. comm.* C. Simpfendorfer; P. Kyne). Accordingly, it was suggested that this species could be removed from the assessment. As a precautionary measure, the species were retained in the assessment. However further consideration will need to be given to a) the likelihood that these species will interact with gillnet operations, b) the enmeshment potential and c) other risk mitigation measures. These measures/considerations will form part of the Residual Risk Assessment (RRA) component of the *Productivity and Susceptibility Analysis* (PSA).
Chilean devilray	*Mobula tarapacana*	37 041006	**N**	***Not Included***—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 circumglobal, however information is fragmented. Species is unlikely to interact with the ECIF and may not occur on the Queensland east coast (Last *et. al.,* 2016). Accordingly, it was not included in the Level 2 ERA.
Largetooth sawfish (*synonym*—Freshwater sawfish)	*Pristis pristis*	37 025003	**Y**	***Notes***—Included in the Level 2 ERA ***Considerations***—This subgroup of elasmobranchs have experienced notable population declines and their distribution has experienced a significant contraction (Last *et al.*, 2016). This includes in Queensland where there is a degree of uncertainty surrounding the extent of their distribution on the east coast (D'Anastasi *et al.*, 2013; Kyne *et al.*, 2013a; Simpfendorfer, 2013). While the distribution of all four species extends through to the Queensland east coast, evidence suggests that *A. cuspidata* and *P. zijsron* are more likely to be encountered. The distributions of the two remaining species are less certain and in the case of at least one species, *P. clavata*, it may be extirpated from most if not all of the Queensland east coast (*ECIFFF Bycatch Management Workshop, Townsville, 14–15 May 2019*). From an ERA perspective, uncertainty surrounding the distribution of *Pristis* species makes it difficult to assess the level of risk. For species like *P. clavata* and *P. pristis*, range contractions may mean that the ECIF
Narrow sawfish	*Anoxypristis cuspidata*	37 025002	**Y**	
Green sawfish	*Pristis zijsron*	37 025001	**Y**	
Dwarf sawfish	*Pristis clavata*	37 025004	**Y**	

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				will not interact with these species. While noting this possibility, 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. It is for these reasons that all four species were included in the Level 2 ERA. It is recognised though that the decision to include some of these species in the Large Mesh Net Fishery SOCC Level 2 ERA is precautionary.
Bottlenose wedgefish (synonym—whitespotted guitarfish)	*Rhynchobatus australiae*	37 026005	**Y**	***Notes***—Included in the Level 2 ERA. ***Considerations***—In Queensland, commercial fishers cannot take or possess more than 5 guitarfish (*Family Rhinidae*) and/or shovelnose rays (*Family Rhinobatidae*) for trade or commerce (limit = a combined maximum total). Recreational fishers are limited to an in-possession limit of 1. While the listed species are not afforded additional protections under the EPBC Act, *R. australiae* has been included in the *Convention on the Conservation of Migratory Species* (CMS) list. Further, the wedgefish complex (*Family Rhinidae* inc. *Rhynchobatus* spp.*)* and Guitarfish (*Glaucostegus* spp.) have been listed under the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES). The listing of wedgefish and guitarfish on CMS or CITES may have implications for commercial fisheries in Queensland. Given these considerations and the potential for ECIF operators to interact with *R. australiae*, *R. palpebratus* and *G. typus*, 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 the Fisheries Regulations 2008 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**	
Giant shovelnose ray	*Glaucostegus typus*	37 027010	**Y**	
Estuary stingray	*Hemitrygon fluviorum*	37 035008	**Y**	***Notes***—Included in the Level 2 ERA. 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*. The species is not afforded

ECIF—Large Mesh Net Fishing (gillnets & ring nets)				
Common name	***Species name***	***CAAB***	***Include***	***Considerations***
				additional protections under fisheries legislation and is not listed as a threatened or migratory species under the EPBC Act. As a consequence, the species is not classified (internally) as a *Species of Conservation Interest* (SOCI) and it can be retained for sale in the ECIF. 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). However, *H. fluviorum* is more common in inshore waters. To date there has been no reports of *H. fluviorum* being retained for sale in the ECIF. 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 and threadfin. The extent of these interactions (if any) 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. While the species has been included in the Large Mesh Net Fishery SOCC Level 2 ERA, this decision is considered precautionary.

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). For the purpose of this Ecological Risk Assessment, the highest overlap percentage was used to assign scores to the *availability* attribute (Table 3)* Represents species where maps were not initially available or lacked detail and were revised and refined using alternate sources (refer Appendix D).

Common name	Species	CAAB	2016	2017	2018	Highest %	Availability risk score
			% Overlap	% Overlap	% Overlap		
Marine Turtles							
Green turtle	*Chelonia mydas*	39 020002	7.2	6.4	5.8	7.2	1
Loggerhead turtle	*Caretta caretta*	39 020001	7.2	6.4	5.8	7.2	1
Hawksbill turtle	*Eretmochelys imbricata*	39 020003	7.2	6.4	5.8	7.2	1
Flatback turtle	*Natator depressus*	39 020005	7.2	6.4	5.8	7.2	1
Olive Ridley turtle	*Lepidochelys olivacea*	39 020004	7.2	6.4	5.8	7.2	1
Leatherback turtle	*Dermochelys coriacea*	39 021001	7.2	6.4	5.8	7.2	1
Sirenia							
Dugong	*Dugong dugon*	41 206001	24.8	21.9	20.0	24.8	2
Dolphins							
Common dolphin	*Delphinus delphis*	41 116001	6.9	6.1	5.5	6.9	1
Australian snubfin dolphin	*Orcaella heinsohni*	41 116010	34.8	30.0	28.2	34.8	3
False killer whale*	*Pseudorca crassidens*	41 116013	6.9	6.1	5.5	6.9	1
Australian humpback dolphin	*Sousa sahulensis*	41 116014	23.9	21.2	18.9	23.9	2
Spinner dolphin*	*Stenella longirostris*	41 116017	6.9	6.1	5.4	6.9	1
Common bottlenose dolphin*	*Tursiops truncatus*	41 116019	6.9	6.1	5.4	6.9	1
Indo-Pacific bottlenose dolphin*	*Tursiops aduncus*	41 116020	7.1	6.3	5.6	7.1	1

Common name	Species	CAAB	2016	2017	2018	Highest %	Availability risk score
			% Overlap	% Overlap	% Overlap		
Sharks							
Shortfin mako shark	*Isurus oxyrinchus*	37 010001	0.7	0.8	0.7	0.8	1
Speartooth shark	*Glyphis glyphis*	37 018041	2.2	1.2	0.7	2.2	1
Scalloped hammerhead shark	*Sphyrna lewini*	37 019001	9.7	8.5	7.6	9.7	1
Great hammerhead shark	*Sphyrna mokarran*	37 019002	5.9	5.2	4.5	5.9	1
Winghead shark*	*Eusphyra blochii*	37 019003	9.9	8.7	7.8	9.9	1
Smooth hammerhead shark	*Sphyrna zygaena*	37 019004	6.8	6.2	5.5	6.8	1
Batoids							
Green sawfish	*Pristis zijsron*	37 025001	13.3	11.8	10.6	13.3	2
Narrow sawfish	*Anoxypristis cuspidata*	37 025002	7.6	6.2	5.6	7.6	1
Largetooth sawfish	*Pristis pristis*	37 025003	12.0	10.8	8.4	12.0	2
Dwarf sawfish	*Pristis clavata*	37 025004	0.0	0.0	0.0	0.0	1
Eyebrow wedgefish*	*Rhynchobatus palpebratus*	37 026004	15.0	13.5	9.7	15.0	2
Bottlenose wedgefish*	*Rhynchobatus australiae*	37 026005	11.7	10.1	8.8	11.7	2
Giant shovelnose ray	*Glaucostegus typus*	37 027010	12.4	11.0	9.6	12.4	2
Estuary stingray*	*Hemitrygon fluviorum*	37 035008	48.4	42.5	40.2	48.4	3
Kuhl's devil Ray*	*Mobula kuhlii*	37 041001	11.6	10.2	8.9	11.6	2
Giant devil ray	*Mobula mobular*	37 041002	17.3	16.6	14.7	17.3	2
Bentfin devil ray	*Mobula thurstoni*	37 041003	6.7	6.1	4.8	6.7	1
Giant manta ray	*Mobula birostris*	37 041004	7.1	6.3	5.6	7.1	1
Reef manta ray	*Mobula alfredi*	37 041005	13.5	11.9	10.7	13.5	2

Appendix D—Residual Risk Analysis

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
<u>***Marine turtles***</u> Loggerhead turtle *(C. caretta)* Olive ridley turtle *(L. olivacea)* Leatherback turtle *(D. coriacea)*	*Fecundity (Productivity)*	Large Mesh Net Fishery	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* attributes 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.*
<u>***Marine turtles***</u> Loggerhead turtle *(C. caretta)*	*Maximum size (Productivity)*	Large Mesh Net Fishery	1	2	The loggerhead turtle (*C. caretta*) was initially assigned a low (1) risk score for this 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.
Marine turtles Flatback turtle *(N. depressus)* Olive ridley turtle *(L. olivacea)* Leatherback turtle *(D. coriacea)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	1	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. In reality, the potential or likelihood that all marine turtle species will interact with or encounter net operations in the ECIF is less uniform. For example, data on the known distribution of the olive ridley turtle indicates that species primarily inhabits waters of northern Australia (Limpus, 2008). A small number have been reported from east coast gillnets (*n* = 3 since 2003) and records contained within the *Marine Wildlife Stranding and Mortality Database* (nets & ghost nets) are primarily based in the Gulf of Carpentaria. When compared to other sectors of the ECIF (the Tunnel Net Fishery and Ocean Beach Fishery), there is more potential for this species to interact with gillnets and ring nets. This risk though will be lower in the current fishing environment as: a) effort in this sub-fishery is more concentrated in central and southern Queensland and b) effort levels decrease substantially as you progress further north (Department of Agriculture and Fisheries, 2019c). Accordingly, the risk posed by net fishing to this species is expected to be higher in the Gulf of Carpentaria.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					While flatback turtles inhabit shallower inshore waters, they are primarily found in tropical waters of northern Australia. Data on this species also indicates that nesting occurs further north from Bundaberg to the Torres Strait (Department of the Environment, 2019ac; Limpus, 2007). While the footprint of the Large Mesh Net Fishery extends into this area, a high percentage of the intensively fished effort grids occur below the Great Barrier Reef Marine Park. Further, total effort in the Large Mesh Net Fishery declines as you progress further north and into the areas more preferred by flatback turtles. The Leatherback turtle prefers deeper, pelagic waters and is generally considered to be an oceanic species (Eckert *et al.*, 2012; Limpus, 2009; Wallace *et al.*, 2013). No major nesting sites have been recorded in Australia, although limited density nesting has been reported in some areas of central eastern Australia (from the Sunshine Coast through to central New South Wales) (Department of the Environment, 2019ai). However, evidence suggests that the leatherback turtles are encountered with less frequency in Queensland when compared to green turtles. For example, only five leatherback turtles have been reported through the *Species of Conservation Interest* (SOCI) logbook since 2003. In the *Marine Wildlife Stranding and Mortality and Stranding Database*, nine leatherback turtles have been reported across all sources of mortality (*e.g.* fishing, ghost nets, boat strike) between 1999–2011 (Department of Environment and Science, 2017). ***Key changes to the PSA scores*** The effort distributions of the Large Mesh Net Fishery combined with the known distribution and movements of the flatback, olive ridley, and leatherback turtle indicate that the preliminary scores assigned to the *encounterability* attribute are too precautionary. This inference is supported by information contained in the SOCI logbook, a former *Fisheries Observer Program* and the *Marine Wildlife Stranding and Mortality and Stranding Database*. This data shows that the majority of marine turtle–net interactions on the Queensland east coast involve the green turtle, hawksbill turtle, and

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					loggerhead turtle (Department of Agriculture and Fisheries, 2019c; Department of Environment and Science, 2017; Greenland *et al.*, 2002; Haines *et al.*, 1999; Meager & Limpus, 2012). Given the above factors, the following amendments were made to the preliminary risk ratings as part of the RRA*:* - Scores assigned to the *encounterability* attribute for olive ridley turtles, flatback turtles, and leatherback turtles was reduced from high (3) to low (1). The above changes were largely done in accordance with *Guideline 1: rating due to missing, incorrect, or out of date information* specifically out-of-date data. The changes also align with *Guideline 2: additional scientific assessment & consultation* (*pers. comm.* C. Limpus).
<u>Dolphins</u> *Australian humpback dolphin (S. sahulensis)*	*Size at maturity (Productivity)*	Large Mesh Net Fishery	3	2	In the PSA, the Australian humpback dolphin (*S. sahulensis*) was assigned a precautionary high-risk score (3) for the *size at maturity* attribute. Subsequent consultation on the dolphin species that occur in Queensland waters and their biology indicated that size of maturity for this species would be ≤2 metres (*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) as part of the RRA. The above changes were largely done in accordance with *Guideline 1: rating due to missing, incorrect, or out of date information,* specifically incorrect and out-of-date data (*pers. comm.* J. Meager).
<u>Dolphins</u>	*Age at maturity (Productivity)*	Large Mesh Net Fishery	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-risk score (3) for the *age at maturity* attribute. Subsequent consultation on the dolphin species that

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Australian humpback dolphin (S. sahulensis)					occur in Queensland waters and their biology indicated that the *age at maturity* for this species would be less than 15 years (*pers. comm.* J. Meager). ***Key changes to the PSA scores*** The above changes were largely done in accordance with *Guideline 1: rating due to missing, incorrect, or out of date information* specifically out-of-date data (*pers. comm.* J. Meager). The changes also align with *Guideline 2: additional scientific assessment & consultation.*
<u>Dolphins</u> *Common bottlenose dolphin (T. truncatus)*	*Size at maturity (Productivity)*	Large Mesh Net Fishery	3	3	*Age at maturity* for the common bottlenose dolphin (*T. truncatus*) was not known and the species was assigned a precautionary high-risk score (3) for this attribute as part of the PSA. Subsequent consultation on this species and their biology indicated that there were no studies on Australian populations. However, studies on other populations provided estimates of around 2.8–2.9m and that *size at maturity* is likely to be >2.7m (*pers. comm.* J. Meager). ***Key changes to the PSA scores*** No change to the score but feedback provided during the consultation process supports the assignment of a high-risk score.
<u>Dolphins</u> *Common bottlenose dolphin (T. truncatus)* *Indo-Pacific bottlenose dolphin* *(T. aduncus)*	*Availability (Susceptibility)*	Large Mesh Net Fishery	3	1	Distribution maps obtained through the *Species of National Environmental Significance* database (Department of the Environment and Energy, 2019a), did not include the common bottlenose (*T. truncatus*) or the Indo-Pacific bottlenose dolphin (*T. aduncus*). Accordingly, the 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-risk rating for this attribute.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					While noting the high-risk rating and the justifications used, these values were viewed as 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). These maps though provided a more accurate representation of the current situation. ***Key changes to the PSA scores*** Based on the revised overlap assessments, the preliminary scores assigned to the *availability* attribute in the PSA were reduced from high (3) to low (1). These changes were largely 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)*	Large Mesh Net Fishery	3	2	Data on the common bottlenose dolphin indicates that the species is found in a wide range of environments (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 Environment, 2019ae; Hale *et al.*, 2000). In the ECIF, a higher percentage of the net effort is reported from inshore waters adjacent to the Queensland coastline and in offshore waters <30m deep (Qfish: <u>http://qfish.fisheries.qld.gov.au/query/19a9bfad-0d3b-4313-924d-49a8faf818d3/map</u>). A preference for deeper water environments combined with the estimated depth profile of the fishery (at present) indicates that operators in the ECIF are more likely to encounter the Indo-Pacific bottlenose dolphin (*T. aduncus*). The Indo-Pacific bottlenose dolphin

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					inhabits shallow coastal waters on the continental shelf, around islands, estuaries, and reefs (Department of the Environment, 2019n; Hale *et al.*, 2000). ***Key changes to the PSA scores*** Based on the available information, the preliminary score assigned to the *encounterability* attribute in the PSA 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 *i.e.* they are found in shallower waters and b) a portion of the large mesh net 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 1: rating due to missing, incorrect, or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Dolphins</u> *Short-beaked common dolphin (D. delphis)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	1	The short-beaked common dolphin (*D. delphis*) or common dolphin, was included in the assessment as a precautionary measure as it has been reported within the StrandNET data. Distributional data for the short-beaked common dolphin is limited. In Australia, the species inhabits offshore waters (Filby *et al.*, 2010; Mason *et al.*, 2016) and is rarely observed in Northern Australian waters (Department of the Environment, 2019o; Jefferson & Waerebeek, 2002). In Australia, they apparently occur in two main locations, a cluster in the south-eastern Indian Ocean and another in the Tasman Sea (Department of the Environment, 2019o). In Queensland, the distribution of the short-beaked dolphin is limited to southern Queensland. While the species has not been reported through the SOCI logbooks or

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					through a previous *Fisheries Observer Program*, it has been recorded though the Shark Control Program (pers. comm. J. Meager; Department of Agriculture and Fisheries, 2020a; Department of Environment and Science, 2017). The shark control program uses mesh sizes larger than what is permitted in the ECIF and the *selectivity* of the nets for dolphins is much higher. All of these interactions have been in waters adjacent too and south of the sunshine coast in south-east Queensland. ***Key changes to the PSA scores*** Based on the known distribution and habitat preferences, interactions with the short-beaked common dolphin are expected to be low and infrequent. If the species were to interact with the ECIF it would more than likely be at the southern reaches of the fishery. This suggests that scores assigned to the *encounterability* attribute in the PSA were overly cautious. Accordingly, the score for this attribute was 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 2: additional scientific assessment & consultation,* and *Guideline 3: at risk with spatial assumptions.*
<u>Dolphins</u> *False killer whale (P. crassidens)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	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). 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 low (when compared to other species). While it is recognised that the species can move into shallow waters (Baird, 2018; Baird, 2009; Department of the Environment, 2019u), this does not appear to be a regular occurrence in Queensland and regular ECIF interactions with this species are unlikely.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					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 too precautionary. Accordingly, the score assigned to this attribute was 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*.
Dolphins *Spinner dolphin (S. longirostris)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	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). As the species has not been reported within the SOCI data or in the now ceased *Fisheries Observer Program*, the decision to include the species in the assessment was precautionary. While the spinner dolphin is considered to be a pelagic species, it has been observed in shallow water environments including in the Great Barrier Reef Marine Park (Braulik & Reeves, 2018; Department of the Environment, 2019w). This was the catalyst for the species receiving a high (3) risk score for the *encounterability* attribute. While the species has been observed in shallower waters, risk estimates provided by the PSA were viewed as an overestimate. The spinner dolphin is more frequently observed beyond the Australian Economic Exclusion Zone and in waters exceeding 200m deep (Department of the Environment, 2019w). The IUCN redlist assessment indicates that the species prefers tropical surface water that is typified by a shallow mixed layer, a sharp thermocline and relatively small annual variations in surface temperatures (Braulik &

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Reeves, 2018). They often form large pods with the size of the pod generally increasing as you progress further away from the shoreline. ***Key changes to the PSA scores*** Based on the known distribution and habitat preferences, it is anticipated that the ECIF will present as a lower risk with respect to the *encounterability* attribute. While the species has been observed within ECIF fishing grounds, habitat preferences suggest that they are more likely to be encountered outside of the prescribed fishing grounds. Considering the depth range, habitat preferences, and behavioural patterns of the species, the score assigned to this attribute in the PSA was considered too precautionary. Accordingly, the score for this attribute was 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 2: additional scientific assessment & consultation,* and *Guideline 3: at risk with spatial assumptions*.
<u>Dolphins</u> *False killer whale (P. crassidens)* *Spinner dolphin (S. longirostris)*	*Availability (Susceptibility)*	Large Mesh Net Fishery	1	1	Distribution maps for both the false killer whale (*P. crassidens*) and the spinner dolphin (*S. longirostris*) lacked detail. In the RRA, the overlap percentages for these two species could be refined using data obtained through the IUCN (Baird, 2018; Braulik & Reeves, 2018). These refinements did not alter the original scores. ***Key changes to the PSA scores*** No change to either score.
<u>Sirenia</u> *Dugong (D. dugon)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	2	Dugongs inhabit shallow water environments and the known distribution has a high degree of overlap with the prescribed areas of the fishing symbols used in the ECIF. Of the sub-fisheries that operate in the ECIF, dugong interactions are more likely to occur in the Large Mesh Net Fishery. This inference is supported by data submitted through the SOCI logbooks and compiled through StrandNET. This data shows that all but one of the

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					dugong interactions/mortalities where there was a confirmed or inferred link to (illegal and legal) net fishing activities involved larger mesh nets. The other interaction was with a tunnel net in 2005 (based on 1999–2015 data; Department of Environment and Science, 2017). Interactions between large mesh net operations and dugongs are well documented (Department of the Environment, 2018; Marsh, 2009; Marsh *et al.*, 2005; Meager *et al.*, 2013). The potential consequences of these types of interactions have also been explored in detail and, in a number of instances, resulted in increased protections. On 14th August 1997, the Federal and Queensland Governments announced additional protection measures for dugongs in the southern Great Barrier Reef and Hervey Bay regions. Central to this were the establishment of a two-tiered Dugong Protection Area (DPA) system—Zone A DPAs and Zone B DPAs (Meager *et al.*, 2013; Queensland Government, 2002). Zone A DPAs afford additional protections to significant dugong habitats and prohibit the use of foreshore set nets and offshore set and drift nets.[23] In Zone B DPAs, mesh netting is still permitted however operators are restricted in terms of the type, size, and location of the net and in attendance provisions (Meager *et al.*, 2013; Queensland Government, 2002). These measures are mirrored in legislation governing the use of marine resources in the Great Barrier Reef Marine Park, referred to within as *Special Management Areas* (Great Barrier Reef Marine Park Authority, Undated). These measures are still in effect and continue to afford dugongs with additional protections from net fishing activities. The introduction of the DPAs has also been recognised as a highly effective measure for reducing the number of fishing-related mortalities in the prescribed areas (referenced inannual dugong reports; Department of Environment and Science, 2017).

[23] *Excludes in the Hervey Bay – Great Sandy Strait Protection Area, where specialised fish netting practises are allowed to continue with modifications*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Outside of the DPAs, dugongs are provided further protections through State and Commonwealth Marine Parks *e.g. Great Barrier Reef Marine Park*, *Moreton Bay Marine Park,* and *Great Sandy Marine Park*. In these areas, commercial netting is prohibited in key areas including within Moreton Bay; one of the key strongholds for the southernmost dugong population and among the top 10 habitats for the species (Department of National Parks Sport and Racing, 2015). In the Large Mesh Net Fishery, the implementation and use of net restrictions/prohibitions has limited the interaction potential in some of the more notable dugong regions. These measures, by extension, would help to reduce the level of risk associated with this attribute. It is recognised that dugong interactions and fishing-related mortalities still occur outside of these protected areas. Further, there is still a degree of uncertainty surrounding the number of dugongs that interact with the fishery each year. Reasons for this uncertainty include post-capture mortalities, cryptic mortalities, an increased risk of predation, uncertainty surrounding the cause of death, and in some instances the non-reporting of interactions and/or their active concealment (Biddle *et al.*, 2011). These factors limited the extent of any score reduction applied in this section of the Level 2 ERA. ***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). Further reductions in the scores assigned to this attribute were not considered due to uncertainty in the catch, interaction, and release fate data. The above change was done in accordance with *Guideline 2: additional scientific assessment & consultation*, *Guideline 3: at risk with spatial assumptions,* and *Guideline 7: management arrangements relating to seasonal spatial and depth closures*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Sharks *Speartooth shark (G. glyphis)*	*Age at maturity (Productivity)*	Large Mesh Net Fishery	3	2	There is limited information on the biology of the speartooth shark (Compagno *et al.*, 2009; Department of the Environment, 2015) including on the age at sexual maturity. As no data were available on the biology of this species, this attribute was assigned a precautionary high-risk score (3) in the PSA. 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 of 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 maturity* attribute was reduced from high (3) to medium (2). Changes made as part of the RRA were done in accordance with *Guideline 1: rating due to missing, incorrect, or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Sharks *Speartooth shark (G. glyphis)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	2	The Large Mesh Net Fishery operates in a diverse range of inshore (<2m) and offshore (>2m) environments with operators targeting a range of species (Department of Agriculture and Fisheries, 2019c). This includes in environments where speartooth sharks may be encountered and/or in habitats that are preferred by the species. Evidently, the diversity of fishing operations in the ECIF (both in depth and fishing environments) was one of the reasons why the species was assigned a high-risk rating for this attribute.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					The geographical distribution of the speartooth shark is highly contracted and the species is known from a few scattered localities in northern Australia and New Guinea (Compagno *et al.*, 2009; Department of the Environment, 2019e; Last *et al.*, 2016). Research indicates that the speartooth shark distribution on the Queensland east coast is restricted to rivers north of Cairns and Cape Tribulation (Last & Stevens, 2009). This information though may be outdated with a series of unsuccessful surveys leading to hypotheses that the species may be extirpated from the Queensland east coast (Pillans *et al.*, 2009). Data from the ECIF shows that areas north of Cairns report lower levels of net effort and at lower concentrations (Department of Agriculture and Fisheries, 2019c). This data also shows that the overwhelming majority of large mesh net operations in the ECIF operate outside of the known distribution of the speartooth shark (Department of Agriculture and Fisheries, 2019c). It is recognised that large mesh nets are used in habitats preferred by speartooth sharks *e.g.* turbid, shallow, fast running tidal water in the upper reaches of coastal rivers (Peverell *et al.*, 2006). Similarly, river and estuarine operations in far north Queensland have the potential to interact with the species if it still occurs on the Queensland east coast. If this were to occur the fishery could have a significant and long-term impact on the sustainability of remanent populations. While noting this risk, data on the known distribution and the ECIF effort footprint / participation rates suggests the encounterability risk is lower than what was reported in the PSA. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute for the speartooth shark was reduced from high (3) to medium (2). This change recognises the current distribution of effort and the fact that the majority of effort occurs outside of the known distribution. While large mesh net fishers operate in habitats that support speartooth sharks, there is

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					little evidence that the species is being encountered within the areas of operation. If, however the species is being encountered in the fishery and not being reported (*e.g.* due to misidentifications), there could be significant, long-term implications for remnant populations. This risk was the main reason why the score assigned to the *encounterability* attribute was not reduced further. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* with consideration given to *Guideline 4: at risk in regards to level of interaction/capture with a zero or negligible level of susceptibility*. *Note—While the encounterability scores were reduced the potential long-term consequences of this type of interaction will be higher in this species. If data on the known east coast distribution improves and/or the fishing environment shifts further north, scores assigned to this attribute as part of the RRA may need to be reviewed*
<u>Sharks</u> *Smooth hammerhead shark (S. zygaena*)	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	1	The distribution of the smooth hammerhead shark (*S. zygaena*) extends into Queensland but it is primarily found in temperate waters. Encounters with the smooth hammerhead are more likely to occur in south-east Queensland and New South Wales. While the species has been observed north of these areas, they are generally found in lower numbers and smaller densities (*pers. comm,* C. Simpfendorfer). This was reflected in the assessment of the *availability* attribute. In the *encounterability* PSA assessment, the species was assigned the highest risk score as it inhabits a wide range of inshore and pelagic environments. This will include areas that are being actively fished with large mesh nets. The species though will be exposed to smaller amounts of effort and it will be encountered with less frequency when compared to other hammerhead shark species. To this extent, the *encounterability* potential for this species was assessed as being lower than the scalloped hammerhead (*S. lewini*), great hammerhead (*S. mokarran*), and the winghead shark (*E. blochii*).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Key changes to the PSA scores The preliminary score assigned to the *encounterability* attribute for the smooth hammerhead shark as part of the PSA was reduced from high (3) to low (1). These changes recognise the current distribution of effort and the fact that the species will only interact with a small portion of the prescribed fishing area of the ECIF *i.e.* south-east Queensland. Due to this reason, large mesh net fishers are less likely to encounter this species when compared to other hammerhead shark species. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation,* and *Guideline 4: at risk in regards to level of interaction/capture with a zero or negligible level of susceptibility*.
<u>Sharks</u> *Great hammerhead shark (S. mokarran)*	*Selectivity (Susceptibility)*	Large Mesh Net Fishery	1	3	In the PSA, body size was used as the primary determinant for scores assigned to the *selectivity* attribute. As the great hammerhead (*S. mokarran*) has a maximum total length of 6m the species was 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*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Sharks *Winghead shark (E blochii)*	*Availability (Susceptibility)*	Large Mesh Net Fishery	2	1	In the initial assessment the winghead shark (*E. blochii*) was assigned a medium-risk score for the *availability* attribute. In the RRA this score was refined and recalibrated using an alternate map from the IUCN (Smart & Simpfendorfer, 2016). ***Key changes to the PSA scores*** The preliminary score assigned to this attribute in the PSA was reduced from medium (2) to low (1) based on the revised map assessment. This amendment was done in accordance with *Guideline 2: additional scientific assessment & consultation*
Batoids *Kuhl's devilray (M. kuhlii*)	*Age at maturity (Productivity)*	Large Mesh Net Fishery	3	2	*Age at maturity* for Kuhl's devilray (*M. kuhlii*) is not known and the species was assigned a precautionary high-risk score (3) for this attribute as part of the PSA. Known information on the *age at maturity* for other mobula rays indicate that the complex reaches sexual maturity from 5–15 years. While species-specific data is lacking for Kuhl's devilray, maturity estimates for other species were considered acceptable proxies. ***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*.
Batoids *Kuhl's devilray (M. kuhlii)*	*Availability (Susceptibility)*	Large Mesh Net Fishery	2	1	In the initial assessment the Kuhl's devilray was assigned a medium-risk score for the *availability* attribute. In the RRA this score was refined and recalibrated using an alternate map from the IUCN (Bizzarro *et al.*, 2009). ***Key changes to the PSA scores*** The preliminary score assigned to this attribute in the PSA was reduced from medium (2) to low (1) based on the revised map assessment. This amendment was done in

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					accordance with *Guideline 1: rating due to missing, incorrect, or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Batoids *Kuhl's devilray (M. kuhlii)* *Bentfin devilray (M. thurstoni*)	*Selectivity (Susceptibility)*	Large Mesh Net Fishery	3	2	In the initial assessment the Kuhl's devilray (*M. kuhlii*) and the bentfin devilray (*M. thurstoni*) were assigned a high-risk score (3) for the *selectivity* attribute. While noting this assessment, the risk of entanglement for these species would be lower due to their morphology (disc width approximately twice the size of the disc length) and the current mesh size restrictions. ***Key changes to the PSA scores*** The preliminary PSA 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* (*pers. comm.* P. Kyne)*.* While this score may still represent a risk overestimate, further reductions in the score were not supported by the available information.
Batoids *Bentfin devilray (M. thurstoni*)	*Age at maturity (Productivity)*	Large Mesh Net Fishery	3	2	*Age at maturity* for the bentfin devilray (*M. thurstoni*) is not known and the species was assigned a precautionary high-risk score (3) for this attribute as part of the PSA. Known information on the *age at maturity* for other mobula rays indicate that the complex reaches sexual maturity from 5–15 years. While species-specific data is lacking for the bentfin devilray, maturity estimates for other species were considered acceptable proxies. ***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 1: rating due to missing, incorrect, or out of date information* and *Guideline 2: additional scientific assessment & consultation.*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Batoids *Giant manta ray (M. birostris)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	1	The giant manta ray (*M. birostris*) has a broad distribution and is found in tropical, sub-tropical and temperate waters (Marshall *et al.*, 2018a). It is generally viewed as a pelagic/oceanic species (Couturier *et al.*, 2011), although individuals can be encountered on shallow reefs. The broad habitat profile was an influential factor in the species receiving a high-risk score for the *encounterability* attribute. While the giant manta ray has a broad habitat profile, it is more commonly associated with coastlines that have regular upwellings, oceanic island groups, and offshore pinnacles or seamounts (Marshall *et al.*, 2018a; Marshall *et al.*, 2009)**.** These regions are typically located outside of areas where gillnet fishing occurs (*pers. comm.* C. Simpfendorfer). This in itself reduces the likelihood of the Large Mesh Net Fishery catching this species in the ECIF and, in terms of the Level 2 ERA, its *encounterability* potential. *Note—consultation received during the species rationalisation process suggested that M. birostris could be removed from the assessment as it was unlikely to interact with the fishery. The species though is one of the few afforded additional protections under Fisheries legislation and it was retained in the assessment as a precautionary measure.* ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute for the giant manta ray (*M. birostris*) was reduced from high (3) to low (1). This change recognises the (current) distribution of effort and the fact that the species is unlikely to occur in great numbers where gillnet fishing occurs (*pers. comm.* C. Simpfendorfer; P. Kyne). These amendments were done in accordance with *Guideline 2: additional scientific assessment & consultation*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Batoids *Giant devilray (M. mobular)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	2	In the PSA, the giant devilray (*M. mobular*) was assigned a high-risk rating for *encounterability*. This score rating reflects the broad nature of the habitat/bathymetry descriptions for this species. Subsequent discussions on the distribution of mobulid species on the Queensland east coast indicated that most interactions are likely to be with the Kuhl's devilray (*M. kuhlii*) or the bentfin devilray (*M. thurstoni*) (*pers. comm.* P. Kyne). It was also noted that while *M. mobular* may be encountered in this fishery, these interactions would be infrequent. ***Key changes to the PSA scores*** The score assigned to the *encounterability* attribute was reduced from high (3) to medium (2) for this species on the back of scientific advice. It is conceivable that this score still represents an overestimate for this species. This inference though cannot be confirmed without further information on the distribution of species on the Queensland east coast. This amendment was done in accordance with *Guideline 2: additional scientific assessment & consultation*.
Batoids *Reef manta ray (M. alfredi)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	2	The reef manta (*M. alfredi*) is commonly sighted on the continental shelf, around tropical and subtropical coral, and rocky reefs, around islands, and along the coastline (Couturier *et al.*, 2011; Couturier *et al.*, 2018; Germanov *et al.*, 2019). This contrasts with the giant manta ray (*M. birostris*) which is considered to be more of an oceanic species. Research has shown that the reef manta forms a number of aggregations along the east Australian coastline including at Lady Elliot Island, North Stradbroke Island and off of Byron Bay (Couturier *et al.*, 2011). The species shows a high degree of site fidelity and aggregation sites are often easily accessible. As a consequence, unregulated and illegal tourism is frequently identified as a threat for these species (Couturier *et al.*, 2011; Couturier *et al.*, 2018; Germanov *et al.*, 2019).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					When compared to the giant manta ray (*M. birostris*), the reef manta is thought to be more common along the Pacific and Indian Ocean coastal regions of Australia (Couturier *et al.*, 2011; Marshall *et al.*, 2009). While site fidelity is evident in this species, individuals will undertake seasonal migrations. As such, the species is more likely to be encountered by large mesh net fishers (when compared to *M. birostris*). In the PSA, the species was assigned a high-risk score for the *encounterability* attribute due to it having a relatively broad habitat description *e.g.* a pelagic and inshore species that can be found in and around coral or rocky reefs (Last *et al.*, 2016). The tendency of this species though is to aggregate in areas that attract lower levels of net fishing (*e.g.* around coral reefs and rocky reefs; particularly in south east Queensland). This suggests that the *encounterability* rate will be lower than what is assumed in the PSA. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute for the reef manta (*M. alfredi*) was reduced from high (3) to medium (2).These changes recognise the current distribution of effort and the fact that the key aggregation sites for this species will occur in areas where net fishing is less prevalent (*e.g.* around coral reefs and rocky reefs). As the species undertakes seasonal migration there is some potential for it to interact with the ECIF. The number of interactions is still expected to be low (*pers. comm.* P. Kyne) but cannot be confirmed without direct verification or validation. Due to these reasons the attribute was classified as a medium (2) risk instead of low (1). These amendments were done in accordance with *Guideline 2: additional scientific assessment & consultation*.
<u>Batoids</u>	*Post-capture mortality (Susceptibility)*	Large Mesh Net Fishery	3	1	In the PSA, the giant devilray (*M. mobular*), giant manta ray (*M. birostris*), and the reef manta (*M. alfredi*) were all assigned a high-risk rating for *post-capture mortality*. These scores were due to an absence of information on post-capture survival rates. Due to their

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Giant manta ray (M. birostris) *Giant devilray (M. mobular)* *Reef manta ray (M. alfredi)*					size, entanglements with the giant manta ray, the giant devilray, and reef manta would be rare (*pers. comm.* P. Kyne; C. Simpfendorfer). This factor combined with their morphology of the species (disc widths much larger than their disc length) make 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 all three species were reduced from high (3) to low (1).These changes recognises the higher probability of contact without capture events and initiatives that restrict the entanglement potential *e.g.* mesh size restrictions. 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> *Kuhl's devilray (M. kuhlii)* *Bentfin devilray (M. thurstoni*)	*Post-capture mortality (Susceptibility)*	Large Mesh Net Fishery	3	2	In the PSA, the Kuhl's devilray (*M. kuhlii*) and the bentfin devilray (*M. thurstoni*) were assigned a high-risk rating for *post-capture mortality*. These scores were due to an absence of information on post-capture survival rates. 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*** Preliminary scores assigned to the *post-capture mortality* attribute for these two species were reduced from high (3) to medium (2). These changes were less severe when compared to the giant devilray (*M. mobular*), giant manta ray (*M. birostris*) and the reef manta (*M. alfredi*). This differential is due to the Kuhl's devilray and bentfin devilray being smaller species. 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.*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Batoids *Largetooth sawfish (P. pristis)* *Green sawfish (P. zijsron)*	*Selectivity (Susceptibility)*	Large Mesh Net Fishery	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 assigned green (*P. Pristis*) and largetooth sawfish (*P. zijsron*) were assigned a low-risk score (1) for this attribute, with the narrow (*A. cuspidata*) and dwarf (*P. clavata*) sawfish assigned a high (3) risk score. For the sawfish complex, *selectivity* criteria are negated by their tooth rostrum which increases the likelihood of entanglement. These entanglements are likely to occur across a wide range of size classes. ***Key Changes to the PSA scores*** Preliminary risk scores assigned to the largetooth sawfish and green sawfish for the *selectivity* attribute were increased from low (1) to high (3). These 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 (bycatch management workshop, Townsville, 14–15 May 2019*).
Batoids *Largetooth sawfish (P. pristis)* *Dwarf sawfish (P. clavata)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	1	The Large Mesh Net Fishery operates in a diverse range of inshore (<2m) and offshore (>2m) environments with operators targeting a range of species (Department of Agriculture and Fisheries, 2019c). This includes habitats and bathymetries where the largetooth sawfish (*P. pristis*) and the dwarf sawfish (*P. clavata*) may be found. Evidently, the diversity of fishing operations in the ECIF (both in depth and fishing environments) was one of the reasons why the species was assigned a high-risk rating for this attribute. When compared to other batoids, there is limited information on the distribution of the largetooth sawfish and dwarf sawfish. While sawfish (in general) were widespread, the complex has experienced significant range contractions (D'Anastasi *et al.*, 2013; Department of the Environment, 2015; Kyne *et al.*, 2013a; Kyne *et al.*, 2013b; Simpfendorfer, 2013). On the Queensland east coast, the distribution of both species is uncertain and the largetooth and dwarf sawfish may now be extirpated from the region.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Historical records suggest that, if found on the east coast, they are confined to waters north of Cairns (Department of the Environment, 2019ag; h; Last *et al.*, 2016; Last & Stevens, 2009). Data from the ECIF shows that areas north of Cairns report lower levels of net effort and at lower concentrations (Department of Agriculture and Fisheries, 2019c). This data also shows that the overwhelming majority of large mesh net operations in the ECIF operate outside of the known distribution of the sawfish species (Department of Agriculture and Fisheries, 2019c). This suggests the *encounterability* risk is lower than what was reported in the PSA. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute for the largetooth sawfish and the dwarf sawfish were reduced from high (3) to low (1). These changes recognise the current distribution of effort and the fact that the majority of effort occurs outside of the known distribution. While large mesh net fishers operate in habitats that have the potential to support sawfish populations, there is limited evidence to suggest that these two species are being encountered within the current area of operation. 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 (bycatch management workshop, Townsville, 14–15 May 2019*) and *Guideline 4: at risk in regards to level of interaction/capture with a zero or negligible level of susceptibility*. *Note—While the encounterability scores were reduced the potential, long-term consequences of this type of interaction will be higher in this complex. If data on the known east coast distribution improves and/or the fishing environment shifts further north, scores assigned to this attribute as part of the RRA may need to be reviewed*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Batoids *Largetooth sawfish (P. pristis)* *Green sawfish (P. zijsron)* *Narrow sawfish (A. cuspidata)* *Dwarf sawfish (P. clavata)*	*Post-capture mortality (Susceptibility)*	Large Mesh Net Fishery	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 dedicated ECIF bycatch management workshop (Townsville, 14–15 May 2019) suggest that animals will survive the initial enmeshment *i.e.* providing the gills are not damaged or significantly impeded, the animal will still be able to breath until its release. The handling and subsequent release of these animals arguably presents more of a risk. Due to 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 killed in an attempt to preserve gear or accelerate the extraction process. As noted, there is limited information on the post-release survival rates for captured sawfish (Department of the Environment, 2015). As a consequence, there is a high degree of uncertainty on how well a sawfish survives an interaction event if it is handled and released correctly. Similarly, there is limited information on current handling practices and/or how educated fishers are with respect to the handling and release of sawfish caught in gillnets. These data deficiencies were the primary reason why all four sawfish species were assigned a high (3) score for *post-capture mortalities*. With additional information, further education and (potentially) quantification of the current handling practices and their effectiveness, these scores could be reduced. ***Key changes to the PSA scores*** No change but this is an area where future ERAs could be refined and improved with additional information.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
<u>***Batoids***</u> *Eyebrow wedgefish (R. palpebratus)* *Bottlenose wedgefish (R. australiae)*	*Age at maturity (Productivity)*	Large Mesh Net Fishery	3	2	There is limited information on the age and growth of *R. palpebratus* and *R. australiae* including on their age of sexual maturity. This was reflected in the preliminary scores assigned as part of the PSA. A limited study on the age and growth of a broader *Rhynchobatus* complex indicates that these species grow to at least 12 years of age with males reaching maturity at an estimated 3–5 years (Rigby, 2019; Simpfendorfer *et al.*, 2019; White *et al.*, 2014). As this estimate is based on a combined male sample, it is difficult to determine how these results translate to either species and 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*** To accommodate the above considerations, PSA scores assigned to the *age at maturity* attribute for the two wedgefish species were downgraded from high (3) to medium (2). With additional information the scores assigned to this attribute could be reduced further. A reduction to low risk (1) was not considered given a) uncertainty surrounding the age at sexual maturity for females and b) an absence of species-specific data. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation*.
<u>***Batoids***</u> *Bottlenose wedgefish (R. australiae)*	*Availability (Susceptibility)*	Large Mesh Net Fishery	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 (3) risk ratings 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). This amendment was done in accordance with *Guideline 2: additional scientific assessment & consultation.*
<u>Batoids</u> *Estuary stingray (H. fluviorum)*	*Availability (Susceptibility)*	Large Mesh Net Fishery	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 map (Kyne *et al.*, 2016) and the scores assigned to this attribute were revised. ***Key changes to the PSA scores*** The use of an alternate map provides a more accurate account of the *availability* risk posed to the estuary stingray. The inclusion of this data, while improving the accuracy of the assessment, did not alter the risk rating for this attribute.
<u>Batoids</u> *Estuary stingray (H. fluviorum)*	*Encounterability (Susceptibility)*	Large Mesh Net Fishery	3	2	While the estuary stingray is largely associated with mangrove swamps, estuarine and riverine systems (Last *et al.*, 2016), the species has been reported to depths of 20m. This was reflected in the *encounterability* attribute where it was assigned a high (3) risk score. The Large Mesh Net Fishery operates in a diverse range of inshore (<2m) and offshore (>2m) environments including in habitats estuary stingrays are more likely to be encountered. The likelihood of a large mesh net fisher catching this species will vary across the fishery and will depend on the species being targeted. For example, the species is unlikely to be encountered in significant quantities in offshore operations including those that target key species like sharks and grey mackerel (Department of Agriculture and Fisheries, 2019c).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					In inshore areas, the species will more likely be caught by fishers targeting key species in estuaries, riverine systems, or adjacent coastal areas with larger mangrove colonies. In the Large Mesh Net Fishery, the interaction potential is arguably higher for operations targeting key species like barramundi, threadfin, or shallow-water species. Interactions are also more likely in other ECIF sub-fisheries like the Tunnel Net Fishery. 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 sub-fishery. When these factors were considered in the context of the entire Large Mesh Net Fishery, the score assigned this attribute was viewed as 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.*

Appendix E—Summary of the marine turtle interaction data reported through the *Species of Conservation Interest* (SOCI) logbook

Data compiled through the SOCI logbook on the total number interactions and their release fate. Data represents all of the marine turtle records reported from the *East Coast Inshore Fishery* (ECIF) and that compiled for each of the respective marine turtle species.

All marine turtle records										
	Gill netting		**Ring netting**		**Seine/Haul netting**		**Tunnel net**		**Total**	
State	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**
2003	40	0	1	0	0	0	6	0	47	0
2004	673	4	18	0	19	0	228	0	938	4
2005	201	0	0	0	10	0	189	0	400	0
2006	220	1	0	0	0	0	0	0	220	1
2007	180	1	0	0	0	0	0	0	180	1
2008	291	12	0	0	0	0	0	0	291	12
2009	132	2	0	0	0	0	0	0	132	2
2010	96	1	0	0	0	0	0	0	96	1
2011	42	0	0	0	0	0	0	0	42	0
2012	8	0	46	0	0	0	0	0	54	0
2013	7	2	9	0	0	0	0	0	16	2
2014	3	0	31	0	0	0	0	0	34	0
2015	1	1	52	0	0	0	7	0	60	1
2016	20	0	117	0	0	0	102	0	239	0
2017	15	0	140	0	0	0	70	0	225	0
Total	1929	24	414	0	29	0	602	0	2974	24

Green turtle (Chelonia mydas)										
	Gill netting		**Ring netting**		**Seine/Haul netting**		**Tunnel net**		**Total**	
State	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**
2003	33	0	1	0			6	0	40	0
2004	618	1	16	0	18	0	223	0	875	1
2005	169	0			10	0	187	0	366	0
2006	167	0							167	0
2007	125	0							125	0
2008	276	0							276	0
2009	131	1							131	1
2010	81	1							81	1
2011	40	0							40	0
2012	4	0	45	0					49	0
2013	4	2	8	0					12	2
2014	0	0	31	0					31	0
2015	0	1	52	0			7		59	1
2016	15	0	110	0			102		227	0
2017	1	0	128	0			70		199	0
Total	1664	6	391	0	28	0	595	0	2678	6

Appendix E cont.—*Summary of the marine turtle interaction data reported by operators in the ECIF through the Species of Conservation Interest (SOCI) logbook. Data separated by species, fishing method and release state.*

Loggerhead turtle (Caretta caretta)										
	Gill netting		**Ring netting**		**Seine/Haul netting**		**Tunnel net**		**Total**	
State	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**
2003	7	0							7	0
2004	11	0	2	0	1	0	5	0	19	0
2005	0	0					1	0	1	0
2006	22	1							22	1
2007	8	0							8	0
2008	11	12							11	12
2009	0	1							0	1
2010	13	0							13	0
2011	0	0							0	0
2012	3	0	1	0					4	0
2013	0	0	1	0					1	0
2014	2	0							2	0
2015	0	0							0	0
2016	1	0	7	0					8	0
2017	9	0	11	0					20	0
Total	87	14	23	0	1	0	6	0	117	14

Hawksbill turtle (Eretmochelys imbricata)										
	Gill netting		**Ring netting**		**Seine/Haul netting**		**Tunnel net**		**Total**	
State	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**
2003	0	0							0	0
2004	30	3							30	3
2005	4	0					1	0	5	0
2006	0	0							0	0
2007	0	0							0	0
2008	1	0							1	0
2009	0	0							0	0
2010	0	0							0	0
2011	0	0							0	0
2012	0	0							0	0
2013	3	0							3	0
2014	0	0							0	0
2015	0	0							0	0
2016	2	0							2	0
2017	0	0	1	0					1	0
Total	40	3	1	0	0	0	1	0	42	3

Appendix E cont.—*Summary of the marine turtle interaction data reported by operators in the ECIF through the Species of Conservation Interest (SOCI) logbook. Data separated by species, fishing method and release state.*

Flatback turtle (Natator depressus)										
	Gill netting		**Ring netting**		**Seine/Haul netting**		**Tunnel net**		**Total**	
State	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**
2003	0	0							0	0
2004	0	0							0	0
2005	0	0							0	0
2006	0	0							0	0
2007	0	0							0	0
2008	0	0							0	0
2009	0	0							0	0
2010	0	0							0	0
2011	0	0							0	0
2012	0	0							0	0
2013	0	0							0	0
2014	1	0							1	0
2015	0	0							0	0
2016	2	0							2	0
2017	0	0							0	0
Total	3	0	0	0	0	0	0	0	3	0

Leatherback turtle (Dermochelys coriacea)										
	Gill netting		**Ring netting**		**Seine/Haul netting**		**Tunnel net**		**Total**	
State	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**
2003	0	0							0	0
2004	2	0							2	0
2005	0	0							0	0
2006	0	0							0	0
2007	0	0							0	0
2008	0	0							0	0
2009	1	0							1	0
2010	0	0							0	0
2011	0	0							0	0
2012	0	0							0	0
2013	0	0							0	0
2014	0	0							0	0
2015	0	0							0	0
2016	0	0							0	0
2017	3	0							3	0
Total	6	0	0	0	0	0	0	0	6	0

Appendix E cont.—*Summary of the marine turtle interaction data reported by operators in the ECIF through the Species of Conservation Interest (SOCI) logbook. Data separated by species, fishing method and release state.*

Olive ridley turtle (Lepidochelys olivacea)										
	Gill netting		**Ring netting**		**Seine/Haul netting**		**Tunnel net**		**Total**	
State	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**
2003	0	0							0	0
2004	0	0							0	0
2005	0	0							0	0
2006	0	0							0	0
2007	0	0							0	0
2008	0	0							0	0
2009	0	0							0	0
2010	1	0							1	0
2011	0	0							0	0
2012	0	0							0	0
2013	0	0							0	0
2014	0	0							0	0
2015	0	0							0	0
2016	0	0							0	0
2017	2	0							2	0
Total	3	0	0	0	0	0	0	0	3	0

Species unknown / Not specified										
	Gill netting		**Ring netting**		**Seine/Haul netting**		**Tunnel net**		**Total**	
State	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**	**Alive**	**Dead**
2003	0	0							0	0
2004	12	0							12	0
2005	28	0							28	0
2006	31	0							31	0
2007	47	1							47	1
2008	3	0							3	0
2009	0	0							0	0
2010	1	0							1	0
2011	2	0							2	0
2012	1	0							1	0
2013	0	0							0	0
2014	0	0							0	0
2015	1	0							1	0
2016	0	0							0	0
2017	0	0							0	0
Total	126	1	0	0	0	0	0	0	126	1

Appendix F—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 a 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 (*i.e.* 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 of particular importance when identifying priority risk areas 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, 2019c) 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 F1) and b) the likelihood of a particularly adverse consequence occurring due to these activities or events (Table F2). Central to this is the establishment of a Likelihood x Consequence matrix that estimates the risk based on scores assigned to each component (Table F3).

***Table F1**. 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 F2**. Criteria used to assign indicative scores of the likelihood that fishing activities in the East Coast Inshore Fin Fish Fishery (ECIF) 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 F3**. 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 F2), criteria used to assign scores (0–4) were based on the outputs of the semi-quantitative assessment (PSA/RRA results outlined in section 4, Table 7). In the likelihood assessment (Table F1), 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 = Consequence x Likelihood) for each species (Table F3).

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 F1 and F2. The Likelihood x Consequence matrix used to assign risk ratings is provided as Table F3.

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 waiting to the probability (likelihood) of a fishery contributing or causing a severe or major event under the current conditions (*e.g.* 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

Trends in the LCA mirrored those of the PSA/RRA with the green (*C. mydas*), loggerhead (*C. caretta*) and hawksbill (*E. imbricata*) turtle receiving the highest risk rating. There is a higher probability of the ECIF interacting with the green and loggerhead turtle along the Queensland east coast and the outputs of the LCA for the hawksbill turtle (*E. imbricata*) aligned with the original assessment (Table F4). For these three species, the LCA supports retention of the original risk rating along with the medium-risk rating for the flatback turtle (*N. depressus*).

Outputs of the LCA for the olive ridley turtle (*L. olivacea*) and the leatherback (*D. coriacea*) turtle were lower than the PSA. These results combined with the species' interaction potential and the current fishing environment suggest there is a lower probability of the ECIF contributing to a severe or major consequence over the short to medium term. These results support the assignment of a *precautionary* risk rating for these two species.

Dugong

The results of the LCA aligned with estimates obtained through the PSA/RRA (Table F4). These outputs indicate 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 short beaked dolphin (*D. delphis*), the false killer whale (*P. crassidens*) and the spinner dolphin (*S. longirostris*). Conversely, the LCA supports retainment 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 F4).

Sharks

The shark LCA mirrored that of the marine turtle complex, in that the risk estimates were lower than the PSA/RRA (Table F4). The notable difference between these two complexes is that four of the five species (hammerheads) can be retained for sale in the ECIF. Stock assessments indicate that the great (*S. mokarran*) and scalloped (*S. lewini*) are being fished below Maximum Sustainable Yield (MSY) (Leigh, 2015). While the winghead shark (*E. blochii*) does not currently have a MSY estimate for the east coast, catches for this species are comparatively low (Department of Agriculture and Fisheries, 2019c). There is however room within the current management regime for catch to increase for one or more of these species. This issue is compounded by the fact that there is a degree of uncertainty surrounding total catch and mortality rates for individual species. This was viewed as a significant factor in the ECIF given the size of the fishery and the distribution of effort. These factors were reflected in the likelihood scores and contributed to the species receiving higher scores for the consequence component (Table F4).

The smooth hammerhead shark (*S. zygaena*) had the lowest score of the complex (Table F4). The smooth hammerhead shark has a smaller overlap with the ECIF effort footprint and fewer reported interactions. Both of these factors reduce the likelihood of the fishery making a significant contribution to a severe or major consequence.

While the speartooth shark (*G. glyphis*) scored high on the consequence component, there is limited evidence that the fishery interacts with this species and/or that it still occurs in areas where the ECIF currently operates. Fishing activities though have been identified as a key contributor to the decline of speartooth shark populations on the Queensland east coast. For this reason, the species was assigned a higher likelihood score. This score assumes that if speartooth sharks still inhabit areas of the Queensland east coast, there is a higher likelihood that the fishery will contribute to an undesirable event.

Outputs of the LCA support the assignment of precautionary risk ratings for the smooth hammerhead shark. Conversely, high-risk ratings were retained for the scalloped hammerhead shark, great hammerhead shark and winghead shark. While the speartooth shark received a higher score as part of the LCA, this risk would only come to fruition if the species still inhabited key areas of its historical range (Table F4).

Batoids

The LCA of the batoid subgroup supported the assignment of *precautionary* risk ratings for the majority of the species assessed (Table F4). For devilrays, these results were intimately linked with the complex having low interaction rates and a smaller entanglement risk. The suitability and applicability of the risk rating for Kuhl's devilray (*M. kuhlii*) required further consideration as it registered a higher risk score due to it being the species most likely to interact with the fishery. It is noted though that the Kuhl's devilray has comparatively low and infrequent interactions with this sector of the ECIF. The morphology of the species combined with current mesh size restrictions also reduces the risk that an interaction will end in entanglement. When adopting a weight-of-evidence approach, the LCA lends support to adoption of a *precautionary* risk rating for this species as well.

While shovelnose rays and guitarfish can be retained for sale in the ECIF, the complex is managed under fairly stringent in possession limits (*n* = 5 combined). These measures prevent the species being targeted in significant quantities and/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 *precautionary* risk ratings (Table F4).

Risk ratings for the sawfish complex and the estuary stingray were more varied, ranging from low to high. An absence of reports in the fishery and on the Queensland east coast contributed to largetooth (*P. pristis*) and dwarf (*P. clavata*) sawfish receiving lower likelihood scores and risk ratings. These two species share similarities with the speartooth shark in that the risk rating reflects the low probability of an ECIF operator encountering the species on the Queensland east coast. When a sawfish does interact with the ECIF it will more likely involve the narrow (*A. cuspidata*) and green (*P. zijsron*) sawfish; hence the higher LCA ratings.

The estuary stingray (*H. fluviorum*) was the only batoid outside of sawfish that recorded a LCA rating above low (Table F4). The estuary stingray can be retained for sale if it is caught in waters not covered by the *Nature Conservation Act 1992.* For this reason, the species received a higher score for the likelihood component of the LCA. Stingrays only constitute a small component of the ECIF catch with estuary rays (if retained) considered a minor species. This species is also afforded considerable protection in key areas of south-east Queensland; suggesting that risk ratings obtained through the PSA/RRA are an overestimate.

Table F4. *Results of the Likelihood & Consequence Analysis for species assessed as part of the Large Mesh Net SOCC 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*	3	3	9	Medium
Hawksbill turtle	*Eretmochelys imbricata*	2	3	6	Medium
Flatback turtle	*Natator depressus*	2	2	4	Low
Olive ridley turtle	*Lepidochelys olivacea*	2	2	4	Low
Leatherback turtle	*Dermochelys coriacea*	2	2	4	Low
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
Short-beaked common dolphin	*Delphinus delphis*	1	3	3	Low

Common name	Species name	Likelihood	Consequence	Matrix score	Risk category
False killer whale	*Pseudorca crassidens*	1	3	3	Low
Spinner dolphin	*Stenella longirostris*	1	3	3	Low
Sharks					
Great hammerhead shark	*Sphyrna mokarran*	4	3	12	High
Scalloped hammerhead shark	*Sphyrna lewini*	4	3	12	High
Winghead shark	*Eusphyra blochii*	4	3	9	High
Smooth hammerhead	*Sphyrna zygaena*	1	3	3	Low
Speartooth shark	*Glyphis glyphis*	2	4	8	Medium
Batoids					
Narrow sawfish	*Anoxypristis cuspidata*	3	3	9	Medium
Green sawfish	*Pristis zijsron*	3	4	12	High
Largetooth sawfish	*Pristis pristis*	1	4	4	Low
Dwarf sawfish	*Pristis clavata*	1	4	4	Low
Bottlenose wedgefish	*Rhynchobatus australiae*	1	3	3	Low
Eyebrow wedgefish	*Rhynchobatus palpebratus*	1	3	3	Low
Giant shovelnose ray	*Glaucostegus typus*	1	3	3	Low
Giant manta ray	*Mobula birostris*	1	3	3	Low
Reef manta ray	*Mobula alfredi*	1	3	3	Low
Kuhl's devilray	*Mobula kuhlii*	2	3	6	Medium
Giant devilray	*Mobula mobular*	1	3	3	Low
Bentfin devilray	*Mobula thurstoni*	1	3	3	Low
Estuary stingray	*Hemitrygon fluviorum*	2	3	6	Medium