

Sustainable Fisheries Strategy

2017–2027

Level 2 Ecological Risk Assessment Tunnel Net Fishery (East Coast Inshore Fishery)

**Level 2 Ecological Risk Assessment
Tunnel Net Fishery (East Coast Inshore Fishery)**

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Executive Summary

In May 2019, a whole-of-fishery or Level 1 Ecological Risk Assessment (ERA) was released for the *East Coast Inshore Fishery* (ECIF). 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.

In the Level 2 ERA, the focus of the assessment shifts to individual species, with risk evaluations based on a *Productivity & Susceptibility Analysis* (PSA). The PSA evaluates risk through an assessment of seven biological attributes (*age at maturity, maximum age, fecundity, maximum size, size at maturity, reproductive strategy, and trophic level*) and up to seven fisheries-specific attributes (*availability, encounterability, selectivity, post-capture mortality, management strategy, sustainability assessments and recreational desirability / other fisheries*). 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.

As the ECIF incorporates multiple sub-fisheries and apparatus, risk was assessed separately for the large mesh nets (gillnets and ring nets), the Tunnel Net Fishery and the Ocean Beach Fishery. The focus of this assessment being the Tunnel Net Fishery which operates under the N10 fishery symbol and within the confines of the *Moreton Bay* and *Great Sandy Marine Parks* (Department of Agriculture and Fisheries, 2019e). The scope of the Level 2 assessment was based on the outputs of the Level 1 ERA (Jacobsen *et al.*, 2019) and considered the risks posed to the target & byproduct species ecological component and a range of species that have ongoing conservation concerns (*Species of Conservation Concern* or SOCC). The SOCC subgroup included a number of no-take species such as marine turtles and dugongs.

A review of catch data, current legislation and international instruments produced a list of 33 target & byproduct species and 84 SOCC that were considered for inclusion in the Tunnel Net Fishery Level 2 ERA. This list was rationalised to 23 species consisting of 16 teleosts (target & byproduct), three marine turtles (SOCC), three batoids (SOCC) and dugongs. The omitted species were either teleosts with low rates of retention or SOCC with low or limited potential to interact with this sector of the ECIF (Jacobsen *et al.*, 2019). When and where appropriate, consideration will be given to including these species in subsequent ERAs involving the Tunnel Net Fishery.

When the outputs of the PSA and RRA were taken into consideration, all of the target & byproduct species were classified as either a low ($n = 6$, 37.5%) or medium ($n = 10$, 62.5%) risk. These results were largely attributed to the fact that the Tunnel Net Fishery has a comparatively small effort footprint, lower participation rates and measures in place to minimise the risk posed to regulated species and sizes e.g. provisions requiring the tunnel of the net to remain submerged for the duration of the fishing event. In line with these assessments, the Tunnel Net Fishery would be a contributor of risk for most target & byproduct species included in this assessment vs. the main driver of risk.

The Level 2 assessment for the SOCC was more complicated with all seven species categorised as being at a medium ($n = 6$ species) or high ($n = 1$ species) risk. The final risk ratings were heavily influenced by the life-history constraints of the species assessed, with attributes based on reproduction and longevity identified as the key drivers of risk. As with the target and byproduct species, the operational constraints of the fishery were identified as a key mitigator of risk. However, the risk posed to the SOCC subgroup has also been reduced through the management framework e.g. mesh/net size restrictions, requirements for the tunnel of the net to remain submerged for the duration of the fishing event, net attendance provisions and spatial closures implemented as part of zoning plans covering the Great Sandy and Moreton Bay Marine Parks.

Precautionary elements included in the methodology, combined with data deficiencies, contributed to the production of more conservative risk profiles. This was of particular relevance to the SOCC where a number of the final risk ratings were more representative of the potential risk. **Managing these risks in the Tunnel Net Fishery, 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 a lower priority.** It is recognised though that the Tunnel Net Fishery will be a contributor of risk for a number of the species and further information is required on fine-scale movements of effort, catch compositions, release fates and the effectiveness of some management initiatives (e.g. net attendance provisions).

A number of the risks identified in the Level 2 ERA are being actively addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* including mandating the use of bycatch reduction devices (scheduled for implementation in September 2021), the introduction of a *Data Validation Plan* and the development of an ECIF-specific harvest strategy (Department of Agriculture and Fisheries, 2017; 2018a; b; 2020b). These initiatives will improve the level of understanding on how the Tunnel Net Fishery interacts with these species (e.g. catch compositions, interaction rates, discards) and will contribute to a lowering of the risk rating for a number of the species included in this assessment. With additional information and improved mechanisms to monitor catch in real or near-real time, it is anticipated that a number of the species will be omitted from future ERAs involving the Tunnel Net Fishery including a number of the SOCC.

The outputs of the Tunnel Net Fishery Level 2 ERA will assist in identifying priority risk areas for this fishery. The following also been identified as areas where risk profiles can be refined and the level of risk reduced for key species. These recommendations are complimented within the report by complex-specific recommendations aimed at reducing risk or improving the accuracy of assessments involving individual species.

General recommendations

1. *Mandate the use of bycatch reduction devices in the Tunnel Net Fishery to aid in the removal of non-target species and minimise the length of the interaction.*
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) and minimise the risk of non-compliance with Species of Conservation Interest (SOCI) reporting requirements.*
3. *Establish a measure to estimate the gear-affected area and, when available, reassess the risk posed to teleosts using a more quantitative ERA method e.g. base Sustainability Assessment for Fishing Effects (bSAFE).*

Summary of the outputs from the Tunnel Net Fishery Level 2 Ecological Risk Assessment.

Common name	Species name	Productivity	Susceptibility	PSA score
Target & Byproduct				
Mullet				
Sea mullet	<i>Mugil cephalus</i>	1.29	1.86	Low
Fantail mullet	<i>Paramugil georgii</i>	1.29	2.14	Low
Diamondscale mullet	<i>Liza vaigiensis</i>	1.29	2.14	Low
Flathead				
Dusky flathead	<i>Platycephalus fuscus</i>	1.57	2.14	Medium
Bartailed flathead	<i>Platycephalus australis</i>	1.67	2.57	Precautionary Medium
Northern sand Flathead	<i>Platycephalus endrachtensis</i>	1.50	2.57	Precautionary Medium
Yellowtailed flathead	<i>Platycephalus westraliae</i>	1.43	2.57	Precautionary Medium
Whiting				
Trumpeter whiting	<i>Sillago maculata</i>	1.43	2.71	Precautionary Medium
Sand whiting	<i>Sillago ciliata</i>	1.29	2.14	Low
Bream				
Yellowfin bream	<i>Acanthopagrus australis</i>	1.29	2.14	Low
Tarwhine	<i>Rhabdosargus sarba</i>	1.43	2.57	Medium
Garfish				
Snubnose garfish	<i>Arrhamphus sclerolepis</i>	1.29	2.43	Precautionary Medium
Three-by-two garfish	<i>Hemiramphus robustus</i>	1.29	2.43	Precautionary Medium
Trevally / Family Carangidae				
Giant trevally	<i>Caranx ignobilis</i>	1.86	2.57	Precautionary Medium
Golden trevally	<i>Gnathanodon speciosus</i>	1.86	2.43	Precautionary Medium
Other				
Scribbled rabbitfish	<i>Siganus spinus</i>	1.29	2.71	Low
SOCC				
Marine turtles				
Green turtle	<i>Chelonia mydas</i>	2.29	2.00	Medium
Loggerhead turtle	<i>Caretta caretta</i>	2.29	2.00	Precautionary Medium
Hawksbill turtle	<i>Eretmochelys imbricata</i>	2.29	2.00	Precautionary Medium
Sirenia				
Dugong	<i>Dugong dugon</i>	2.71	1.50	Precautionary Medium
Batoids				
Bottlenose wedgefish	<i>Rhynchobatus australiae</i>	2.57	2.00	Precautionary High
Giant shovelnose ray	<i>Glaucostegus typus</i>	2.43	2.00	Precautionary Medium
Estuary stingray	<i>Hemirhynchus fluviorum</i>	2.14	2.00	Medium

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Definitions & Abbreviations

AEEZ	– <i>Australian Exclusive Economic Zone.</i>
AFMA	– <i>Australian Fisheries Management Authority.</i>
bSAFE	– <i>base Sustainability Assessment for Fishing Effects.</i> The <i>Sustainability Assessment for Fishing Effects</i> 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.
BMP	– <i>Bycatch Management Plan.</i>
CAAB	– <i>Codes for Australian Aquatic Biota.</i>
CMS	– <i>Convention on the Conservation of Migratory Species of Wild Animals.</i>
CITES	– <i>Convention on International Trade in Endangered Species of Wild Fauna and Flora.</i>
CSIRO	– <i>Commonwealth Scientific and Industrial Research Organisation.</i>
ECIF	– <i>East Coast Inshore Fishery.</i>
Ecological Component	– Broader assessment categories that include <i>Target & Byproduct</i> (harvested) species, <i>Bycatch</i> , <i>Species of Conservation Concern</i> , <i>Marine Habitats</i> and <i>Ecosystem Processes</i> .
Ecological Subcomponent	– Species, species groupings, marine habitats and categories included within each Ecological Component.
EPBC Act	– <i>Environment Protection and Biodiversity Conservation Act 1999.</i>
ERA	– <i>Ecological Risk Assessment.</i>
ERAEF	– <i>Ecological Risk Assessment for the Effects of Fishing.</i> A risk assessment strategy established by Hobday <i>et al.</i> (2011) and employed by the AFMA.
False positive	– The situation where a species at low risk is incorrectly assigned a higher-risk rating due to the method being used, data limitation etc. In the context of an ERA, false positives are preferred over false negatives.
False negative	– The situation where a species at high risk is assigned a lower-risk rating. When compared, false-negative results are considered to be of more concern as the impacts/consequences can be more significant.
GBRMP	– <i>Great Barrier Reef Marine Park.</i>

GBRMPA	– <i>Great Barrier Reef Marine Park Authority.</i>
Gillnets	– Gillnets include general purpose mesh nets (excluding ring nets), set mesh nets and nets that are neither fixed nor hauled <i>i.e.</i> 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), tunnel nets (N10 fishery symbol) or small mesh net fishing activities under the N11 fishery symbol.
ITQ	– Individual Transferrable Quota.
MEY	– Maximum Economic Yield.
MSY	– Maximum Sustainable Yield.
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, tunnel nets (N10) and seine nets used in the Ocean Beach Fishery (K1–K8 fishery symbol).
PSA	– <i>Productivity & Susceptibility Analysis.</i> 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 <i>Fisheries (General) Regulations 2019</i> 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>i.e.</i> 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	– <i>Sustainability Assessment for Fishing Effects.</i> 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 <i>Status of Australian Fish Stocks.</i> Refer to www.fish.gov.au for more information.
SCP	– <i>Shark Control Program.</i>
SOCC	– <i>Species of Conservation Concern.</i> 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.
- TACC – Total Allowable Commercial Catch Limit.
- TEP – Threatened, Endangered & Protected.

1 Introduction

Ecological Risk Assessments (ERA) are important tools for sustainable natural resource management and they are being used increasingly in commercial fisheries to monitor long-term risk trends for target and non-target species. In Queensland, ERAs have previously been developed on an as-needs basis and these assessments have often employed alternate methodologies (Department of Agriculture and Fisheries, 2019c). 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, 2018c). 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; c; d; 2020b).

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

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

As the ECIF incorporates multiple sub-fisheries and apparatus, risk was assessed separately for large mesh nets (gillnets and ring nets), the Tunnel Net Fishery and the Ocean Beach Fishery (Jacobsen *et al.*, 2021a; b; Pidd *et al.*, 2021). The focus of this assessment being the Tunnel Net Fishery which operates under the N10 fishery symbol and within the confines of the *Moreton Bay* and *Great Sandy Marine Parks* (Department of Agriculture and Fisheries, 2019e). The scope of the Level 2 assessment was based on the outputs of the Level 1 ERA (Jacobsen *et al.*, 2019) and considered the risks posed to the target & byproduct species ecological component and a range of species that have ongoing conservation concerns or SOCC. The SOCC subgroup included a number of no-take species including marine turtles and dugongs.

¹The *East Coast Inshore Fishery* (ECIF) was formally referred to as the *East Coast Inshore Fin Fish Fishery* or ECIFFF.

2 Methods

2.1 The Fishery

The ECIF is one of the more complicated 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, 2018g; 2019e; 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, 2019e).

In Queensland, tunnel nets are only permitted for use under the N10 fishery symbol and their use is confined to sections of the *Moreton Bay* and *Great Sandy Marine Parks* (Department of Agriculture and Fisheries, 2019e). As there are only 22 N10 fishery symbols, the maximum operating potential for the fishery is smaller than the Large Mesh Net Fishery ($n = 184$ N1, N2, N4 fishery symbols) and Ocean Beach Fishery ($n = 36$ K-fishery symbols).² The footprint of the fishery is further restricted by provisions governing the use of marine resources in each of the respective marine parks. From an ERA perspective, these restriction mean that the Tunnel Net Fishery will have a more nuanced and regionally specific risk profile. It will also limit the number of species that interact with the fishery and the extent of these interactions. For these reasons, the Tunnel Net Fishery will be a cumulative risk factor for most of these species *versus* the main driver of risk.

Outputs of the Level 2 ERA were based on the current fishing environment and management arrangements used to regulate activities in the Tunnel Net Fishery at the time of the assessment (Department of Agriculture and Fisheries, 2019e). It is recognised that the broader management regime for the ECIF is being reviewed as part of the Strategy (Department of Agriculture and Fisheries, 2017) and a number of alternate management strategies are being developed and considered for this sector of the fishery *e.g.* mandating the use a bycatch reduction device and the development of a dedicated bycatch management plan (Department of Agriculture and Fisheries, 2019a; b). This review is ongoing and a high number of the alternative strategies are still in development and are yet to be adopted or fully implemented. For these reasons, outputs from the Level 2 ERA will only consider arrangements that are in place and enforceable at the time of the assessment.

In addition to the management reforms, the Tunnel Net Fishery 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 impacts or cumulative risks involve a wider range of stakeholders and are difficult to address through a fisheries management framework. Accordingly, cumulative risk comparisons may

² While they are separate symbols with their own regulations, fishers with K1–K8 symbol are permitted use of any net described under the N1 fishery symbol.

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.seamapaaustralia.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 *Moreton Bay Marine Park* and *Great Sandy Marine Park*. Where possible regional distribution maps were sourced for direct comparison with effort distribution data (Whiteway, 2009).

Fisheries data used in the Level 2 ERA were obtained through the fisheries logbook program (including *Species of Conservation Interest* or SOCI logbook), a previous *Fisheries Observer Program* (FOP), the *Fishery Monitoring Program* and the *Statewide Recreational Fishing Survey* (Department of Agriculture and Fisheries, 2021; Teixeira *et al.*, 2021; Webley *et al.*, 2015). This information was supplemented with data from ancillary sources including from the *Marine Wildlife Stranding and Mortality Database*, herein 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 tunnel net Level 2 ERA was determined by the outcomes of the whole-of-fishery (Level 1) assessment (Jacobsen *et al.*, 2019). This assessment identified a number of high-risk elements that will now be progressed through a finer-scale (Level 2) ERA including target & byproduct species, bycatch, marine turtles, dugongs, batoids and sharks (Table 1).

The primary focus of this ERA was key target species, byproduct species and species with ongoing conservation concerns. While the assessment does not cover all species that interact with the Tunnel Net Fishery, the structure of the Level 2 ERA allows for additional species to be included, for example, if catch and effort increases for a particular species or the marketability of a bycatch species increases substantially.

2.3.1 Target & Byproduct Species

A preliminary list of target & byproduct species was compiled using catch data submitted through the logbook monitoring program from 2017–2019 (inclusive). Catch reported against each species or species complex was summed across years and ranked from highest to lowest. Cumulative catch comparisons were then used to identify the species / species complexes that made up 95% of the total

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.

catch. Any categories with low species resolution (e.g. unspecified teleosts) were removed from the analysis and the *Codes for Australian Aquatic Biota* (CAAB; <http://www.marine.csiro.au/data/caab/>) used to expand multi-species catch categories. A secondary review was then undertaken to remove duplicates, species with low or negligible catches, and species that have limited potential to interact with the fishery. A full overview of the species rationalisation process for target & byproduct species has been provided in Appendix A.

Table 1. Summary of the outputs from the Level 1 (whole-of-fishery) Ecological Risk Assessment for the East Coast Inshore Fishery (ECIF) (Jacobsen et al., 2019).

Ecological Component	Level 1 Risk Rating	Progression
Target & Byproduct	High	Level 2 ERA (this report)
Bycatch*	Intermediate / High	Level 2 ERA*
Species of Conservation Concern (SOCC)		
Marine turtles	High	Level 2 ERA (this report)
Dugongs	Intermediate / High	Level 2 ERA (this report)
Whales	Low / Intermediate	Not progressed further.
Dolphins**	High	Level 2 ERA**
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**
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 (e.g.) regulations, product quality etc.

** Subgroup will have comparatively low interactions with the Tunnel Net Fishery and the 'high' risk rating is more applicable to other sectors of the ECIF. When and where appropriate, the risk posed to this subgroup will be assessed as part of Level 2 ERAs for the Large Mesh Net Fishery and the Ocean Beach Fishery.

2.3.2 Species of Conservation Concern

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

For the purposes of this ERA, the expanded list of species was collectively referred to as the *Species of Conservation Concern* or SOCC. This classification aligns with the Level 1 ERA (Jacobsen *et al.*, 2019) and reflects the fact that the subgroup includes species that can be retained for sale and species afforded additional protections under State or Commonwealth legislation. As the preliminary list included species with limited potential to interact with the Tunnel Net Fishery, a final review was undertaken to ensure that all SOCC included in the analysis were relevant to this fishery. A summary of the species rationalisation process and the justifications used to include or omit a SOCC from the Level 2 ERA has been provided in Appendix B.

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 *i.e.* 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. 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 both the fishing intensity and the degree of overlap between a species' distribution and fishing effort (Hobday *et al.*, 2011; Zhou *et al.*, 2009). These parameters are used to determine the 'gear effected area' and the estimate of risk is sensitive to this quantity (Hobday *et al.*, 2011). The gear affected area being 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). This in itself can be difficult to calculate for species with poorly defined geographical distributions and those that have insufficient datasets. In the context of this ERA, this will be a factor for a number of the species included in the analysis; especially the SOCC (Australian Fisheries Management Authority, 2017).

In the Tunnel Net Fishery, the ability to determine the gear-affected area is restricted by data limitations; particularly on the length of the tunnel, the swept area and the fetch of the net. Under the current regulations, tunnel net fishers are only required to report the total length of net being used and the dominant mesh size. They are not required to report the size of the tunnel being used, the distance

between the two ends (the size of the net opening) and/or if they are using a bycatch reduction device.⁴ Tunnel nets also utilise different mesh sizes to limit the meshing potential of the wings and maximise the use of the tunnel to trap fish. These differences will have a bearing on net selectivity and the size of the area being actively fished. Without this data, there is an increased probability that attempts to quantify overlap percentages will result in an over-estimate of the gear-affected area.

Due to this uncertainty and the limitations of SAFE in assessing risk for key groups, the PSA was adopted for the first phase of the tunnel net Level 2 ERA. As a high number of the initiatives instigated under the *Queensland Sustainable Fisheries Strategy 2017–2027* are designed to improve information levels (Department of Agriculture and Fisheries, 2017), there may be more avenues to apply SAFE in subsequent ERAs. This includes the extended use of *Vessel Tracking* which will increase the level of information on fine-scale effort movements and aid in the transition to a SAFE assessment; particularly for the target & byproduct species ecological component.

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 maturity*, *maximum size and age*, *fecundity*, *reproductive strategy* and *trophic level* (Table 2). Productivity attributes used in the Level 2 assessment were consistent with the ERAEF (Hobday *et al.*, 2011) and were applied across all ecological components subject to a PSA. Criteria used to assign each attribute a score of low (1), medium (2) or high (3) risk are outlined in Table 2.

Table 2. Scoring criteria and cut-off scores for the productivity component of the PSA. Attributes and the corresponding 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).

⁴ Current regulations require the tunnel of the net to be <200m long and have a width of between 1.5 and 4m (Department of Agriculture and Fisheries, 2019e).

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.*, 2007; Hobday *et al.*, 2011). 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 (2017, 2018 and 2019) 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).

As the Tunnel Net Fishery forms part of the ECIF, overlap percentages were based on the effort footprint of the broader fishery. Effort distribution maps for the Tunnel Net Fishery revealed that the effort footprint for this sub-fishery is <10% of that reported for the entire ECIF. Based on these calculations, it is reasonable to assume that overlap percentages of all 23 species (target, byproduct and SOCC) are below 10% and all were assigned a low (1) risk rating for this attribute. If circumstances changes and/or there is a significant expansion in the Tunnel Net Fishery, this assumption will need to be reviewed.

- **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 (*i.e.* 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. In the Large Mesh Net Fishery (*e.g.* gillnets and ring nets), *selectivity* was determined by the size of the mesh used and the body size of the animal. This criteria was viewed as less suited to a tunnel net as the apparatus is set in a fixed location, utilises smaller mesh sizes and relies on the trapping of fish *verse* their enmeshment. Accordingly, a more generalised set of criteria was used for the Tunnel Net Fishery (Table 3).

In this iteration of the Tunnel Net Fishery Level 2 ERA, *selectivity* was based on the entire apparatus *i.e.* the wings and tunnel of the net. The decision to include both aspects of the apparatus in the *selectivity* definition was due to the fact that the use of a bycatch reduction device (BRD) is not mandatory in the Tunnel Net Fishery.⁵ In this fishery, BRDs consist of a grid that is set across the opening of the tunnel and prevents larger animals from entering this section of the

⁵ While the use of a BRD in the Tunnel Net Fishery is not mandatory, at least one region (Moreton Bay) already operates under an Code of Best Practice which includes the use of a tunnel grid (Thompson *et al.*, 2012).

net (Ocean Watch Australia, 2012). Of notable importance, the use of a BRD in the Tunnel Net Fishery is will become mandatory as of 1 September 2021. Once implemented, there will be sufficient grounds to confine future *selectivity* assessments to just the tunnel of the net.

- **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 as scores assigned to this attribute will be influenced by data limitations or require further qualitative input or expert opinion. In the absence of expert judgement and/or independent field observations the default value for the PCM attribute will be high (3) (Hobday *et al.*, 2011; Hobday *et al.*, 2007).

In addition to the four baseline attributes, the Level 2 ERA included three additional susceptibility attributes for target & byproduct species: *management strategy*, *sustainability assessments* and *recreational desirability / other fisheries*. These attributes were included in the assessment to address risks associated with other fishing sectors (e.g. recreational and charter fisheries) and management limitations for key species (e.g. an absence of effective controls on catch or effort). While the additional attributes are not included in the ERAEF, variations of all three have been used in risk assessments involving species experiencing similar fishing pressures (Patrick *et al.*, 2010; Furlong-Estrada *et al.*, 2017).

In the Level 2 ERA, the three additional susceptibility attributes will be used to further reduce the influence of false positives or risk overestimations for key species. In the Tunnel Net Fishery Level 2 ERA, the three additional attributes considered the following.

- **Management strategy**—Considers the suitability of the current management arrangements including the ability to manage risk through time e.g. the presence of an effective control on total catch or effort (if appropriate), regional management, biomass estimates that are directly linked to species-specific Total Allowable Commercial Catch (TACC) limits *etc.* This attribute was considered to be of particular relevance to multi-species fisheries where the management regime often lacks species-specific control measures and for species where the risk has been reduced through (e.g.) the use of quotas based on biological reference points like *Maximum Sustainable Yield* (MSY) and *Maximum Economic Yield* (MEY).
- **Sustainability assessments**—The *sustainability assessment* attribute is directly linked to the level of information that is available on the stock structure and status of harvested species. Species where sustainability status has been confirmed through stock assessments or the national *Status of Australian Fish Stocks* (SAFS) will be assigned a lower-risk scores. Conversely, species that are being fished above key biomass reference points (e.g. MSY), have been assessed as depleting, overfished, or recovering in the most recent SAFS assessment and/or have no assessment will be assigned more precautionary risk scores.
- **Recreational desirability / other fisheries**—Specifically included in the PSA to account for the risk posed by recreational fishing, charter fishing and non-ECIF commercial fisheries. Few of the species targeted by tunnel net fishers are retained for sale in commercial fisheries outside of the ECIF (e.g. Large Mesh Net Fishery and Ocean Beach Fishery). For this reason, the majority of the non-commercial risks come from the recreational and charter fishing sectors.

Table 3. Scoring criteria and cut-off scores for the susceptibility component of the PSA. Attributes and the corresponding scores/criteria are largely aligned with 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			
<i>Option 1. Overlap of species range with fishery.</i>	<10% overlap.	10–30% overlap.	>30% overlap.
<i>Option 2. Global distribution & stock proxy considerations.</i>	Globally distributed.	Restricted to same hemisphere / ocean basin as fishery.	Restricted to same country as fishery.
Encounterability			
<i>Option 1. Habitat type</i>	Low overlap with fishery area.	Medium overlap with fishery area.	High overlap with fishery area.
<i>Option 2. Depth check</i>	Low overlap with fishery area.	Medium overlap with fishery area.	High overlap with fishery area.
Selectivity	Low susceptibility to gear selectivity.	Moderate susceptibility to gear selectivity.	High susceptibility to gear selectivity.
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.
Management strategy	Species-specific management of catch or effort (e.g. TACC limits) based on biomass estimates/reference points. Management regime able to actively address emerging issues within the current framework.	Catch or effort restricted in some capacity (e.g. species-specific TACC limits or analogous arrangements), restrictions based on arbitrary or outdated biomass estimates / reference points. Limited capacity to address emerging catch and effort trends without legislative amendments or reforms.	Harvested species do not have species-specific catch limits or robust input & output controls. Management regime based at the whole-of-fishery level.
Sustainability assessments	Sustainability confirmed through stock assessments / biomass estimates.	Sustainability confirmed through indicative sustainability assessments & weight of evidence approach e.g. national SAFS.	Not assessed, biomass depleted, declining or not conducive to meeting Strategy targets.
Recreational desirability / other fisheries	<33% retention.	33–66% retention.	>66% retention.

For the purpose of this ERA, recreational retention rates were used as an indicative assessment of a species popularity across the two sectors (Table 3). It is however acknowledged that the charter fishery is monitored and managed as a separate entity. When and where appropriate the impacts of this sector will be given further consideration as part of the *Residual Risk Assessment* (RRA). In addition to the recreational and charter fisheries, tunnel net species will be retained for sale in other sectors of the ECIF (Department of Agriculture and Fisheries, 2019e). As these risk come from within the fishery, catch reported from these sectors of the ECIF were not taken into consideration as part of the *recreational desirability / other fisheries* assessment. Instead they will be assessed as part of the Level 2 assessment for the Large Mesh Net Fishery (gillnets and ring nets) and Ocean Beach Fishery.

The three additional susceptibility attributes were only applied to retainable product and therefore were not include in assessments involving most of the SOCC subgroups.

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 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.

2.4.3 Uncertainty

A number of factors including imprecise or missing data and the use of averages or proxies can contribute to the level of uncertainty surrounding the PSA. Examples of which include the use of a default high score for attributes missing data and the use of values based at a higher taxon *i.e.* genera or family level (Hobday *et al.*, 2011). In the Level 2 ERA uncertainty is examined through a baseline assessment of each risk profile to determine the proportion of attributes assigned a precautionary

high-risk rating due to data deficiencies. As species with greater data deficiencies are more likely to attract the default high-risk rating, their profiles are more likely to fall on the conservative side of the spectrum. In these instances, it may be more appropriate to address these risks and data deficiencies through measures like the *Queensland Sustainable Fisheries Strategy—Monitoring and Research Plan* (Department of Agriculture and Fisheries, 2018d).

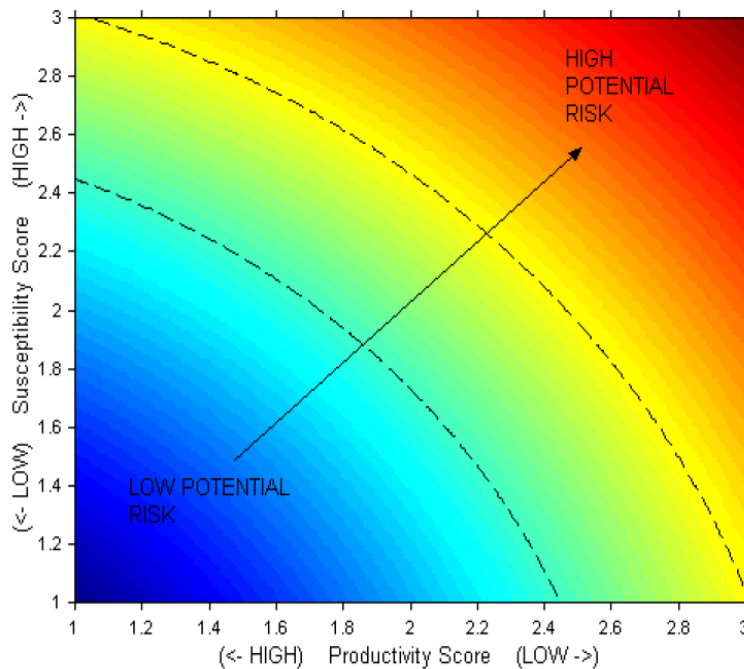


Figure 1. PSA plot demonstrating the two-dimensional space which species units are plotted. PSA scores for species units represent the Euclidean distance or the distance between the origin and the productivity (x-axis), susceptibility (y-axis) intercept (excerpt from Hobday *et. al.*, 2007).

2.4.4 Residual Risk Analysis (RRA)

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

The RRA framework was based on guidelines established by CSIRO and the *Australian Fisheries Management Authority* (AFMA) (Australian Fisheries Management Authority, 2018). 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, 2018). 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 (Level 2) ERAs (Department of Agriculture and Fisheries, 2018c; Jacobsen *et al.*, 2019).

In instances where the RRA resulted in an amendment to the preliminary score, full justifications were provided (Appendix C) 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 Australian Fisheries Management Authority (AFMA) Ecological Risk Assessment, Residual Risk Assessment Guidelines (Australian Fisheries Management Authority, 2018).

Guidelines	Summary
Guideline 1: Risk rating due to missing, incorrect or out of date information.	Considers if <i>susceptibility</i> and/or <i>productivity</i> attribute data for a species is missing or incorrect for the fishery assessment and is corrected 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 oversight committees established as part of the <i>Queensland Sustainable Fisheries Strategy 2017–2027</i> e.g. <i>Fisheries Working Groups</i> and the <i>Sustainable Fisheries Expert Panel</i> .
Guideline 3: At risk with spatial assumptions.	Provides further consideration to the spatial distribution data, habitat data and any assumptions underpinning the assessment.
Guideline 4: At risk in regards to level of interaction/capture with a zero or negligible level of susceptibility.	Considers observer or expert information to better calculate <i>susceptibility</i> for those species known to have a low likelihood or no record of interaction nor capture with the fishery.
Guideline 5: Effort and catch management arrangements for target & byproduct species.	Considers current management arrangements based on effort and catch limits set using a scientific assessment for key species.
Guideline 6: Management arrangements to mitigate against the level of bycatch.	Considers management arrangement in place that mitigate against bycatch by the use of gear modifications, mitigation devices and catch limits.
Guideline 7: Management arrangements relating to seasonal, spatial and depth closures.	Considers management arrangements based on seasonal, spatial and/or depth closures.

3 Results

3.1 Productivity & Susceptibility Analysis (PSA)

3.1.1 Target & Byproduct Species

The majority of the catch (82%) reported from the Tunnel Net Fishery was assigned to one of nine catch categories. Of this catch, the majority was reported as *Mullet—unspecified* (35.5%), *Bream—unspecified* (20.3%), *Whiting—unspecified* (15.5%) and spinefoot / scribbled rabbitfish (10.8%). The remainder consisted of smaller quantities of inshore species like garfish (*Hyporhamphus* spp.), flathead (*Platycephalus* spp.) and trevally (*Family Carangidae*). These nine catch categories produced a preliminary list of 32 target & byproduct species that were considered for inclusion in the Level 2 ERA. This list was subsequently reduced to 16 species; a number of which were included in the assessment as a precautionary measure (Table 5; Appendix A).

Productivity scores for the target & byproduct species ranged from 1.29 to 2.29 (*average* = 1.71). These scores showed a high degree of variability which was largely driven by data deficiencies; particularly for the *age at maturity*, *maximum age* and *size at maturity* attributes (Table 5). Of the target and byproduct species assessed, the bartailed flathead (2.29) and northern sand flathead (2.14) had the highest productivity scores. At 1.29, sand whiting, snubnose garfish and yellowfin bream registered the lowest productivity score of the assessment (Table 5). The *susceptibility* component of the PSA showed less variability with four of the seven attributes receiving the maximum score for all 16 species (Table 5). Eight of the 16 species recorded an assessment high *susceptibility* score of 2.71. The remaining species all registered *susceptibility* scores >2.00, the lowest being yellowfin bream at 2.14 (Table 5).

Based on their *productivity* and *susceptibility* scores, one species (yellowfin bream) was assigned a preliminary low-risk rating. The remaining species were all assigned preliminary ratings of medium ($n = 8$) or high ($n = 7$) risk (Table 5).

3.1.2 Species of Conservation Concern

The Tunnel Net Fishery is restricted in legislation to sections of the *Moreton Bay Marine Park* and the *Great Sandy Marine Park* (Department of Agriculture and Fisheries, 2019e). These provisions not only restrict the footprint of the fishery but also limit the number of SOCC that will interact with this sector of the ECIF. This was reflected in the species rationalisation process where only seven of the 84 species were identified for inclusion in the Tunnel Net Fishery Level 2 ERA (Appendix B): three marine turtles, three batoids and dugongs (Table 5; Appendix B).⁶ Of these seven species, only the bottlenose wedgefish and giant shovelnose ray can be retained for sale. As both of these species are listed under CITES, they were assessed as part of the SOCC subgroup instead of the target & byproduct species ecological component.

When the *productivity* and *susceptibility* scores were taken into consideration, four species were assigned preliminary high-risk ratings including all three batoids. The exceptions being marine turtles which registered preliminary scores within the medium-risk category (Table 5).

⁶ The list of target and byproduct species does not include shovelnose rays and guitarfish as they did not meet the 95% catch threshold. As these species are afforded additional legislative protections and or are included in international instruments like CITES and CMS, they were assessed as part of the SOCC Level 2 ERA.

Table 5. Preliminary risk ratings compiled as part of the Productivity & Susceptibility Analysis (PSA) including the scores assigned to each attribute based on criteria outlined in Table 2 and 3. 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	Management Strategy	Sustainability assessments	Recreational desirability / other fisheries	Susceptibility	PSA score
Target & Byproduct																		
Mullet																		
Sea mullet	<i>Mugil cephalus</i>	1	2	1	2	2	1	1	1.43	1	3	3	3	3	1	3*	2.43	2.82
Fantail mullet	<i>Paramugil georgii</i>	3*	3*	1	1	3*	1	1	1.86	1	3	3	3	3	3*	3*	2.71	3.29
Diamondscale mullet	<i>Liza vaigiensis</i>	3*	3*	1	1	3*	1	1	1.86	1	3	3	3	3	3*	3*	2.71	3.29
Flathead																		
Dusky flathead	<i>Platycephalus fuscus</i>	1	2	1	1	2	1	3	1.57	1	3	3	3	3	1	2	2.29	2.77
Bartailed flathead	<i>Platycephalus australis</i>	3*	3*	1	2	3*	1	3	2.29	1	3	3	3	3	3*	3*	2.71	3.55
Northern sand flathead	<i>Platycephalus endrachtensis</i>	3*	3*	1	1	3*	1	3	2.14	1	3	3	3	3	3*	2	2.57	3.35
Yellowtailed flathead	<i>Platycephalus westraliae</i>	3*	3*	1	1	1	1	3	1.86	1	3	3	3	3	3*	3*	2.71	3.29
Whiting																		
Trumpeter whiting	<i>Sillago maculata</i>	1	2	1	1	1	1	3	1.43	1	3	3	3	3	3*	3	2.71	3.07

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	Management Strategy	Sustainability assessments	Recreational desirability / other fisheries	Susceptibility	PSA score
Sand whiting	<i>Sillago ciliata</i>	1	2	1	1	1	1	2	1.29	1	3	3	3	3	1	3*	2.43	2.75
Bream																		
Yellowfin bream	<i>Acanthopagrus australis</i>	1	2	1	1	1	1	2	1.29	1	3	3	3	3	1	1	2.14	2.50
Tarwhine	<i>Rhabdosargus sarba</i>	1	2	1	1	1	1	3	1.43	1	3	3	3	3	3*	1	2.43	2.82
Garfish																		
Snubnose garfish	<i>Arrhamphus sclerolepis</i>	1	1	1	1	1	1	3*	1.29	1	3	3	3	3	3*	3*	2.71	3.00
Three-by-two garfish	<i>Hemiramphus robustus</i>	3*	3*	1	1	3*	1	3	2.14	1	3	3	3	3	3*	3*	2.71	3.46
Trevally / Family Carangidae																		
Giant trevally	<i>Caranx ignobilis</i>	1	3	1	2	2	1	3	1.86	1	3	3	3	3	3*	2	2.57	3.17
Golden trevally	<i>Gnathanodon speciosus</i>	2	2	1	2	2	1	3	1.86	1	3	3	3	3	3*	1	2.43	3.06
Other																		
Scribbled rabbitfish	<i>Siganus spinus</i>	1	3*	2	1	3*	2	1	1.86	1	3	3	3	3	3*	3*	2.71	3.29

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	Management Strategy	Sustainability assessments	Recreational desirability / other fisheries	Susceptibility	PSA score
SOCC																		
Marine turtles																		
Green turtle	<i>Chelonia mydas</i>	3	3	3	2	2	2	1	2.29	1	3	3	1	N/A	N/A	N/A	2.00	3.04
Loggerhead turtle	<i>Caretta caretta</i>	3	3	3	1	2	2	3	2.43	1	3	3	1	N/A	N/A	N/A	2.00	3.15
Hawksbill turtle	<i>Eretmochelys imbricata</i>	3	3	3	1	2	2	2	2.29	1	3	3	1	N/A	N/A	N/A	2.00	3.04
Sirenia																		
Dugong	<i>Dugong dugon</i>	3	3	3	3	3	3	1	2.71	1	3	3	3*	N/A	N/A	N/A	2.50	3.69
Batoids⁷																		
Bottlenose wedgefish	<i>Rhynchobatus australiae</i>	3*	3*	3*	2	2	3	3	2.71	1	3	3	3*	3	3*	3*	2.71	3.84
Giant shovelnose ray	<i>Glaucostegus typus</i>	2	2	3*	2	2	3	3*	2.43	1	3	3	3*	3	3*	3*	2.71	3.64
Estuary stingray	<i>Hemirtrygon fluviorum</i>	2	2	3*	1	1	3	3	2.14	3*	3	3	3*	N/A	N/A	N/A	3.00	3.69

⁷ The bottlenose wedgefish (*R. australiae*) and giant shovelnose ray (*G. typus*) can be retained for sale in the Tunnel Net Fishery. Both were assessed in the SOCC complex as they have been listed under CITES. Similarly, the estuary stingray (*H. fluviorum*) was assessed as a SOCC as it is listed under the Nature Conservation Act 1992 (Qld).

3.2 Uncertainty

3.2.1 Target & Byproduct Species

When compared, data deficiencies were more prevalent in assessments involving the target & byproduct species ecological component. As teleosts have *r*-selected life-histories, the use of precautionary scores in the *productivity* assessment contributed to the production of more conservative risk profiles. For example, six teleosts were assigned precautionary high-risk scores (3) for *age at maturity* and/or *size at maturity* (Table 5). However, it can be inferred that age and size at maturity for these species will be, at the very least, below the threshold of a high-risk rating (Table 3).

In the *susceptibility* component, most attributes were assigned scores based on the available data and a clear understanding of their management regime. The notable exceptions being *sustainability assessments* and *recreational desirability / other fisheries* where the majority were assigned a precautionary high-risk score (3) for one or both of these attributes (Table 5 & 6). In these instances, it will be more difficult to assess the extent of any risk overestimation as it will be highly dependent on the species and their potential to interact with fishers across sectors.

3.2.2 Species of Conservation Concern

In the SOCC, precautionary high-risk ratings were largely confined to the batoids subgroup (Table 5). In the *productivity* assessment, attributes linked with a species longevity and reproduction were most influenced by data deficiencies (Table 6). As these species have low reproductive rates, the use of precautionary high-risk scores for the *fecundity* attribute will not contribute to the production of a false-positive result. The situation for the remaining attributes is more complex and, in these instances, the use of precautionary scores may have contributed to the production of more conservative risk assessments (Table 6).

In the *susceptibility* component of the PSA, data deficiencies were more influential in assessments involving the *post-capture mortality* attribute (Table 6). These scores reflect deficiencies in the amount of data that is available on SOCI-tunnel net interactions and post-release survival rates. For this attribute, the extent of any (potential) risk overestimation will be dependent on the species in question, the extent of the interaction and their level of protection *i.e.* a no-take species or retainable product.

3.3 Residual Risk Analysis

The Level 2 ERA for the Tunnel Net Fishery covers an array of species with varying life-history traits, habitat preferences and information gaps. Similarly, tunnel net operations have a number of key nuances in terms of where they are allowed to be used and how they are used in the marine environment. These complexities were reflected in the RRA where a number of the risk profiles were amended to consider additional information, regional distributions, 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 C.

Table 6. Summary of the number of attributes that were assigned a precautionary high (3) score due to data deficiencies. * Management strategy, sustainability assessments and recreational desirability / other fisheries were only applied to retainable product.

	Age at maturity	Maximum age	Fecundity	Maximum size	Size at maturity	Reproductive strategy	Trophic level	Availability	Encounterability	Selectivity	Post-capture mortality	Management strategy*	Sustainability assessments*	Recreational desirability / other fisheries*
Target & Byproduct (n = 16)														
No. Species	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Species missing data	6	7	0	0	6	0	1	0	0	0	0	0	12	9
% Unknown Information	38%	44%	0%	0%	38%	0%	6%	0%	0%	0%	0%	0%	75%	56%
SOCC (n = 7)														
No. Species	7	7	7	7	7	7	7	7	7	7	7	2	2	2
Species missing data	1	1	3	0	0	0	1	0	0	0	3	0	2	2
% Unknown Information	14%	14%	43%	0%	0%	0%	14%	0%	0%	0%	43%	0%	100%	100%
All Species (n = 23 max)														
No. Species	23	23	23	23	23	23	23	23	23	23	23	18	18	18
Species missing data	7	8	3	0	6	0	2	0	0	0	3	0	14	11
% Unknown Information	30%	35%	13%	0%	26%	0%	9%	0%	0%	0%	13%	0%	78%	61%

3.3.1 Target & Byproduct Species

Eight target or byproduct species received precautionary high-risk scores (3) for at least one of the seven *productivity* attributes assessed (Table 5). In the RRA, a number of these scores were reduced through the use of proxies from species with similar morphological and biological traits (Table 7). In the target & byproduct species assessment, the majority of these amendments involved secondary mullet species. For these species, biological parameters used in the sea mullet assessment were viewed as a suitable proxy. A similar strategy was employed for the flathead complex, the only other non-SOCC species whose productivity scores were amended as part of the RRA (Appendix C).

All of the *susceptibility* RRA amendments involved the *management strategy* and *recreational desirability / other fisheries* attributes (Table 7). In the RRA, further consideration was given to the suitability of the *management strategy* criteria (Table 3) and how they were applied to tunnel net species. The RRA reviewed the status of the species within the fishery, their catch history and the suitability, applicability and effectiveness of the current management arrangements. This weight-of-

evidence approach supported a reduction in the *management strategy* attribute scores for a number of species including those within the mullet, flathead, whiting and bream complexes (Appendix C).

A number of the target and byproduct species included in the Level 2 ERA had limited recreational data or catch estimates based at a higher taxonomic level e.g. mullet (Webley *et al.*, 2015). Further investigation of recreational surveys and charter fishery data indicated that the listed species were less likely to be at risk from cumulative fishing pressures. Accordingly, the majority of scores assigned to the *recreational desirability / other fisheries* attribute were adjusted downwards as part of the RRA (Appendix C). The notable exceptions being yellowfin bream and tarwhine where retention rates may underestimate harvest rates for legal sized fish and the cumulative fishing risk posed to these species (Appendix C).

As a result of the RRA, the risk profiles of 13 species were amended with 12 scores decreasing and one increasing (Table 5; Table 7). For nine of these species, these reductions resulted in a reclassification of the overall risk rating. The most significant reductions were for the fantail mullet (high to low), diamondscale mullet (high to low), dusky flathead (medium to low) and sand whiting (medium to low). Based on the revised RRA scores, five species were assessed as being at low risk from fishing activities in the Tunnel Net Fishery; the remaining target & byproduct species were classified as medium risk (Table 7).

3.3.2 Species of Conservation Concern

Marine Turtles

Due to the precautionary nature of the PSA, scores assigned 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 one species, the loggerhead turtle, these initial estimates provided an unrealistic account of the species fecundity. In the RRA, the number of offspring per year was recalculated using mean values for each of the aforementioned parameters (Appendix C). As a result of these amendments scores assigned to the *fecundity* attribute for the loggerhead turtle were downgraded from high (3) to medium (2). This change reduced the *productivity* score of both species but did not alter their final risk ratings (Table 7).

Sirenia (Dugongs)

Two amendments were made to the preliminary risk profile for dugongs (Table 7). The *encounterability* attribute was downgraded from a high (3) to a low (1) in recognition of the fact that the fishery has a contracted footprint and operates within the confines of two state-based marine parks. Within these areas dugongs are afforded considerable protection from net fishing activities including in high-value habitats and areas where dugongs occur at higher densities (Appendix C).

The second amendment involved the *post-capture mortality* attribute which was assigned a high-risk rating due to data deficiencies. This score was downgraded from high (3) to low (1) in recognition of the strategies already being employed in the fishery to minimise the risk posed to marine megafauna e.g. the use of smaller mesh sizes in the wing of the net, a requirement to keep the tunnel of the net submerged for the duration of the fishing event, in attendance provisions and industry-led initiatives advocating for the use of bycatch reduction devices in Moreton Bay (Appendix C).

Changes to the *susceptibility* assessment were reflected in the overall score and the species was reclassified as a medium risk (Table 7).

Table 7. Residual Risk Assessment (RRA) of the preliminary scores assigned as part of the Productivity and Susceptibility Analysis (PSA). Pink shaded squares represent the 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	Management Strategy	Sustainability assessments	Recreational desirability / Other fisheries	Susceptibility	PSA score
Target & Byproduct																		
Mullet																		
Sea mullet	<i>Mugil cephalus</i>	1	2	1	1	2	1	1	1.29	1	3	3	3	1	1	2	2.00	2.38
Fantail mullet	<i>Paramugil georgii</i>	1	2	1	1	2	1	1	1.29	1	3	3	3	1	3	2	2.29	2.62
Diamondscale mullet	<i>Liza vaigiensis</i>	1	2	1	1	2	1	1	1.29	1	3	3	3	1	3	2	2.29	2.62
Flathead																		
Dusky flathead	<i>Platycephalus fuscus</i>	1	2	1	1	2	1	3	1.57	1	3	3	3	2	1	2	2.14	2.66
Bartailed flathead	<i>Platycephalus australis</i>	1	2	1	2	2	1	3	1.67	1	3	3	3	3	3	2	2.57	3.06
Northern sand flathead	<i>Platycephalus endrachtensis</i>	1	2	1	1	2	1	3	1.50	1	3	3	3	3	3	2	2.57	2.98
Yellowtailed flathead	<i>Platycephalus westraliae</i>	1	2	1	1	1	1	3	1.43	1	3	3	3	3	3	2	2.57	2.94
Whiting																		
Trumpeter whiting	<i>Sillago maculata</i>	1	2	1	1	1	1	3	1.43	1	3	3	3	2	3	3	2.57	2.94

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	Management Strategy	Sustainability assessments	Recreational desirability / Other fisheries	Susceptibility	PSA score
Sand whiting	<i>Sillago ciliata</i>	1	2	1	1	1	1	2	1.29	1	3	3	3	2	1	2	2.14	2.50
Bream																		
Yellowfin bream	<i>Acanthopagrus australis</i>	1	2	1	1	1	1	2	1.29	1	3	3	3	2	1	2	2.14	2.50
Tarwhine	<i>Rhabdosargus sarba</i>	1	2	1	1	1	1	3	1.43	1	3	3	3	3	3	2	2.57	2.94
Garfish																		
Snubnose garfish	<i>Arrhamphus sclerolepis</i>	1	1	1	1	1	1	3	1.29	1	3	3	3	1	3	3	2.43	2.75
Three-by-two garfish	<i>Hemiramphus robustus</i>	1	1	1	1	1	1	3	1.29	1	3	3	3	1	3	3	2.43	2.75
Trevally / Family Carangidae																		
Giant trevally	<i>Caranx ignobilis</i>	1	3	1	2	2	1	3	1.86	1	3	3	3	3	3	2	2.57	3.17
Golden trevally	<i>Gnathanodon speciosus</i>	2	2	1	2	2	1	3	1.86	1	3	3	3	3	3	2	2.43	3.17
Other																		
Scribbled rabbitfish	<i>Siganus spinus</i>	1	1	2	1	1	2	1	1.29	1	3	3	3	3	3	1	2.71	2.75

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	Management Strategy	Sustainability assessments	Recreational desirability / Other fisheries	Susceptibility	PSA score
SOCC																		
Marine turtles																		
Green turtle	<i>Chelonia mydas</i>	3	3	3	2	2	2	1	2.29	1	3	3	1	N/A	N/A	N/A	2.00	3.04
Loggerhead turtle	<i>Caretta caretta</i>	3	3	2	2	2	2	3	2.43	1	3	3	1	N/A	N/A	N/A	2.00	3.15
Hawksbill turtle	<i>Eretmochelys imbricata</i>	3	3	3	1	2	2	2	2.29	1	3	3	1	N/A	N/A	N/A	2.00	3.04
Sirenia																		
Dugong	<i>Dugong dugon</i>	3	3	3	3	3	3	1	2.71	1	1	3	1	N/A	N/A	N/A	1.50	3.04
Batoids⁸																		
Bottlenose wedgefish	<i>Rhynchobatus australiae</i>	2	3	3	2	2	3	3	2.57	1	3	3	1	2	3	1	2.00	3.26
Giant shovelnose ray	<i>Glaucostegus typus</i>	2	2	3	2	2	3	3	2.43	1	3	3	1	2	3	1	2.00	3.15
Estuary stingray	<i>Hemirtrygon fluviorum</i>	2	2	3	1	1	3	3	2.14	1	2	3	1	N/A	N/A	N/A	2.00	2.93

⁸ The bottlenose wedgefish (*R. australiae*) and giant shovelnose ray (*G. typus*) can be retained for sale in the Tunnel Net Fishery. Both were assessed in the SOCC complex as they have been listed under CITES. Similarly, the estuary stingray (*H. fluviorum*) was assessed as a SOCC as it is listed under the Nature Conservation Act 1992 (Qld).

Batoids

The majority of amendments made to the batoid risk profiles involved *susceptibility* attributes; namely *post-capture mortality*, *availability* and *encounterability* (Table 7, Appendix C). In the PSA, all three species were assigned a precautionary high-risk score (3) for the *post-capture mortality* attribute due to data deficiencies (Table 5). In the RRA, scores for this attribute were refined with the bottlenose wedgefish and giant shovelnose ray dropping to a medium (2) risk and the estuary stingray reclassified as low (1) risk (Table 7, Appendix C). In the RRA of the *availability* and *encounterability* attributes, further consideration was given to the distribution of the estuary stingray and the potential for this species to interact with the fishery (Appendix C). As a result of these considerations, scores assigned to both attributes were reduced as part of the RRA (Table 7; Appendix C).

The remaining RRA involved the bottlenose wedgefish, the giant shovelnose ray and the *recreational desirability / other fisheries attribute*. In these two instances, a review of the current management arrangements and the available data supported a score reduction (Table 7; Appendix C). Analogous reductions could not be made to the estuary stingray risk profile as the species cannot be retained for sale in areas covered by the *Nature Conservation Act 1992*. Therefore, the estuary stingray was not included in assessments involving the *recreational desirability / other fisheries attribute* (Table 5 & 7).

As a result of changes made as part of the RRA, the overall risk classification for the giant shovelnose ray and the estuary stingray was reduced from high to medium. While the risk score for the bottlenose wedgefish was reduced, it was not sufficient to drop the species to a medium risk rating. It is noted though that the final risk score for the bottlenose wedgefish (3.26) was marginally above the medium/high-risk threshold (Fig. 1).

4 Risk Evaluation

4.1 Tunnel Net Fishery

When the results of the PSA and RRA were taken into consideration, the Level 2 ERA indicated that fishing activities in the Tunnel Net Fishery presented a low to medium risk to the majority of the species assessed. These results are (generally) lower than what has been observed in other ECIF sub-fisheries including in the Large Mesh Net Fishery (Jacobsen *et al.*, 2021a; b; Pidd *et al.*, 2021). This is to be expected given that the footprint of the Tunnel Net Fishery is smaller and located within the confines of the *Moreton Bay* and *Great Sandy Marine Parks* (Department of Environment and Science, 2020a; b; Department of National Parks Sport and Racing, 2015a; b).

At a fishery level, there are a number of measures in place that minimise the risk to both non-target and target species including provisions that:

- a) limit the number of N10 (tunnel net) fishing symbols;
- b) require the tunnel of the net to be set in place before the rest of the net is deployed; and
- c) require the tunnel of the net to extend out to sea beyond low water for at least 30m in waters at least 30cm deep.

These measures are complimented by net attendance provisions that require at least one fisher to be within 100m of the net while it is in operation.

From an ERA perspective, the above measures minimise the risk that non-target species (e.g. SOCC or fish below minimum legal size limits) will sustain significant injuries, experience longer-term complications or die as a result of the interaction. It also suggests that the final ratings for some species represent a false positive or a risk over-estimation. In the Level 2 ERA, false positives are more likely to be observed in secondary targets, species with low rates of harvest and SOCC that have infrequent interactions with the Tunnel Net Fishery. This inference 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 D).⁹

While noting the above constraints, the Level 2 ERA did identify a number of areas where the risk posed to non-target species could be reduced and the accuracy of the risk profiles improved. At a whole-of-fishery level, future ERAs would gain significant benefit from the collection of additional data on species compositions, retention rates and discard fates. This information would improve the accuracy of risk profiles and (potentially) allow for refinements to be made to the scope of the ERA. For instance, improved information on catch compositions and interaction rates would (likely) facilitate a risk-score reduction for a number of species and enable low-risk complexes to be excluded from future ERAs including a number of the SOCC.

Outside of data collection, the most significant and arguably simplest risk-mitigation measure is to mandate the use of a tunnel grid or analogous bycatch reduction device (BRD). This alone would prevent marine megafauna from entering the tunnel of the net and help minimise the length of the interaction. As the use of BRD is not (currently) mandatory in the Tunnel Net Fishery, the Level 2 ERA adopted a more precautionary approach.¹⁰ This risk is now being actively addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* with the use of a tunnel grid becoming mandatory from September 2021. This measure though has yet to be fully implemented and as a consequence could not be accounted for in this iteration of the Tunnel Net Fishery Level 2 ERA.

If and when the use of a tunnel grid becomes mandatory, there will be clear implications for the ERA process. For example, there will be sufficient grounds to confine the definition of net selectivity to just the tunnel of the net. If this were to occur, the majority of the SOCC would be assigned a low (1) risk rating for this attribute. This would see all of the SOCC classified as a medium risk with a number edging closer to the threshold of a low-risk rating (Fig. 1). When compared, mandating the use of a BRD will yield limited benefits for target & byproduct species as they are smaller and are actively targeted and retained in this sector of the ECIF.

General recommendations

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

⁹ *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 D). The LCA is a fully qualitative assessment and was used to provide an indicative assessment of how conservative an assessment 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.*

¹⁰ *A grid is placed at the start of the tunnel in some operations to prevent marine megafauna from entering the main part of the apparatus. One region of the tunnel fishery, Moreton Bay, operates under a code of best practice which already encourages the use of a tunnel grid to minimise the impact of the fishery on non-target species (Thompson et al., 2012).*

2. Mandate the use of bycatch reduction devices in the Tunnel Net Fishery to aid in the removal of non-target species, improve post-interaction survival rates and minimise the length of the interaction.
3. Establish a measure to estimate the gear-affected area and, when available, reassess the risk posed to teleosts species using a more quantitative ERA method e.g. bSAFE.

4.2 Target & Byproduct Species

Risk profiles compiled as part of the Level 2 assessment were based on management arrangements applied to the fishery at the time of writing. This assessment did not consider management reforms being proposed for the fishery including those contained within the draft ECIF harvest strategy (released September 2020; Department of Agriculture and Fisheries, 2020b). The draft ECIF harvest strategy places greater emphasis on regional management, establishes a three-tiered system transitioning key species to output controls and contains harvest control rules to manage the long-term take of secondary target species (Department of Agriculture and Fisheries, 2020b).

Once finalised and implemented, the ECIF harvest strategy will (likely) result in a risk score reduction for a number of species included in this assessment (Table 7). In a large number of instances, this reduction will facilitate the lowering of individual risk ratings. For example, the introduction of a quota-based harvest strategy with supporting harvest control rules, could facilitate the assignment of a low (1) risk rating for the *management strategy* attribute. If this were to occur, all 16 teleosts would register risk scores lower than 3.00 (medium risk) and seven species would be classified as low risk (Table 7).

As a draft harvest strategy has already been released for the ECIF (Department of Agriculture and Fisheries, 2020b), the outputs of the current assessment could be viewed as a worst case scenario for the Tunnel Net Fishery. The expectation being that an updated Level 2 ERA will consider the content of any harvest strategy implemented at the time of the assessment. If and when this occurs, the current study will provide a baseline of assessments that can be compared to future ERAs. By extension, the outputs of this assessment will be of vital importance when determining the effectiveness of measures implemented as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017).

4.2.1 Mullet

Common name	Species name	Risk Rating
Sea mullet	<i>Mugil cephalus</i>	Low
Fantail mullet	<i>Paramugil georgii</i>	Low
Diamondscale mullet	<i>Liza vaigiensis</i>	Low

Mullet makes a significant contribution to the total ECIF catch (Department of Agriculture and Fisheries, 2019e) with the majority being retained in the Ocean Beach Fishery. Ocean beach fishers utilise seine nets and actively target near-shore schools of fish between 1 April and 31 August (Department of Agriculture and Fisheries, 2019e). This sector harvests three to four times the mullet reported from the Tunnel Net Fishery (2016–2019 inclusive) and it will be the key driver of risk for this complex (Jacobsen *et al.*, 2021b). As such, the Tunnel Net Fishery is viewed as a contributor of risk for this complex.

Mullet catch in the broader ECIF has poor species resolution with the majority reported as *unspecified* (Department of Agriculture and Fisheries, 2019e; 2020a). A high percentage of this catch will consist of sea mullet (*M. cephalus*; Lovett *et al.*, 2018) and this species is considered to be a good indicator for the rest of the complex. Despite not being managed under output controls (*i.e.* a TACC limit), evidence suggests that sea mullet are being managed effectively on the Queensland east coast. Sea mullet has long catch history and stock sustainability has been confirmed through multiple assessments and indicative sustainability evaluations (Lovett *et al.*, 2018; Smith & Deguara, 2002; Stewart *et al.*, 2018; Virgona *et al.*, 1998). Cumulative fishing pressures will also be lower for this species as it is not a primary target for recreational fishers. These factors were given significant weighting in the RRA and were reflected in scores assigned to the *management strategy*, *sustainability assessments*, and *recreational desirability / other fisheries* attributes (Table 7; Appendix C).

The inclusion of fantail (*P. georgii*), and diamondscale (*L. vaigiensis*) mullet recognises the fact that these species will be caught in conjunction with sea mullet (Table 7; Appendix B). When compared to sea mullet, data sets for secondary mullet species are less developed and their risk profiles needed to account for a number of data deficiencies (Appendix C). Where possible, these deficiencies were addressed in the RRA through the use of proxies. The use of proxies helped refine the risk profiles of both species and produced ratings that were more reflective of the actual risk *verse* the potential risk (Table 7). As proxies were based on the highest attribute score assigned to the complex (Appendix C), it is unlikely that the RRA would have contributed to the production of a false-negative result (*i.e.* a risk underestimation).

While difficult to quantify without additional information, expectations are that all three mullet species will display a similar resilience to regional fishing pressures. It is recognised though that fantail and diamondscale mullet are targeted with less frequency and fishing mortality rates will be lower for these species. For these reasons, it is likely that the risk posed to the fantail and diamondscale mullet will be equal to if not lower than sea mullet. However, future ERAs would benefit from additional information on mullet catch compositions (commercial and recreational) and improved biological data. This information would reduce the reliance of the ERA on sea mullet data (Appendix C), enable refinements to be made to the scope of the Level 2 ERA and facilitate the removal of low-risk species.

The Level 2 ERA indicates that mullet are at low risk of being fished unsustainably within the current fishing environment. In the absence of output controls, there is a longer-term risk that catch levels within the entire ECIF will increase beyond key sustainability reference points (Department of Agriculture and Fisheries, 2019e). This longer-term risk is now being addressed through the harvest strategy development process (Department of Agriculture and Fisheries, 2020b). Under the draft ECIF harvest strategy, sea mullet are classified as a *Tier 2* species and it will be transitioned to a management system that relies on the use of output controls in south-east Queensland (Department of Agriculture and Fisheries, 2020b). Secondary mullet species are listed in *Tier 3* and are a lower priority for quota management. They will however be subject to increased monitoring and harvest control rules ensuring that shifting fishing pressures do not present an unacceptable level of risk (Department of Agriculture and Fisheries, 2020b).

Species-specific recommendations

1. Implement output-based management for mullet that minimises the long-term risk of overfishing; noting the cross-jurisdictional nature of sea mullet stocks and the targeting of the species in both QLD and NSW.
2. If outputs controls are not viable, maintain a stock assessment regime that upholds a high level of certainty that the stock is still being sustainably fished within Queensland and across jurisdictions.
3. Improve catch composition data and identify mechanisms to improve data on harvest rates for secondary mullet species, allowing for further refinements to be made to the ERA process and facilitate the removal of some species.

4.2.2 Flathead

Common name	Species name	Risk Rating
Dusky flathead	<i>Platycephalus fuscus</i>	Medium*
Bartailed flathead	<i>Platycephalus australis</i>	Precautionary Medium
Northern sand Flathead	<i>Platycephalus endrachtensis</i>	Precautionary Medium
Yellowtailed flathead	<i>Platycephalus westraliae</i>	Precautionary Medium

* The risk score for the dusky flathead was 2.66 which is just above the low-risk / medium-risk threshold (>2.64).

The situation surrounding flathead is similar to mullet in that a single species, the dusky flathead (*P. fuscus*), will be responsible for the majority of the catch and effort (Leigh *et al.*, 2019). The remainder of the catch will consist of smaller quantities of bartailed (*P. australis*), northern sand (*P. endrachtensis*) and yellowtail (*P. westraliae*) flathead.

Morphological similarities among flathead species limits the potential for species-specific reporting and leads to coarse-scale species compositions. For example, all of the flathead catch from the ECIF is reported as *unspecified* (Department of Agriculture and Fisheries, 2019e). This lack of resolution creates uncertainty surrounding species-specific rates of fishing mortality and limits the scope of any sustainability assessment. Improving the level of information on flathead catch compositions would assist with this process and provides further avenues to reduce scores assigned to one or more of the *susceptibility* attributes e.g. *management strategy*, *encounterability* and *recreational desirability / other fisheries*. A score reduction in any one of these attributes would see at least one of the species, the dusky flathead, reclassified as low risk in the Tunnel Net Fishery (Table 7).

As flathead are not managed under output controls (e.g. a TACC), catch and effort can increase under the current management regime. This was a notable risk factor for flathead and was assessed accordingly as part of the *management strategy* evaluation (Table 7). In the mullet RRA, a weight-of-evidence approach supported the assignment of lower scores for the *management strategy* attribute (Appendix C). In the flathead assessment, the weight-of-evidence was viewed as more circumstantial and resulted in fewer amendments (Appendix C).¹¹ This in part was due to the cross-sector appeal of

¹¹ In the mullet RRA, the *management strategy* score was reduced from high (3) to low (1) across the complex. This compares to the flathead RRA where only the dusky flathead *management strategy* attribute score was reduced from high (3) to medium (2).

flathead and greater uncertainty surrounding total rates of harvest for individual species (Table 7; Appendix C).

Unlike mullet, flathead are viewed as a primary target for recreational fishers and harvest rates in this sector are roughly equal to that reported from the commercial net fishery (Department of Agriculture and Fisheries, 2019e; 2021; Leigh *et al.*, 2019; McGilvray *et al.*, 2018a; Teixeira *et al.*, 2021; Webley *et al.*, 2015). Flathead stocks are highly accessible (Broadhurst *et al.*, 2003; Gray & Barnes, 2015) and these species are at higher risk of experiencing a regional overfishing event due to cumulative fishing pressures. This is more likely to occur in areas with higher populations including in south-east Queensland where regions like the *Moreton Bay* and *Great Sandy Marine Parks* remain popular recreational fishing locations. Given their habitat preferences, the risk posed to these species will be more pronounced in inshore areas and/or where there is a greater overlap between commercial and recreational fishing effort.

Of the four species assessed, only the dusky flathead has been the subject of a detailed quantitative stock assessment (Leigh *et al.*, 2019). This stock assessment considered the cumulative fishing pressures exerted on this species and determined that a) regional stocks were being fished sustainably across sectors and b) the species was likely to meet long-term targets under the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; Leigh *et al.*, 2019). In the Level 2 ERA, this resulted in the species being assigned a low (1) risk rating for the *sustainability assessment* attribute (Table 7). There was however limited grounds to extend this assessment across the entire complex given the level of information on catch compositions and the cumulative fishing pressures exerted on each of the secondary species.

With improved information, the current suite of *sustainability assessments* could be extended to include one or more of the secondary species. In these instances, indicative sustainability evaluations are viewed as a more appropriate course of action *verse* a resource intensive quantitative stock assessment. This information would improve the accuracy of future ERAs and inform the need to undertake more extensive management reforms. It is recognised though that secondary flathead species may be viewed as lower priorities for stock assessments and sustainability evaluations.

Going forward, management of regional flathead stocks will improve with the introduction of an ECIF-specific harvest strategy. Under the draft harvest strategy, dusky flathead will be classified as a *Tier 2* species and it will be transitioned to an output controlled management system (Department of Agriculture and Fisheries, 2020b). For this species, the outputs of the Level 2 ERA can be viewed as the 'high water mark'. The situation surrounding the bartailed, northern sand and yellowtail flathead is less certain as all three will be classified as *Tier 3* species. *Tier 3* species are viewed as lower priorities in terms of stock assessments and will not be transitioned to output controls. They will however be subject to increased monitoring and catch triggers will be used to manage shifting fishing pressures (Department of Agriculture and Fisheries, 2020b).

In terms of future assessments, this complex would derive benefit from additional assessment using the *Sustainable Assessment of Fishing Effects* or SAFE approach. Comparisons have shown that SAFE method produces fewer false positives and may provide greater differentiation in terms of the risk posed to each species (Zhou & Griffiths, 2008; Zhou *et al.*, 2016). The ability to assess these species using SAFE will be predicated on management's ability to quantify the gear-affected area. If this cannot be achieved, future PSA-based ERAs would benefit from improved information on the biology of these species, flathead catch compositions and more refined assessment of regional fishing

pressures. A number of these areas are being actively addressed as part of the Strategy (Department of Agriculture and Fisheries, 2017; 2018a; b; c; d; 2020b).

Species-specific recommendations

1. *Improve flathead catch composition data and identify mechanisms to improve data on harvest rates for secondary species, allowing for refinements to be made to the ERA process and facilitate the removal of some species.*
2. *Increase understanding of fishing pressures on secondary flathead species and explore the need for the inclusion of these species in a stock assessment or indicative sustainability evaluations (e.g. SAFS).*
3. *Implement measures to assess regional cumulative fishing pressures and examine the need for fine-scale fisheries management (e.g. regionally-specific management to address the non-uniform distribution of flathead species in the ECIF).*

4.2.3 Whiting

Common name	Species name	Risk Rating
Sand whiting	<i>Sillago ciliata</i>	Low
Trumpeter whiting	<i>Sillago maculata</i>	Precautionary Medium

The whiting complex incorporates a range of species that have the potential to interact with fishers on the Queensland east coast including sand (*S. ciliata*), trumpeter (winter) (*S. maculata*), goldenline (*S. analis*) and northern (*S. sihama*) whiting. As the majority of the commercial and recreational catch consists of sand and trumpeter whiting, these two species were prioritised for assessment (Appendix B). When and where appropriate, additional species will be assessed in subsequent ERAs.

Of the two primary species, sand whiting will be retained in larger quantities across the commercial and recreational fishing sectors (Department of Agriculture and Fisheries, 2019e; 2020a). While trumpeter whiting will interact with tunnel nets, they are more likely to be encountered and retained in the recreational fishing sector (*pers. comm.* T. Ham). Sand whiting are subject to more stringent management restrictions and their take is limited by a 23cm minimum legal size (MLS) limit and a 30-fish multi-species (combined) recreational possession limit.¹² The take of trumpeter whiting is not subject to any size restrictions and the species has a more generous recreational possession limit ($n = 50$ fish). This translates to a higher rate of retention and was one of the reasons why trumpeter whiting were assigned a higher-risk rating (Table 7).

While sand whiting is not managed through output controls, the Level 2 ERA indicates that the risk posed to this species is being managed in the Tunnel Net Fishery (Table 7). Stock assessments and indicative evaluations have confirmed the sustainability of sand whiting stocks (Leigh *et al.*, 2019; McGilvray & Hall, 2018) and *productivity* scores suggest that the species can withstand higher rates of fishing mortality (Table 7). As sand whiting harvest is dominated by the commercial sector (77%), cumulative fishing pressures will also be lower for this species (McGilvray & Hall, 2018). In the Level 2 ERA, these factors were considered as part of the *management strategy, sustainability assessments*

¹² Recreational fishers are permitted a combined total of 30 goldenline whiting, sand whiting and northern whiting.

and *recreational desirability / other fisheries* evaluations and resulted in the species receiving a low overall risk rating (Table 7).

While trumpeter whiting received an elevated rating, the *Likelihood & Consequence Analysis* indicates that this assessment is precautionary (Appendix D). The risk profile for this species was influenced by data deficiencies (e.g. stock sustainability) and the conservative nature of the ERA methodology (Zhou *et al.*, 2016) (Table 5). These factors contributed to the species receiving a risk rating that does not reflect current sustainability concerns. For this reason, the final risk rating for trumpeter whiting was viewed as a false positive or a risk overestimation. Any future reforms that refine the management of this species, confirm stock sustainability and/or provide further insight into the cumulative fishing pressures (e.g. improved catch data) will result in a downgrading of the risk rating assigned to this species. This in turn will provide a more accurate representation of the risk posed to this species in the Tunnel Net Fishery.

As with bream and flathead, the whiting complex will benefit from the introduction of an ECIF-specific harvest strategy. Under the strategy being considered for ECIF, whiting will be classified as a *Tier 1* complex and will be transitioned to a management system that is underpinned by the use of output controls in Management Region 5 (south-east Queensland). Unlike bream and flathead, this limit will be applied across the entire complex and will include both sand and trumpeter whiting (Department of Agriculture and Fisheries, 2020b). While difficult to predict without knowing the final construct of the ECIF harvest strategy, reforms instigated as part of this process will more than likely result in a risk score reduction for both species (Table 7).

At a complex level, future ERAs would benefit from improved data on the composition of the commercial and recreational whiting catch (Department of Agriculture and Fisheries, 2019e; Jacobsen *et al.*, 2019). While both whiting are reported at the species level, these reports are less frequent and underestimate individual rates of fishing mortality. Both species are reported more consistently as *Whiting—unspecified* and there is particularly poor resolution in the commercial catch data (Department of Agriculture and Fisheries, 2019e; 2020a). Mechanisms to improve species differentiation (commercially and recreationally) would promote more accurate risk assessments and provide further avenues to reduce scores assigned to one or more of the attributes. This information would also facilitate a more rapid transition to the SAFE assessment; an ERA approach that has been shown to produce fewer false positive results (Zhou *et al.*, 2016).

Species-specific recommendations

1. *Improve catch composition data and identify mechanisms to improve data on harvest rates for individual species, allowing for refinements to be made to the ERA process and facilitate the removal of some species.*
2. *Explore the need to include trumpeter whiting in a stock assessment or indicative sustainability evaluations (e.g. SAFS).*
3. *Depending on the outputs of any additional assessments, assess the suitability, applicability and effectiveness of the restrictions placed on trumpeter whiting and (if deemed necessary) areas where the cumulative fishing risks can be minimised.*

4.2.4 Bream & Tarwhine

Common name	Species name	Risk Rating
Yellowfin bream	<i>Acanthopagrus australis</i>	Low
Tarwhine	<i>Rhabdosargus sarba</i>	Medium

Similarities in morphology, habitat preferences and distribution has led to yellowfin bream (*A. australis*) and tarwhine (*R. sarba*) being reporting under a complex with coarse-scale species compositions e.g. *Bream—unspecified* (Department of Agriculture and Fisheries, 2019e; 2020a). While lacking species resolution, anecdotal evidence suggests that the majority of this catch is yellowfin bream with tarwhine accounting for a smaller albeit consistent proportion of the catch (*pers. comm.* T. Ham). Improving the level of information on bream species compositions would inform discussions surrounding the need, suitability and applicability of alternate management arrangements for this complex.

As expected, yellowfin bream and tarwhine scored highly across the *encounterability*, *selectivity* and *post-capture mortality* attributes (Table 7). Both species are retained in the Tunnel Net Fishery and are actively targeted across their known distributions, habitats and preferred depths. These risks will be difficult to countenance in future ERAs as the two species will remain an important component of the retained tunnel net catch. Given the permitted areas of operation, sustainability risks in this sector of the ECIF are highly regional and will be restricted to south-east Queensland. Under the draft ECIF harvest strategy, these regional risks will be addressed through the introduction of a yellowfin bream south-east Queensland TACC limit (Department of Agriculture and Fisheries, 2020b).

As bream are not managed under output controls (e.g. a TACC), catch and effort for both species can increase under the current management regime. While not managed under output controls, the Level 2 ERA indicates that the risk posed by tunnel net fishing is being managed in the current fishing environment (Table 7; Appendix B). This inference is partly supported by a yellowfin bream stock assessment and sustainability evaluations that confirm the species is being fished sustainably (Leigh *et al.*, 2019; McGilvray *et al.*, 2018b). These assessments considered the cumulative fishing pressures exerted on this species including those originating from the recreational and charter fishing sectors (Leigh *et al.*, 2019). This was considered to be of significant importance as harvest share for this species (e.g. commercial verse recreational) is roughly equal (McGilvray *et al.*, 2018b).

Best available information indicates that current fishing pressures for yellowfin bream, while sustainable, are not ideal for stock rebuilding. For example, the stock assessment estimates that this species will take around 25 years to reach long-term objectives (B_{60}) outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2018d; Leigh *et al.*, 2019). This estimate also assumes that total catch and effort will not increase substantially over the short to medium term; something that can occur under the current management regime across all sectors of the ECIF. This issue is again being addressed through the harvest strategy development process where yellowfin bream, as a *Tier 2* species, will be prioritised for transition to a management system based on output controls (Department of Agriculture and Fisheries, 2020b).

When compared to yellowfin bream, there is more uncertainty surrounding the risk posed to tarwhine. Unlike yellowfin bream, tarwhine has not been the subject of a detailed stock assessment or an indicative sustainability evaluation. As a consequence, there is less information on the structure of the stocks on the Queensland east coast and/or what level of fishing mortality is required to meet long-

term targets under the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017). In the Level 2 ERA, these deficiencies were given significant weighting and were reflected in scores assigned to the *management strategy, sustainability assessments, and recreational desirability / other fisheries* attributes (Table 7; Appendix C). It is recognised though that the Tunnel Net Fishery poses a lower risk to this species when compared to other sectors of the ECIF and (potentially) the recreational fishing sector (Department of Agriculture and Fisheries, 2021; Pidd *et al.*, 2021; Teixeira *et al.*, 2021).

As with yellowfin bream, tarwhine are likely to benefit from the introduction of an ECIF-specific harvest strategy. These benefits will be smaller for tarwhine as it will be classified as a *Tier 3* species (Department of Agriculture and Fisheries, 2020b). *Tier 3* species are viewed as lower priorities for stock assessment or indicative sustainability evaluations and are unlikely to be transitioned to output controls over the short to medium term. They will however be subject to increased monitoring and catch triggers will be used to manage shifting fishing pressures (Department of Agriculture and Fisheries, 2020b). How these changes influence future risk ratings will be highly dependent on the quality of the catch composition data and management’s capacity to employ alternate ERA methodologies like SAFE.

Species-specific recommendations

1. *Explore mechanisms to improve the level of information on bream catch compositions and avenues to improve our understanding of stock status for species outside of yellowfin bream.*
2. *Implement measures to assess regional cumulative fishing pressures and examine the need for fine-scale fisheries management (e.g. regionally-specific management to address the non-uniform distribution of bream species in the ECIF).*
3. *Depending on the outcomes of above recommendations, review the inclusion of bream in future ERAs with consideration given to removing one or both species as low-risk elements.*

4.2.5 Garfish

Common name	Species name	Risk Rating
Snubnose garfish	<i>Arrhamphus sclerolepis</i>	Precautionary Medium
Three-by-two garfish	<i>Hemiramphus robustus</i>	Precautionary Medium

Garfish are one of the more prominent components of the ECIF catch with >100t retained in the fishery each year (Department of Agriculture and Fisheries, 2019e). While garfish are retained in the Tunnel Net Fishery, a high proportion of the catch is retained by operators using large mesh nets (*i.e.* gillnets and ring nets; Appendix B). Across the fishery, the majority of this catch is reported as *Garfish—unspecified* with only limited amounts reported to species level (Department of Agriculture and Fisheries, 2019e). Anecdotal evidence though suggest that the majority of this catch consists of snubnose garfish (*A. sclerolepis*) and three-by-two garfish (*H. robustus*).

While garfish retention rates are considerable, *productivity* profiles suggest that both species can withstand higher rates of fishing mortality (Table 7). In terms of the Level 2 ERA, these biological traits were key in terms of risk minimisation and mitigation. Conversely, all three are managed under broad-scale management arrangements which includes larger in-possession limits for the charter and recreational fishing sectors (Department of Agriculture and Fisheries, 2018e). These factors were

given considerable weighting in the *susceptibility* component of the PSA and contributed to the species receiving higher-risk ratings (Table 7). While noting these results, there are fewer sustainability concerns surrounding garfish and the outputs of the Level 2 ERA (likely) overestimate the risk posed to these species (Appendix D).

Outside of the commercial sector, garfish will be harvested to varying degrees in the non-commercial fishing sectors. While not viewed as primary targets, these species will be retained when targeting other inshore species like whiting, bream and flathead (Department of Agriculture and Fisheries, 2021; Teixeira *et al.*, 2021). In possession limits for these species are less stringent and will contribute to higher rates of fishing mortality and increased cumulative risks. While noting this risk, the *productivity* of these species minimises the need for significant management reforms including the introduction of more stringent in-possession limits.

Information gaps regarding catch compositions, key sustainability reference points (Department of Agriculture and Fisheries, 2017), total fishing mortality, and the absence of output controls all contributed to the production of more conservative risk assessments. These deficiencies, by extension, produced risk ratings that do not reflect the current sentiment surrounding the sustainability of regional garfish stocks. Improving the level of information in any one of the above areas would improve the accuracy of this assessment and likely result in a risk reclassification. For example, a score reduction to the lowest potential (1) in just one of the *susceptibility* attributes (*e.g. sustainability assessments*) would result in both species being reclassified as low risk in the Tunnel Net Fishery.

Species-specific recommendations

1. *Improve catch composition data and identify mechanisms to improve data on harvest rates for garfish in the Tunnel Net Fishery, allowing for refinements to be made to the ERA process and facilitate the removal of some species.*

4.2.6 Trevally / Family Carangidae

Common name	Species name	Risk Rating
Giant trevally	<i>Caranx ignobilis</i>	Precautionary Medium
Golden trevally	<i>Gnathanodon speciosus</i>	Precautionary Medium

The *Carangidae* complex contains a high number of morphologically similar species that are often caught during the same fishing event. It can be difficult to differentiate between species in an active fishing environment and this portion of the catch is frequently reported with generic identifiers *e.g. Trevally—unspecified* (Department of Agriculture and Fisheries, 2019e; Fowler *et al.*, 2018). While some trevally are reported to the species level, this occurs with less frequency (Appendix B) and underestimates harvest rates for individual species. In the mullet (refer 4.2.1) and flathead (refer 4.2.2) complex, where similar catch reporting trends were observed, inferences could be drawn in terms of the dominant species caught *e.g. sea mullet and dusky flathead*. This is more difficult to do in this complex as the catch tends to be more multidimensional (*pers. comm.* T. Ham).

The multi-species nature of the trevally catch combined with identification issues has inhibited management’s ability to conduct stock assessments and/or compile indicative sustainability evaluations (Department of Agriculture and Fisheries, 2018f; Fowler *et al.*, 2018). As such, there is limited information on how current harvest levels compare to key sustainability reference points (Department of Agriculture and Fisheries, 2017). These deficiencies make it difficult to assess the

suitability of the current management arrangements or evaluate the effectiveness of alternate strategies e.g. the use of species or complex-specific TACC limits. Introducing mechanisms to improve catch compositions (commercially and recreationally) would facilitate the development of more accurate risk assessments and provide further insight into the suitability and applicability of alternate management arrangements.

While the outputs of the Level 2 ERA indicate that the trevally complex is at a medium risk in the Tunnel Net Fishery (Appendix C), these results are more representative of the potential risk. Limited species-specific catch data and *sustainability assessments* increased uncertainty surrounding harvest levels, restricted assessments of management efficacy and contributed to the production of more conservative risk assessments. These risks are being addressed through the *Queensland Sustainable Fisheries Strategy 2017–2027* and the harvest strategy development process. The trevally complex is classified as a *Tier 3* complex under the draft harvest strategy and they will be subject to increased monitoring and catch triggers (Department of Agriculture and Fisheries, 2020b). If implemented, these measures will likely contribute to a reduction in the risk scores assigned to both species.

Species-specific recommendations

1. *Improve catch composition data and identify mechanisms to improve data on harvest rates for individual species; allowing for further refinements to be made to the ERA process.*
2. *Explore the need to include key trevally species in indicative sustainability evaluations (e.g. SAFS) to improve the understanding of the stock status of key species.*

4.2.7 Rabbitfish

Common name	Species name	Risk Rating
Scribbled rabbitfish	<i>Siganus spinus</i>	Low

Scribbled rabbitfish (*S. spinus*) are a consistent component of the tunnel net catch and it is viewed as a target species in this sector of the ECIF (Appendix B). At a whole-of-ECIF level, the species is taken in smaller quantities (Appendix A) and it is considered a low priority for stock assessments or indicative sustainability evaluations. This is partly due to the fact that there are fewer concerns surrounding the long-term sustainability of this species on the Queensland east coast.

As expected, the *productivity* component of the PSA was the key factor in terms of mitigating the risk posed to this species (Table 7). As teleosts, scribbled rabbitfish display typical *r-selected* life-history traits including more rapid rates of growth, reaching sexual maturity at a (comparatively) early age and increased fecundity (King & McFarlane, 2003). These traits translated to *productivity* scores of low (1) or medium (2) for the majority of the attributes assessed (Table 7). While proxies were used for *maximum size* and *size at maturity*, the assigned values provide a reasonable account of the *productivity* risks for this species (Appendix C). With improved biological data, additional refinements could be made to the risk profile for this species. If this were to occur some consideration should be given to excluding the species from future ERAs as a low-risk element.

Of the remaining attributes, *management strategy* and *sustainability assessments* arguably provide the greatest avenues to reduce the risk score for this species. When compared to other species, the management regime for scribbled rabbitfish is less specific and it does not include the use of output controls. As this formed the basis of the *management strategy* assessment (Table 3), the species was

were assigned a high-risk score for this attribute (Table 7). Similarly, the species has not been the subject of a detailed stock assessment and it was assigned a high-risk score for *sustainability*. It is recognised though that harvest rates for this species may not warrant additional management. Further, scribbled rabbitfish will not become a stock assessment priority unless demand, catch or effort increases significantly across the entire ECIF. Based on current catch and effort trends, this is not expected to occur over the short to medium term (Department of Agriculture and Fisheries, 2019e).

Going forward, scribbled rabbitfish would derive benefit from additional assessment using the *Sustainable Assessment of Fishing Effects* or SAFE approach. Comparisons have shown that SAFE method produces fewer false positives and may provide greater differentiation in terms of the risk posed to this species (Zhou & Griffiths, 2008; Zhou *et al.*, 2016). The ability to use this method will, again, be predicated on management's ability to quantify gear-affected area. Alternatively, improved information on catch rates, discards and release fates may allow the species to be excluded from future iterations of the Tunnel Net Fishery Level 2 ERA.

Species-specific recommendations

Not applicable at the species level. However, future ERAs would benefit from the collection of additional data on total fishing mortality across sectors (retained + discarded), and the collection of specific regional distribution data to explore avenues for refinement of risk scores within the *availability* attribute.

4.3 Species of Conservation Concern

A number of the species included in the Level 2 ERA will interact infrequently with the Tunnel Net Fishery. Including these species in the Level 2 ERA provides the assessment with additional scope and will assist management if the current fishing environment changes significantly. This approach also minimises the potential of an at-risk species being omitted from the analysis. The inherent trade off with this approach is that the final ratings for some species may reflect a potential risk *verse* the actual risk. In these instances, there is a lower probability of the risk coming to fruition over the short to medium term and implementing species-specific risk mitigation strategies or management reforms are viewed as a lower priority. For the purpose of this ERA, these are classified as *precautionary* risk assessments as they will not require management beyond what is already being undertaken as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017).

At a species-specific level, biological and life-history constraints were a key driver of risk for most SOCC and, in some instances, was the main contributor of risk (Table 7). These constraints were highly influential in the SOCC risk profiles and highlights the inherent challenge of managing fishing-related risks for species with *k*-selected life histories. In fisheries where there is an increased risk of mortality, these biological constraints are significant as even low levels of fishing mortality may have long-term implications for key species and regional populations.

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.

4.3.1 Marine Turtles

Common name	Species name	Risk Rating
Green turtle	<i>Chelonia mydas</i>	Medium
Loggerhead turtle	<i>Caretta caretta</i>	Precautionary Medium
Hawksbill turtle	<i>Eretmochelys imbricata</i>	Precautionary Medium

When compared to other sectors of the ECIF, the Tunnel Net Fishery will present a lower risk to this subgroup (Jacobsen *et al.*, 2021a). Marine turtles are more likely to survive a fishing event and their release often only requires a manipulation of the net. Of the three species assessed, tunnel net fishers are more likely to interact with green turtles (*C. mydas*). Research indicates that the green turtle has the largest population on the Queensland east coast (Department of the Environment, 2019x; Limpus, 2008) and the species is relatively abundant in the Moreton Bay and Great Sandy regions. It is also the only SOCI reported from the Tunnel Net Fishery over the 2006 to 2018 period ($n = 181$ interactions) (Appendix E; Department of Agriculture and Fisheries, 2019d). Interactions with the two remaining species, while still possible, will be low in number and infrequent.

As marine turtles are air breathers, one of the most significant risks posed by net fishing is drowning as a result of net entanglements and exhaustion. This is viewed as less of a risk in the Tunnel Net Fishery as the method relies on trapping fish *verse* their enmeshment. This risk though is not mitigated entirely and will be highest in the tunnel of the net where mesh sizes are larger. Of notable importance, this risk is being actively addressed in at least one sector of the fishery. Tunnel net fishers in Morten Bay operate under a voluntary code of conduct which, among other things, mandates the use of an exclusion grid with bar spacings no larger than 25cm (Thompson *et al.*, 2012). This measure prevents most if not all marine turtles from entering the tunnel and confines them to an area where they can be easily removed. Mandating the use of a bycatch reduction device would ensure that this risk is mitigated across the entire Tunnel Net Fishery.

Outside of *selectivity*, the remaining high-risk elements will be more difficult to address as they relate specifically to the biology of the species assessed. There are however a number of measures already in place that minimise the risk posed to regional marine turtle populations. These include provisions that regulate the structure of the net, the size of a tunnel and define net-setting procedures. Tunnel net fishing activities are further restricted by zoning plans that govern the take and use of marine resources within the *Moreton Bay* and *Great Sandy Marine Parks* (Department of National Parks Sport and Racing, 2015a; b). Both of these zoning plans provide marine turtles with additional protection from net fishing activities including in habitats critical to their survival. In terms of risk management, the above measures reduce the *encounterability* potential for this subgroup and increase the probability of a marine turtle surviving an interaction with a tunnel net.

Given the above considerations and the outputs of the Level 2 ERA, the Tunnel Net Fishery will be a contributor of risk for this subgroup *verse* a key driver of risk. The extent of this contribution will be small when compared to a) other sectors of the ECIF and b) non-fishing related risks like injuries and mortalities stemming from boat strike, the negative consequences of habitat degradation (*e.g.* urban development, runoff) and disease (Department of Environment and Science, 2017; Jacobsen *et al.*, 2021a; b).

Marine turtle recommendations

1. Mandate the use of bycatch reduction devices in the Tunnel Net Fishery to aid in the removal of non-target species and minimise the length of the interaction.
2. Review the resources that are available on handling marine turtles that interact with commercial fishing nets and (if applicable) update to include information for the Tunnel Net Fishery.
3. If and when the use of a bycatch reduction device is mandated in the Tunnel Net Fishery, review the scope of the marine turtle Level 2 ERA and the need to re-assess the Loggerhead turtle (*C. caretta*) and the Hawksbill turtle (*E. imbricata*).

4.3.2 Sirenia (Dugongs)

Common name	Species name	Risk Rating
Dugong	<i>Dugong dugon</i>	Precautionary Medium

As air breathing marine mammals, the risk profile for dugongs will be similar to marine turtles. At 2.71, dugongs (*Dugong dugon*) had the highest *productivity* scores in the Level 2 ERA. This score would have been higher had it not been for the *trophic level* attribute which was assigned the lowest possible value (Table 7). These biological constraints have been identified as one of many factors that have contributed to a decline in dugong numbers on the Queensland east coast (Marsh *et al.*, 2005; Meager *et al.*, 2013). As dugongs are already no-take species and the *productivity* risks relate to their biology, they will be very difficult to address through the fisheries reform agenda.

The probability of a dugong being trapped in the tunnel of the net is relatively low as the wings are set in shallow, intertidal waters where they are less likely to be encountered. This inference is supported by data collected through the SOCI logbooks and the StrandNET program. Data from these two programs indicate that tunnel net fishing was only responsible for one of reported dugong mortalities (Biddle *et al.*, 2011; Department of Agriculture and Fisheries, 2019d; Flint & Limpus, 2013; Greenland & Limpus, 2005; 2006). As tunnel nets operate in regions with higher dugong populations, there is a heightened risk of the animals experiencing a contact without capture event e.g. swimming into a set net. While these events increase the risk of entanglement, there is little evidence that this impacts on the long-term health of the animal. The veracity of this assessment though will be difficult to confirm without improved catch monitoring and validation techniques.

When the key drivers of risk were taken into consideration (Table 7), the risk rating assigned to this species was considered precautionary. As with marine turtles, the Tunnel Net Fishery will be a contributor of risk for this species *verse* the main driver of risk. The extent of this contribution can only be determined with additional information on catch and interaction rates or lack thereof. This information will be important when attempting to understand the impact of the fishery on this species and how it compares to external risk factors like habitat degradation and boat strike (Jacobsen *et al.*, 2019). In the unlikely event that a dugong is caught in the tunnel of the net, there is a higher probability of the animal being released alive. Mandating the use of BRDs in the Tunnel Net Fishery would further reduce this risk and (potentially) facilitate the removal of dugongs from subsequent ERAs involving this sector of the ECIF.

Dugong recommendations

1. Mandate the use of a tunnel grid or an analogous bycatch reduction device to restrict access to the key component of the net, aid in the removal of non-target marine megafauna (e.g. dugongs), minimise the length of the interaction and improve post-interaction survival rates.

4.3.3 Batoids

4.3.3.1 Stingrays

Common name	Species name	Risk Rating
Estuary stingray	<i>Hemirhynchus fluviorum</i>	Medium

The estuary stingray (*H. fluviorum*) is not protected under fisheries legislation and it is not classified as one of the *Species of Conservation Interest* (SOCI). However, it is listed as *Near Threatened* in the *Nature Conservation (Wildlife) Regulation 2006* (Qld) and cannot be retained for commercial purposes if caught in a national park (*Nature Conservation Act 1992*).¹³ This listing was the impetus behind the inclusion of the estuary stingray in the Tunnel Net Fishery SOCC Level 2 ERA.

While the species prefers environments with prominent mangrove communities, it can be found to water depths of 20m and over sandy substrates preferred by tunnel net operations. The species has the potential to interact with tunnel net operations and it is plausible that small quantities are retained inadvertently by operators e.g. due to misidentifications, confusion surrounding the species' protection status and the absence of a SOCI classification. Catch records indicate that batoids are retained in smaller quantities across the entire ECIF; 2009–19 average = 3.57t, range = 1.59–7.33t (Department of Agriculture and Fisheries, 2019e).¹⁴ This average drops to less than one tonne when tunnel net fishing is considered in isolation. As stingray catch data has poor species resolution, it is difficult to ascertain if estuary stingrays are included in this component of the catch (Department of Agriculture and Fisheries, 2019e).

Biological information on the estuary stingray is limited but the species is born at around 11cm disc width and reaches sexual matures at 40–45cm disc width (Last *et al.*, 2016; Last & Stevens, 2009; Pierce & Bennett, 2011). Based on these values, the use of a bycatch reduction grid may help to exclude larger rays from the catch and assist with their release. The effectiveness of this measure will be less for smaller rays and could be undermined if the rays were being retained for sale. Of the rays that are released, a high percentage will survive the interaction with limited or non-life threatening injuries. They may however be at a higher predation risk and their capture may have other indirect consequences e.g. capture-induced parturition (either premature birth or abortion) in female rays (*pers. obs.* I. Jacobsen; Adams *et al.*, 2018)

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

¹³ The *Nature Conservation Act 1992* provides additional protections to the estuary stingray in a range of protected areas (Part 4, Div. 1). As the estuary stingray is not protected in fisheries legislation than the species could, theoretically, be taken and retained for sale in the broader ECIF. This however would depend on whether or not the species was found in the area.

¹⁴ Average and range based on post-2008 data as the Shark or 'S' fishing symbol was introduced in 2009. This management changed significantly reduced the number of licences that could retain larger quantities of shark and ray product.

These declines are considered to be most significant in northern New South Wales and in southern Queensland (Kyne *et al.*, 2016). The reasons behind this decline are varied but loss of habitat and their capture in commercial fisheries have been identified as two key contributors. From a fisheries perspective, demersal prawn trawl fisheries are more likely to interact with this species and in higher numbers. However, the Tunnel Net Fishery may contribute to the cumulative fishing pressures exerted on this species. Depending on the region and the number of rays caught, fishing activities in the Tunnel Net Fishery may also exacerbate the impacts of other longer-term risks e.g. habitat loss and their capture in other commercial fisheries.

In the context of the broader ECIF, direct management of the risks posed by tunnel net fishing is not viewed as an immediate or high priority. The Tunnel Net Fishery will be a contributor of risk to this species and further information is required on their capture in this sector of the ECIF including 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. It is recognised that this change will have broader implications for commercial fisheries operating on the Queensland east coast. As the estuary stingray is (at most) a low-value byproduct species, its reclassification is not expected to have a significant or detrimental impact on the viability of the Tunnel Net Fishery or the broader ECIF.

Estuary stingray recommendations

1. *Categorise the estuary stingray (H. fluviorum) as a no-take species under fisheries legislation.*
2. *Mandate the use of a tunnel grid or an analogous bycatch reduction device to restrict access to minimise the capture of larger, mature H. fluviorum in the tunnel of the net.*
3. *Improve the level of information on estuary stingray interactions including on catch rates in critical habitats and locations where the fishery contributes to regional/cumulative fishing pressures.*

4.3.3.2 Guitarfish & Wedgefish

Common name	Species name	Risk Rating
Bottlenose wedgefish	<i>Rhynchobatus australiae</i>	Precautionary High
Giant shovelnose ray	<i>Glaucostegus typus</i>	Precautionary High

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 the Tunnel Net Fishery. Catch data for the entire ECIF indicates that wedgefish, shovelnose rays and guitarfish are retained in small quantities on the Queensland east coast; average = 4.8t, range 0.2–12.2t.¹⁵ This can be partly attributed to in-possession limits that restrict commercial retention rates to a combined maximum of five guitarfish and/or shovelnose rays.¹⁶ This limit applies across all sectors of the ECIF along with a 1.5m maximum total length size limit.

¹⁵ Catch records obtained through QFish: <https://qfish.fisheries.qld.gov.au/>

¹⁶ 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

In addition to the retained catch, a proportion of the guitarfish, wedgefish and shovelnose rays caught in tunnel nets will be discarded as unwanted bycatch. At present, there is limited capacity to validate total guitarfish/wedgefish catch rates (*i.e.* retained and discarded catch) or verify the release fates of unwanted product. As the fishing method relies on the trapping of fish within the enclosed area (*versus* entanglement/enmeshing), post release survival rates for this subgroup are anticipated to be high. This was reflected in the *post-capture mortality* RRA where the score was reduced from high to medium (Table 7, Appendix C). The capacity to reduce this score further was limited by an absence of data of total catch rates and release fates.

The bottlenose wedgefish (*R. australiae*) and the giant shovelnose ray (*G. typus*) 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 primarily 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 (*Rhynchobatus djiddensis*) (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2018a; Last *et al.*, 2016). The bottlenose wedgefish is found in Australian waters and is retained for sale in the Tunnel Net Fishery. 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 ECIF through the use of input and output controls *e.g.* limited licencing, mesh size restrictions, spatial closures, in-possession limits (Department of Agriculture and Fisheries, 2019e).

Given the size of the fishery and the nature of the apparatus, tunnel nets pose a much smaller risk to this subgroup. The extent of this risk may 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

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.

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, their release fates and (if possible) their stock status. As the taxonomy of guitarfish and wedgefish has changed considerably (Last *et al.*, 2016), it is also recommended that the 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. At this point in time though, the management of risk through species-specific reforms are not warranted.

Guitarfish & wedgefish recommendations

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

Summary

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

While the tunnel net Level 2 ERA included a number of species with higher risk ratings, these were heavily influenced by the biological constraints of the species assessed. Similarly, precautionary elements included in the methodology combined with data deficiencies contributed to the development of more conservative risk profiles.

For most of the species assessed, final risk ratings were precautionary and will not require significant species-specific reforms. There are however a number of areas where risk could be managed further including mandating the use of a tunnel grid and improving the level of information on catch rates and release fates. Improvements in these two areas will contribute to a lowering of the risk rating for most species and may negate the need for further ERAs.

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6 Appendices

- Appendix A* – *Summary of the species rationalisation process for **target & byproduct species** including key justifications and considerations.*
- Appendix B* – *Summary of the species rationalisation process for **Species of Conservation Concern (SOCC)** species including key justifications and considerations.*
- Appendix C* – *Residual Risk Analysis of preliminary scores assigned in the Productivity & Susceptibility Analysis (PSA).*
- Appendix D* – *Supplementary Risk Assessment: Likelihood & Consequence Analysis*
- Appendix E* – *Summary of the marine turtle interactions by gear type and species reported from the East Coast Inshore Fishery (ECIF).*

Appendix A—Target & Byproduct Species Rationalisation Process.

1. Overview

Catch data submitted through the commercial logbook system was used to construct a preliminary list of target & byproduct species that were considered for inclusion in the Level 2 ERA. Logbook data was considered over a three-year period (2017–2019 inclusive) with the final species list refined using the following steps.

1. Data for each catch category (*i.e.* species or species groupings) was summed across the relevant period (2017–2019 inclusive) and ranked in order from highest to lowest.
2. Cumulative catch analysis was used to identify all of the categories that made up 95% of the total catch reported from the fishery over this period.
3. Species that fell below the 95% catch threshold were reviewed and, if no anomalies were detected, omitted from the initial list of target & byproduct species. Retention rates for most of these species are low and they are generally viewed as secondary byproduct species. When and where appropriate, these secondary species will be considered for inclusion in subsequent ERAs.
4. Species above the 95% catch threshold (*i.e.* those that were not omitted from the analysis) were then reviewed and the following steps undertaken:
 - a. Where possible, multi-species catch categories were expanded using the relevant CAAB codes (*e.g.* blacktip shark CAAB code 37 018903 includes *Carcharhinus limbatus* and *C. tilstoni*). All additions took into consideration the operating area of the fishery and the potential for the species to interact with the fishery. In some instances, this required the re-inclusion of species that fell below the initial 95% cut-off.
 - b. Duplications resulting from expansion of multi-species catch categories were then removed.
 - c. Catch categories that could not be refined to species level such as *Unspecified fish* were excluded from the analysis.
 - d. Species managed under Total Allowable Commercial Catch (TACC) limits that are directly linked to biomass estimates or managed under harvest strategies were removed. The premise being that the risk posed to this species is currently addressed through management controls. As a precautionary measure, any species whose TACC was not based on a stock assessment or had a stock assessment >5 years old was retained in the assessment.
5. A summary of the species rationalisation process was then completed and justifications provided for why each a target or byproduct species was included or omitted from the analysis.

2. Summary Tables

- *Table A1—Summary of the species that were considered for inclusion in the Tunnel Net Fishery Level 2 ERA.*
- *Table A2—Detailed overview of the key consideration and justifications used as part of the Target & Byproduct Species Rationalisation Process.*

Table A1—Summary of the species that were considered for inclusion in the Tunnel Net Fishery Level 2 ERA.

Common name	Scientific name	CAAB	Included
Mullet			
Sea mullet	<i>Mugil cephalus</i>	37 381002	Y
Fantail (silver) mullet	<i>Paramugil georgii</i>	37 381009	Y
Goldspot (tiger/flat tail) mullet	<i>Liza argentea</i>	37 381004	N
Diamondscale mullet	<i>Liza vaigiensis</i>	37 381008	Y
Bluespot mullet / Sand mullet	<i>Valamugil seheli</i>	37 381017	N
Pinkeye mullet	<i>Trachystoma petardi</i>	37 381011	N
Flathead			
Dusky flathead	<i>Platycephalus fuscus</i>	37 296004	Y
Bartailed flathead	<i>Platycephalus australis</i>	37 296033	Y
Northern sand flathead	<i>Platycephalus endrachtensis</i>	37 296021	Y
Yellowtailed flathead	<i>Platycephalus westraliae</i>	37 296020	Y
Tailor			
Tailor	<i>Pomatomus saltatrix</i>	37 334002	N
Whiting			
Sand (summer) whiting	<i>Sillago ciliata</i>	37 330010	Y
Trumpeter (winter) whiting	<i>Sillago maculata</i>	37 330015	Y
Northern whiting	<i>Sillago sihama</i>	37 330006	N
Goldenline whiting	<i>Sillago analis</i>	37 330003	N
Dart			
Snubnose dart	<i>Trachinotus blochii</i>	37 337075	N
Swallowtail dart	<i>Trachinotus coppingeri</i>	37 337076	N
Bream			
Yellowfin bream	<i>Acanthopagrus australis</i>	37 353004	Y
Tarwhine	<i>Rhabdosargus sarba</i>	37 353013	Y
Luderick	<i>Girella tricuspidata</i>	37 361007	N
Bony bream	<i>Nematalosa erebi</i>	37 085019	N
Pikey Bream	<i>Acanthopagrus pacificus</i>	37 353011	N
Diamondfish / Butter Bream	<i>Monodactylus argenteus</i>	37 356002	N
Garfish			
Snubnose garfish	<i>Arrhamphus sclerolepis</i>	37 234006	N
Three-by-two garfish	<i>Hemiramphus robustus</i>	37 234013	N
Trevally			
Golden trevally	<i>Gnathanodon speciosus</i>	37 337012	Y
Giant trevally	<i>Caranx ignobilis</i>	37 337027	Y
Bigeye trevally	<i>Caranx sexfasciatus</i>	37 337039	N

Common name	Scientific name	CAAB	Included
Turrum (gold spot)	<i>Carangoides fulvoguttatus</i>	37 337037	N
Thicklip trevally	<i>Carangoides orthogrammus</i>	37 337057	N
Bludger trevally	<i>Carangoides gymnostethus</i>	37 337022	N
Blue spot trevally	<i>Caranx bucculentus</i>	37 337016	N
Diamond trevally	<i>Alectis indica</i>	37 337038	N
Silver trevally	<i>Pseudocaranx georgianus</i>	37 337062	N
<i>Other</i>			
Scribbled rabbitfish (spinefoot / happy moments)	<i>Siganus spinus</i>	37 438013	Y
Silver Biddies	<i>Family Gerreidae</i>	37 349000	N
Hardyheads	<i>Family Atherinidae, Family Dentatherinidae</i>	37 246000	N

APPENDIX A2—Detailed overview of the key consideration and justifications used as part of the Target & Byproduct Species Rationalisation Process. *Codes for Australian Aquatic Biota (<http://www.marine.csiro.au/data/caab/>).

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
Mullet			
Sea mullet	<i>Mugil cephalus</i> (37 381002)	Y	<p>Notes—The majority of the mullet catch is retained by operators in the Ocean Beach Fishery. A notable portion of the mullet catch though is retained in the Tunnel Net Fishery e.g. approximately 135t per year. The resolution of the tunnel net data is poor with most of the retained product being reported as <i>Mullet—unspecified</i>. As a consequence, individual species tend to have lower annual catches. However the majority of the catch is expected to consist of sea mullet (<i>M. cephalus</i>) and diamondscale mullet (<i>L. vaigiensis</i>).</p> <p>While goldspot mullet (<i>L. argentea</i>) has been recorded from the Tunnel Net Fishery, catch records are low and highly fragmented. Since 1992, goldspot mullet have only been reported from the tunnel net in three years: 0.8t (1998), <0.1t (2007) and 0.5t (2012). Due to these low and infrequent catches, goldspot mullet was omitted from the initial Tunnel Net Fishery ERA.</p> <p>Research indicates that the pinkeye mullet (<i>T. petardi</i>) has a more southern distribution and has a preference for deeper freshwater coastal streams and estuarine environments (Australian Museum, 2019; Threatened Species Scientific Committee, 2018). Given these factors, <i>T. petardi</i> was considered to be a secondary target species and excluded from the initial Tunnel Net Fishery Level 2 ERA.</p> <p>The bluespot mullet (<i>V. seheli</i>) is also referred to as <i>Moolgarda seheli</i> and, on occasions, referenced as a sand mullet which is a different species (<i>Myxus elongatus</i>). The species has a distribution that extends north from the QLD/NSW border and catch data suggests that it is caught in negligible quantities by tunnel net operations. This species is likely to be a secondary target; particularly when compared to species dominating the mullet catch in Queensland e.g. <i>M. cephalus</i>, <i>L. argentea</i> and <i>L. vaigiensis</i>.</p>
Fantail (silver) mullet	<i>Paramugil georgii</i> (37 381009)	Y	
Diamondscale mullet	<i>Liza vaigiensis</i> (37 381008)	Y	
Goldspot (tiger/flat tail) mullet	<i>Liza argentea</i> (37 381004)	N	
Pinkeye mullet	<i>Trachystoma petard</i> (37 381011)	N	
Bluespot mullet / Sand mullet	<i>Valamugil seheli</i> (also known as <i>Moolgarda seheli</i>) (37 381017)	N	

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<p><u>Catch data summary</u></p> <p><i>Tunnel netting (only)</i></p> <ul style="list-style-type: none"> - <i>Mullet—unspecified</i>: average = 189.1t (range 57.1–225.1t). Catch 2017–2019 (inclusive) = 192.4t at an average of 64.1t - <i>Catch reported as sea mullet</i>: average 4.1t (range 2.9–5.2t). Catch 2017–2019 (inclusive) = 0t total. - <i>Catch reported as fantail (silver) mullet</i>: average 0.8t (range <0.1–2.8t). Catch 2017–2019 (inclusive) = 0.3t total. - <i>Catch reported as diamondscales mullet</i>: average 0.1t (range 0–0.3t). Catch 2017–2019 (inclusive) = 0t total. - <i>Catch reported as tiger/flat tail (Goldspot) mullet</i>: average 0.2t (range <0.1–0.5t). Catch 2017–2019 (inclusive) = 0t total. - <i>Pinkeye mullet, total reported net catch</i>: No catch record of this species for tunnel netting since 2000. - <i>Catch reported as blue spot mullet catch</i>: No catch record of this species for tunnel netting since 2000. <p><i>Net fishing (all)</i></p> <ul style="list-style-type: none"> - <i>Catch reported as Mullet—unspecified (CAAB 37 381000)</i>: historical average (20 years) = 1774t (range 739–2597t). Catch 2017–2019 (inclusive) = 3747t total at an average of 1249t. - <i>Sea mullet catch (Mullet—sea/flathead) (CAAB 37 381002)</i>: historical average (20 years) = 42t (range 2.2–124t). Catch 2017–2019 (inclusive) = 154.5t total at an average of 51.5t. - <i>Catch reported as Mullet—fantail/silver (CAAB 37 381009)</i>: historical average (20 years) = 5.2t (range 1.1–17.3t). Catch 2017–2019 (inclusive) = 10t total.

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<ul style="list-style-type: none"> - Catch reported as Mullet—tiger/flat tail (Goldspot) (CAAB 37 381004): historical average = 2.1t (range 0–8.8t). Catch 2017–2019 (inclusive) = 5.1t total. - Catch reported as Mullet—diamondscale (CAAB 37 381008): historical average = 3.6t (range 1.7–6.5t). Catch 2017–2019 (inclusive) = 9.7t total. - Catch reported as Mullet—pinkeye (CAAB 37 381011): historical average (20 years) = .5t (range 0.1–11.9t). Catch 2017–2019 (inclusive) = 21t total. - Catch reported as Mullet—sand (blue-tailed) (CAAB 37 381017): historical average (20 years) = 0.8t (range 0–3.4t). Catch 2017–2019 (inclusive) = 0.2t total. <p><i>Line fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as Mullet—unspecified (CAAB 37 381000): historical average (20 years) = 0.3t (range 0–1.1t). Catch 2017–2019 (inclusive) = <0.1t. - Sea mullet catch (Mullet—sea/flathead) (CAAB 37 381002): historical average (20 years) = <0.2t. - Catch reported as Mullet—fantail/silver (CAAB 37 381009): historical average <0.2t. - Catch reported as Mullet—tiger/flat tail (Goldspot) (CAAB 37 381004): historical average <0.2t. - Catch reported as Mullet—diamondscale (CAAB 37 381008): historical average <0.2t. - Catch reported as Mullet—pinkeye (CAAB 37 381011): historical average (20 years) = <0.2t. - Catch reported as Mullet—sand (blue-tailed) (CAAB 37 381017): historical average (20 years) = <0.2t.
Bream			
Yellowfin bream	<i>Acanthopagrus australis</i>	Y	Notes —As the majority of the bream catch (84%) is reported as <i>unspecified</i> , a wide range of species were considered for inclusion in the Level 2 ERA. As with whiting, the catch is expected to be dominated by one

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
	(37 353004)		or two key species. Of these, yellowfin bream (<i>A. australis</i>) are more likely to be retained in this sector of the ECIF. As the morphologically similar Tarwhine (<i>R. sarba</i>) is often caught with yellowfin bream (<i>pers. comm.</i> T. Ham) it was also included in the assessment as a precautionary measure.
Tarwhine	<i>Rhabdosargus sarba</i> (37 353013)	Y	It is recognised that the Tunnel Net Fishery will interact with and retain other species of bream including back bream (luderick) and butterbream. Given the size of the fishery, the key species being targeted and annual bream retention rates, the Tunnel Net Fishery is not expected to make a significant contribution to the cumulative risks posed to these species. When and where appropriate, further consideration will be given to including these species in subsequent ERAs for the Tunnel Net Fisheries and Level 2 assessments involving other sectors of the ECIF.
Luderick	<i>Girella tricuspidate</i> (37 361007)	N	
Diamondfish / Butter bream	<i>Monodactylus argenteus</i> (37 356002)	N	<u>Catch data summary</u> <i>Tunnel netting (only)</i>
Bony bream	<i>Nematalosa erebi</i> (37 085019)	N	<ul style="list-style-type: none"> - Catch reported as Bream—unspecified (CAAB 37 53000): average catch 86.2t (range 28.3–157.1t). Catch 2017–2019 (inclusive) = 95.0t total at an average of 31.7t. - Catch reported as Bream—yellowfinned (CAAB 37 353004): average 2.0t (range 0–4.8t). Catch 2017–2019 (inclusive) = 0.1t total. - Catch reported as Bream—tarwhine (CAAB 37 353013): average 2.8t (range 0.2–6.2t). Catch 2017–2019 (inclusive) = 10.1t total and average 3.4t. - Catch reported as Bream—black (luderick) (CAAB 37 361007): average 0.9t (range 0.1–3.2). Catch 2017–2019 (inclusive) = 1,1t total at an average of 0.4t. - Catch reported as Bream—butter (CAAB 37 356002): average 1.1t (range 0–4.6t). Catch 2017–2019 (inclusive) = 7.3t total at an average of 2.4t.

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<ul style="list-style-type: none"> - Catch reported as <i>Bream—bony (herring)</i> (CAAB 37 085019): average <0.1t (range 0). Catch 2017–2019 (inclusive) = 0t total. <p><i>Net fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Bream—unspecified</i> (CAAB 37 53000): historical average (20 years) = 151.9t (range 52–248.6t). Catch 2017–2019 (inclusive) = 213.6t total at an average of 71.2t. - Catch reported as <i>Bream—yellowfinned</i> (CAAB 37 353004): historical average (20 years) = 3.2t (range 0.2–17.5t). Catch 2017–2019 (inclusive) = 1.4t total. - Catch reported as <i>Bream—tarwhine</i> (CAAB 37 353013): historical average (20 years) = 3.8t (range 0.5–6.8t). Catch 2017–2019 (inclusive) = 13.6t total. - Catch reported as <i>Bream—black (luderick)</i> (CAAB 37 361007): historical average (20 years) = 12.7t (range 3.6–25.1t). Catch 2017–2019 (inclusive) = 13t total at an average of 4.3t. - Catch reported as <i>Bream—butter</i> (CAAB 37 356002): historical average (20 years) = 2.7t (range 0.6–9.3t). Catch 2017–2019 (inclusive) = 20.1t total at an average of 6.7t. - Catch reported as <i>Bream—bony (herring)</i> (CAAB 37 085019): historical average (20 years) = 10.8t (range 1.7–33t). Catch 2017–2019 (inclusive) = 23.7t total at an average of 7.9t. <p><i>Line fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Bream—unspecified</i> (CAAB 37 53000): historical average (20 years) = 1.6t (range 0.6–8.7t). Catch 2017–2019 (inclusive) = 3.3t total. - Catch reported as <i>Bream—yellowfinned</i> (CAAB 37 353004): historical average (20 years) = 0.1t (range 0–0.5t). Catch 2017–2019 (inclusive) = 0.3t total.

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<ul style="list-style-type: none"> - Catch reported as <i>Bream—tarwhine</i> (CAAB 37 353013): historical average (20 years) = <0.1t (range 0–01t). Catch 2017–2019 (inclusive) = 0t total. - Catch reported as <i>Bream—black (luderick)</i> (CAAB 37 361007): historical average (20 years) = <0.1t (range 0–0.6t). Catch 2017–2019 (inclusive) = <0.1t total. - Catch reported as <i>Bream—butter</i> (CAAB 37 356002): historical average (20 years) = <0.1t (range 0–<0.1t). Catch 2017–2019 (inclusive) = 0t total. - Catch reported as <i>Bream—bony (herring)</i> (CAAB 37 085019): historical average (20 years) = <0.1t (range 0–0.1t). Catch 2017–2019 (inclusive) = 0t total.
Whiting			
Sand (summer) whiting	<i>Sillago ciliata</i> (37 330010)	Y	<p>Notes—Both sand (summer) whiting (<i>S. ciliata</i>) and trumpeter whiting (<i>S. maculata</i>) are an important component of the ECIF catch and they are retained in multiple sub-fisheries. The resolution of the species data for whiting has declined to a point where almost all the catch is reported as <i>Whiting—unspecified</i> (refer Table below). This is primarily due to a) net fishing having a lower degree of selectivity and b) the likelihood that multiple whiting species will be caught during a single fishing event.</p> <p>Whiting constitute a consistent portion of the catch reported from the Tunnel Net Fishery. This catch, as with the wider ECIF, is reported as part of a broader catch category with minimal amounts recorded at the species level. Historical catch data from the ECIF suggests that the majority of this catch will consist of sand whiting and trumpeter whiting. This was reflected in a recent stock assessment where sand whiting was used as the primary species (Leigh <i>et al.</i>, 2019). Due to these considerations, both sand and trumpeter whiting were included in the analysis.</p> <p>Northern whiting (<i>S. sihama</i>) and goldenline whiting (<i>S. analis</i>) were included in the preliminary species list as they would contribute to the <i>Whiting—unspecified</i> catch. Distributional data suggests that the northern</p>
Trumpeter whiting	<i>Sillago maculata</i> (37 330015)	Y	
Northern whiting	<i>Sillago sihama</i> (37 330006)	N	
Goldenline whiting	<i>Sillago analis</i> (37 330003)	N	

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<p>whiting is unlikely to interact with the Tunnel Net Fishery. While the distribution of the goldenline whiting extends further south, it is not expected to be one of the primary species. Due to these factors the northern and goldenline whiting were viewed as secondary targets and omitted from the analysis. Depending on the information available, the two species may be considered for inclusion in subsequent ERAs examining the risk posed to target and byproduct species in the ECIF.</p> <p><u>Catch data summary</u></p> <p><i>Tunnel net fishing (only)</i></p> <ul style="list-style-type: none"> - Whiting—unspecified (CAAB 37 330000): average catch 59.1t (range 23.0–92.0t). Catch 2017–2019 (inclusive) = 84.6t total at an average of 28.2t. - Catch reported as Whiting—summer (sand whiting) (CAAB 37 330010): average 2.7t (range 2.4–3.0t). Catch 2017–2019 (inclusive) = 0t total. - Catch reported Whiting—trumpeter (CAAB 37 330015): average 0.5t (range 0.1–1.5). Catch 2017–2019 (inclusive) = 0t total. - Catch reported as Whiting—northern (CAAB 37 330006): N/A. - Catch reported as Whiting—Goldenline (CAAB 37 330006): N/A. <p><i>Net fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as Whiting—unspecified (CAAB 37 330000): historical average (20 years) = 266.4t (range 124.57–391.3t). Catch 2017–2019 (inclusive) = 495.7t at an average of 165.2t. - Catch reported as Whiting—summer (sand whiting) (CAAB 37 330010): historical average (20 years) = 15.7t (range 0.6–28.8t). Catch 2017–2019 (inclusive) = 0t total.

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<ul style="list-style-type: none"> - Catch reported as <i>Whiting—trumpeter</i> (CAAB 37 330015): historical average (20 years) = 2.7t (range 0.0–33.5t). Catch 2017–2019 (inclusive) = 0t total. - Catch reported as <i>Whiting—northern</i> (CAAB 37 330006): N/A. - Catch reported as <i>Whiting—goldenline</i> (CAAB 37 330006): N/A. <p><i>Line fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Whiting—unspecified</i> (CAAB 37 330000): historical average (20 years) = 0.5t (range 0–1.1t). Catch 2017–2019 (inclusive) = 0.8t total. - Catch reported as <i>Whiting—summer</i> (sand whiting) (CAAB 37 330010): historical average (20 years) = <0.1t (range 0–0.1t). Catch 2017–2019 (inclusive) = 0t total. - Catch reported as <i>Whiting—trumpeter</i> (CAAB 37 330015): historical average (20 years) = 0.2t (range 0–1t). Catch 2017–2019 (inclusive) = 0.3t total. - Catch reported as <i>Whiting—Northern</i> (CAAB 37 330006): N/A.
Garfish			
Snubnose garfish	<i>Arrhamphus sclerolepis</i> (37 234006)	Y	<p>Notes—Garfish along with bream, whiting and flathead make a notable contribution to the annual tunnel net catch. Garfish though tend to be retained in smaller quantities and viewed as less marketable when compared to other inshore species. While more than one species of garfish will be retained for sale in the Tunnel Net Fishery, all of the catch is reported as <i>Garfish—unspecified</i>. Of those species that interact with the Tunnel Net Fishery, snubnose garfish and the three-by-two garfish will (probably) be the most abundant. Both of these species were included in the tunnel net ERA.</p> <p><i>Tunnel net fishing (only)</i></p>
Three-by-two garfish	<i>Hemiramphus robustus</i> (37 234013)	Y	

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<ul style="list-style-type: none"> - Catch reported as <i>Garfish—snubnose</i> (CAAB 37 234006): 0 catch record of this species for tunnel netting in since 2000. - Catch reported as <i>Garfish—three-by-two</i> (CAAB 37 234013): No catch record of this species for tunnel netting in since 2000. - Catch reported as <i>Garfish—unspecified</i> (CAAB 37 234000): average catch 17.7t (range 5.6–31.2t). Catch 2017–2019 (inclusive) = 17.0t total at an average of 5.7t. <p><i>Net fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Garfish—unspecified</i> (CAAB 37 234000): historical average (20 years) = 151.3t (range 93.6–260.7t). Catch 2017–2019 (inclusive) = 299t total at an average of 99.7t. - Catch reported as <i>Garfish—snubnose</i> (CAAB 37 234006): historical average (20 years) = 0.5t (range 0–1.3t). Catch 2017–2019 (inclusive) = 0t. - Catch reported as <i>Garfish—three-by-two</i> (CAAB 37 234013): no species-specific catch reported. <p><i>Line fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Garfish—unspecified</i> (CAAB 37 234000): historical average (20 years) = 1.5t (range 0.1–7.3t). Catch 2017–2019 (inclusive) = 0.7t total. - Catch reported as <i>Garfish—snubnose</i> (CAAB 37 234006): no species-specific catch reported. - Catch reported as <i>Garfish—three-by-two</i> (CAAB 37 234013): no species-specific catch reported.
Flathead			
Dusky flathead	<i>Platycephalus fuscus</i> (37 296004)	Y	Notes —The flathead complex consists of four morphologically similar species: the bartailed flathead (<i>P. australis</i>), northern sand flathead (<i>P. endrachtensis</i>), the dusky flathead (<i>P. fuscus</i>) and yellowtailed

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
Bartailed flathead	<i>Platycephalus australis</i> (37 296033)	Y	flathead (<i>P. westraliae</i>). The distribution and depth profiles of all four species overlaps with the ECIF (Fishes of Australia, 2019) and they are all likely to be caught in tunnel net operations. However, it is anticipated that the majority of the commercial and recreational catch consists of dusky flathead (<i>P. fuscus</i>) (Leigh <i>et al.</i> , 2019; McGilvray <i>et al.</i> , 2018a).
Northern sand flathead	<i>Platycephalus endrachtensis</i> (37 296021)	Y	While <i>P. fuscus</i> is considered the primary species, catch data for this complex has poor species resolution. All of the reported catch from the commercial net and line fishery is classified as <i>Flathead—unspecified</i> and the key information sources provide little information on species compositions (Department of Agriculture and Fisheries, 2018g; Leigh <i>et al.</i> , 2019; McGilvray <i>et al.</i> , 2018a). From an ERA perspective, these deficiencies create a level of uncertainty in terms of what species should be included and included from the first stage of the Level 2 ERA.
Yellowtailed flathead	<i>Platycephalus westraliae</i> (37 296020)	Y	<p>Due to the above uncertainty in catch data and interaction rates all four species were included in the Level 2 ERA. As dusky flathead is the dominant species, the decision to include all four in the assessment is considered to be precautionary in nature.</p> <p><u>Catch data summary</u></p> <p><i>Tunnel netting (only)—All species</i></p> <ul style="list-style-type: none"> - <i>Flathead—unspecified</i> (CAAB 37 296000): average catch 11.1t (range 4.6–17.9t). Catch 2017–2019 (inclusive) = 12.7t total at an average of 4.2t. - <i>Catch reported as Flathead—dusky</i> (CAAB 37 296004): No catch record of this species for tunnel netting in since 2000. - <i>Catch reported as Flathead—bartailed</i> (CAAB 37 296033): No catch record of this species for tunnel netting in since 2000. - <i>Catch reported as Flathead—northern sand</i> (CAAB 37 296021): No catch record of this species for tunnel netting in since 2000.

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<ul style="list-style-type: none"> - Catch reported as <i>Flathead—yellowtailed</i> (CAAB 37 296020): No catch record of this species for tunnel netting in since 2000. <p><i>Net fishing (all) —All species</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Flathead—unspecified</i> (CAAB 37 296000): historical average (20 years) = 59.2t (range 23.6–98.1t). Catch 2017–2019 (inclusive) = 105.5t total at an average of 35.2t. - Species-specific catch data not available for this complex in the net fishery. <p><i>Line fishing (all)—All species</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Flathead—unspecified</i> (CAAB 37 296000): historical average (20 years) = 0.3t (range 0–1.5t). Catch 2017–2019 (inclusive) = 0.5t. - Species-specific catch data not available for this complex in the commercial line fishery.
Trevally			
Golden trevally	<i>Gnathanodon speciosus</i> (37 337012)	Y	<p>Notes—Defining the scope and extent of the trevally ERA can be difficult as the catch data has poor species resolution. This in part can be attributed to the fact that multiple trevally species may be caught in a single event and it can be difficult to differentiate between similar looking species. Consequently, the majority of catch for this complex is reported as <i>Trevally—unspecified</i> with a few key species recording smaller individual catches. Of the trevally that are caught in the ECIF, the majority of the catch is expected to consist of golden trevally (<i>G. speciosus</i>) and giant trevally (<i>C. ignobilis</i>). These two species were prioritised for assessment as part of the Level 2 ERA.</p>
Giant trevally	<i>Caranx ignobilis</i> (37 337027)	Y	
Bigeye trevally	<i>Caranx sexfasciatus</i> (37 337039)	N	

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
Turrum (gold spot) <i>Note: referred to as Trevally–gold spot in catch data.</i>	<i>Carangoides fulvoguttatus</i> (37 337037)	N	<i>fulvoguttatus</i>), the thicklip trevally (<i>C. orthogrammus</i>), bludger trevally (<i>C. gymnostethus</i>), blue spot trevally (<i>C. bucculentus</i>), the diamond trevally (<i>A. indica</i>) and silver trevally (<i>P. georgianus</i>) were all considered secondary species and were omitted from the analysis. When and where appropriate they will be considered for inclusion in subsequent Level 2 ERAs involving the Tunnel Net Fishery. <u>Catch data summary</u>
Thicklip trevally	<i>Carangoides orthogrammus</i> (37 337057)	N	<i>Tunnel netting (only)—All species</i> - Catch reported as <i>Trevally—unspecified</i> (CAAB 37 337000): average catch 2.4t (range 1.1–8.1t). Catch 2017–2019 (inclusive) = 10.1t total at an average of 3.4t.
Bludger trevally	<i>Carangoides gymnostethus</i> (37 337022)	N	- Catch reported as <i>Trevally–golden</i> (CAAB 37 337012): average 3.2 (range 0.1–12t.0). Catch 2017–2019 (inclusive) = 6.9t total at an average of 2.3t. - Catch reported as <i>Trevally–giant</i> (CAAB 37 337027): average 0.6 (range 0.1–2.2t). Catch 2017–2019 (inclusive) = 0.4t total.
Blue spot trevally	<i>Caranx bucculentus</i> (37 337016)	N	- Catch reported as <i>Trevally—turrum (gold spot)</i> (CAAB 37 337037): average <0.1t (range 0.0–<0.1t). Catch 2017–2019 (inclusive) = <0.1t total.
Diamond trevally	<i>Alectis indica</i> (37 337038)	N	- Catch reported as <i>Trevally—thicklip</i> (CAAB 37 337057): average <0.1t (range 0.0–<0.1t). Catch 2017–2019 (inclusive) = <0.1t total. - Catch reported as <i>Trevally—bludger</i> : (CAAB 37 337022) average <0.1t (range 0.0–<0.1t). Catch 2017–2019 (inclusive) = 0t total.
Silver trevally	<i>Pseudocaranx georgianus</i> (37 337062)	N	- Catch reported as <i>Trevally—blue spot</i> (CAAB 37 337016): average <0.1t (range 0.0–<0.1t). Catch 2017–2019 (inclusive) = 0t total. - Catch reported as <i>Trevally—diamond</i> (CAAB 37 337038): no reported catch.

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<ul style="list-style-type: none"> - Catch reported as <i>Trevally—silver</i> (CAAB 37 337062): average 0.1t (range 0–0.4t). Catch 2015–2017 (inclusive) = 0.4t total. <p><i>Net fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Trevally—unspecified</i> (CAAB 37 337000): historical average (20 years) = 46.1t (range 27.6–69.5t). Catch 2017–2019 (inclusive) = 174.1t total at an average of 58t. - Catch reported as <i>Trevally—golden</i> (CAAB 37 337012): historical average (20 years) = 7.3t (range 0.6–18.7t). Catch 2017–2019 (inclusive) = 20.8t total at an average of 6.9t. - Catch reported as <i>Trevally—giant</i> (CAAB 37 337027): historical average (20 years) = 0.9t (range 0–2.4t). Catch 2017–2019 (inclusive) = 0.7t total. - Catch reported as <i>Trevally—turrum (gold spot)</i> (CAAB 37 337037): historical average (20 years) = 0.4t (range 0.1–3.3t). Catch 2017–2019 (inclusive) = 1.4t total. - Catch reported as <i>Trevally—thicklip</i> (CAAB 37 337057): historical average (20 years) = 0.1t (range 0.0–0.4t). Catch 2017–2019 (inclusive) = 1t total. - Catch reported as <i>Trevally—bludger</i> (CAAB 37 337022): historical average (20 years) = 0.3 (range 0–0.9t). Catch 2017–2019 (inclusive) = 0t total. - Catch reported as <i>Trevally—blue spot</i> (CAAB 37 337016): historical average (20 years) = 0.4t (range 0–1.8t). Catch 2017–2019 (inclusive) = <0.1t total. - Catch reported as <i>Trevally—diamond</i> (CAAB 37 337038): historical average (20 years) = 0.2 (range 0–0.5t). Catch 2017–2019 (inclusive) = 2t total. - Catch reported as <i>Trevally—silver</i> (CAAB 37 337062): historical average = 0.7 (range 0–2t). Catch 2017–2019 (inclusive) = 2.3t total.

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<p><i>Line fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Trevally—unspecified (CAAB 37 337000)</i>: historical average (20 years) = 58.9t total at an average of 76.9t. - Catch reported as <i>Trevally—golden (CAAB 37 337012)</i>: historical average (20 years) = <0.2t. - Catch reported as <i>Trevally—giant (CAAB 37 337027)</i>: historical average (20 years) = 0.2t. - Catch reported as <i>Trevally—gold spot (turrum) (CAAB 37 337037)</i>: historical average (20 years) = 0.2t. - Catch reported as <i>Trevally—thicklip (CAAB 37 337057)</i>: historical average (20 years) = <0.6t. - Catch reported as <i>Trevally—bludger (CAAB 37 337022)</i>: historical average (20 years) = <0.2t. - Catch reported as <i>Trevally—blue spot (CAAB 37 337016)</i>: historical average (20 years) = <0.2t. - Catch reported as <i>Trevally—diamond (CAAB 37 337038)</i>: historical average (20 years) = <0.1t. - Catch reported as <i>Trevally—silver (CAAB 37 337062)</i>: historical average = <0.3t.
Other species			
Scribbled rabbitfish (spinefoot)	<i>Siganus spinus</i> (37 438013)	Y	<p>Notes—Consistent amounts of scribbled rabbitfish (<i>S. spinus</i>) are retained by tunnel net operators in south-east Queensland. Otherwise known as spinefoot or happy moments, it is viewed as a target species in this sector of the ECIF and it was included in the initial target and byproduct species ERA.</p> <p>Catch data summary</p> <p><i>Tunnel net fishing (only)</i></p> <ul style="list-style-type: none"> - Catch reported as scribbled rabbitfish (spinefoot). Total catch: average 39.9 (range 11.0–78.4t). Catch 2017–2019 (inclusive) = 54.7t total at an average of 18.2t.

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<p><i>Net fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Spinefoot (CAAB 37 438000)</i>: historical average (20 years) = 54.7t (range 12.2–118.8t). Catch 2017–2019 (inclusive) = 94.4t at an average of 31.5t. - Catch reported as <i>Scribbled rabbitfish</i>: no species-specific catch reported. <p><i>Line fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Spinefoot (CAAB 37 438000)</i>: historical average (20 years) = 0.1t (range 0–0.4t). Catch 2017–2019 (inclusive) = 0t total. - Catch reported as <i>Scribbled rabbitfish</i>: no species-specific catch reported.
Tailor	<i>Pomatomus saltatrix</i> (37 334002)	N	<p>Notes—Tailor (<i>P. saltatrix</i>) attracts a significant level of attention from both the commercial and recreational fishing sectors. On the Australian east coast, tailor is shared stock and is readily exploited by fishers in Queensland, New South Wales and Victoria (Leigh <i>et al.</i>, 2017; Litherland <i>et al.</i>, 2018). The structure and health of the east coast tailor stock is well understood and the species has been included in a long-term monitoring program that gathers information on size and age classes.</p> <p>A tailor stock assessment was completed in 2017 (Leigh <i>et al.</i>, 2017) with the results indicating that biomass levels were at or around 50% of an unfished population. The stock assessment also estimated the maximum sustainable yield to be 1350t across all fishing sectors <i>i.e.</i> commercial and recreational fishing in both Queensland and New South Wales (Leigh <i>et al.</i>, 2017). This compares with current estimates that place the combined New South Wales / Queensland catch at less than 400t: commercial fisheries = ~185t, recreational fisheries = ~182t. These facts form the basis for the species being assigned a positive stock status evaluation as part of the national <i>Status of Australian Fish Stocks</i> process (Litherland <i>et al.</i>, 2018).</p> <p>In Queensland the commercial take of Tailor is managed under a 120 Total Allowable Commercial Catch (TACC) limit. This limit was introduced in 2002 and the fishery currently utilises about half of the available quota. The majority of this catch is reported from other sectors of the ECIF, namely the Ocean Beach</p>

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<p>Fishery and the Large Mesh Net Fishery. When compared to these sectors, the Tunnel Net Fishery makes a small contribution to the total tailor catch.</p> <p>While the species is not managed as an individual fishery (e.g. like Spanish mackerel), there are broader restrictions on the number of licences that can access the fishery and the use of seine nets in the Ocean Beach Fishery; the key sector in terms of the targeting of this species. In the recreational sector, fishers are restricted by an in possession limit on 20 tailor and the sector has a minimum legal size limit of 35cm. As research indicates that males and females have L_{50}s of 29cm TL and 31cm TL respectively, these measures help ensure that a high percentage of the recreationally caught fish reproduce at least once before they are harvested.</p> <p>There is substantial protections in place to prevent catch increasing beyond key biomass reference points and the take of the species across sectors is being managed effectively. Similarly, there is considerable information on the health of the east coast tailor stock a long-term monitoring program will help to detect broader catch trends. Given the above considerations, Tailor was excluded from the Tunnel Net Fishery Level 2 ERA as the risk is being managed effectively through the current harvest strategy.</p> <p><u>Catch data summary</u></p> <p><i>Tunnel net fishing (only)</i></p> <ul style="list-style-type: none"> - Catch reported as Tailor (CAAB 37 334002): average 5.4t (range 2.8–10.7t). Catch 2017–2019 (inclusive) = 9.8t at an average of 3.3t. - Unspecified: N/A <p><i>Net fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as Tailor (CAAB 37 334002): historical average (20 years) = 101.3t (range 36.8–248.5t). Catch 2017–2019 (inclusive) = 161.6t total at an average of 53.9t.

Common name	Scientific name (CAAB)	Include	Notes, Comments & Catch Data
			<ul style="list-style-type: none"> - Unspecified (Net): N/A. <p><i>Line fishing (all)</i></p> <ul style="list-style-type: none"> - Catch reported as <i>Tailor</i> (CAAB 37 334002): historical average (20 years) = 1.4t (range 0.1–4.5t). Catch 2017–2019 (inclusive) = 0.6t total. - Unspecified (line): N/A <p>Note—Most significant gillnet/ring net catches occurred prior to the introduction of quota of a 120t TACC limit in 2002. Catch in the pre-quota period (1988–2001 inclusive) averaged 151.6t compared to a post quota average of 83t.</p>

Appendix B—Species of Conservation Concern Species Rationalisation Process.

1. Overview

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

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

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

1. All SOCC subgroups that were not classified as medium/high or high risk in the whole-of-fishery (Level 1) ERA (Jacobsen *et al.*, 2019) were removed from the analysis.
2. The distribution of the remaining species were then 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 its distribution and interaction potential were retained in the assessment and further advice sought from scientific experts / key stakeholders.
4. A summary of the species rationalisation process was then compiled (Table B1 and B2) 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 Tunnel Net Fishery are provided in Appendix B3.

2. Summary Tables

- *Table B1—Summary of the Species of Conservation Concern (SOCC) that were considered for inclusion in the Level 2 ERA for the Tunnel Net Fishery.*
- *Table B2—Summary of the species omitted from the analysis whose distribution has no or very low overlap with the Tunnel Net Fishery and/or are highly unlikely to interact with the fishery.*
- *Table B3—Detailed overview of the key consideration and justifications used as part of the SOCC Species Rationalisation Process.*

Table B1—Summary of the Species of Conservation Concern (SOCC) that were considered for inclusion in the Tunnel Net Fishery Level 2 ERA for the.

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

Common name	Species name	CAAB	Tunnel Net
Marine turtles			
Green turtle	<i>Chelonia mydas</i>	39 020002	Y
Loggerhead turtle	<i>Caretta caretta</i>	39 020001	Y
Hawksbill turtle	<i>Eretmochelys imbricata</i>	39 020003	Y
Flatback turtle	<i>Natator depressus</i>	39 020005	N*
Olive Ridley turtle	<i>Lepidochelys olivacea</i>	39 020004	N*
Leatherback turtle	<i>Dermochelys coriacea</i>	39 021001	N*
Sirenia			
Dugong	<i>Dugong dugon</i>	41 206001	Y
Dolphins (odontocetes)			
Australian humpback dolphin	<i>Sousa sahalensis</i>	41 116014	N
Australian snubfin dolphin	<i>Orcaella heinsohni</i>	41 116010	N
Common bottlenose dolphin (Synonym: Offshore or Atlantic bottlenose dolphin)	<i>Tursiops truncatus</i>	41 116019	N
Indo-Pacific bottlenose dolphin	<i>Tursiops aduncus</i>	41 116020	N
Common dolphin	<i>Delphinus delphis</i>	41 116001	N
Spinner Dolphin	<i>Stenella longirostris</i>	41 116017	N
Sharks & Batoids			
School shark	<i>Galeorhinus galeus</i>	37 017008	N*
Green sawfish	<i>Pristis zijsron</i>	37 025001	N*
Bottlenose wedgefish	<i>Rhynchobatus australiae</i>	37 026005	Y
Eyebrow wedgefish	<i>Rhynchobatus palpebratus</i>	37 026004	N*
Giant Shovelnose Ray	<i>Glaucostegus typus</i>	37 027010	Y
Estuary stingray	<i>Hemirhynchus fluviorum</i>	37 035008	Y

Table B2—Summary of the species omitted from the analysis whose distribution has no or very low overlap with the Tunnel Net Fishery and/or are highly unlikely to interact with the fishery.

*Denotes species that were included or omitted in response to advice provided by key stakeholders and members of the scientific community.

Ecological Component & Species	
<p><u>Dolphins (Odontocetes)</u></p> <p>Fraser’s dolphin, <i>Lagenodelphis hosei</i> (CAAB 41 116006)*</p> <p>Striped dolphin, <i>Stenella coeruleoalba</i> (CAAB 41 116016)</p> <p>Spotted dolphin, <i>Stenella attenuata</i> (CAAB 41 116015)*</p> <p>Risso’s dolphin, <i>Grampus griseus</i> (CAAB 41 116005)</p> <p>Rough toothed-dolphin, <i>Steno bredanensis</i> (CAAB 41 116018)*</p> <p>Melon headed whale, <i>Peponocephala electra</i> (CAAB 41 116012)*</p> <p>Short-finned pilot whale, <i>Globicephala macrorhynchus</i> (CAAB 41 116003)*</p> <p>Killer whale, <i>Orcinus orca</i> (CAAB 41 116011)</p> <p>False killer whale, <i>Pseudorca crassidens</i> (CAAB 41 116013)</p> <p>Spinner dolphin, <i>Stenella longirostris</i> (CAAB 41 116017).</p> <p>Pygmy killer whale, <i>Feresa attenuata</i> (CAAB 41 116002)</p> <p>Pygmy sperm whale, <i>Kogia breviceps</i> (CAAB 41 119001)</p> <p>Long-finned pilot whale, <i>Globicephala melas</i> (CAAB 41 116004)</p> <p>Dusky dolphin, <i>Lagenorhynchus obscurus</i> (CAAB 41 116008)</p> <p>Spectacled porpoise, <i>Phocoena dioptrica</i> (CAAB 41 117001)</p> <p>Commerson’s dolphin. <i>Cephalorhynchus commersonii</i> (CAAB N/A)</p> <p>Hourglass dolphin, <i>Lagenorhynchus cruciger</i> (CAAB 41 116007)</p> <p>Southern right whale, <i>Lissodelphis peronii</i> (CAAB 41 116009)</p> <p>Burrnan dolphin, <i>Tursiops australis</i> (CAAB 41 116022)</p>	<p><u>Dolphins (Odontocetes) cont.</u></p> <p>Irrawaddy dolphin, <i>Orcaella brevirostris</i>, (CAAB N/A)</p> <p>Indo-Pacific humpback dolphin, <i>Sousa chinensis</i> (CAAB N/A)</p> <p>Strap toothed whale, <i>Mesoplodon layardii</i> (CAAB 41 120009)</p> <p>Giant beaked whale (aka Arnoux’s), <i>Berardius arnuxii</i> (CAAB 41 120001)</p> <p>Dwarf sperm whale, <i>Kogia sima</i> (CAAB 41 119 002)</p> <p>Southern bottlenose whale, <i>Hyperoodon planifrons</i> (CAAB 41 120003)</p> <p>Tropical bottlenose whale (aka Longman’s), <i>Indopacetus pacificus</i> (CAAB 41 120003)</p> <p>Andrew’s beaked whale, <i>Mesoplodon bowdoini</i> (CAAB 41 120004)</p> <p>Blainvilles’s beaked whale, <i>Mesoplodon densirostris</i> (CAAB 41 120005)</p> <p>Ginkgo-toothed beaked whale, <i>Mesoplodon ginkgodens</i> (CAAB 41 120006)</p> <p>Gray’s beaked whale, <i>Mesoplodon grayi</i> (CAAB 41 120007)</p> <p>Hector’s beaked whale, <i>Mesoplodon hectori</i> (CAAB 41 120008)</p> <p>True’s beaked whale, <i>Mesoplodon mirus</i> (CAAB 41 120010)</p> <p>Shepard’s beaked whale, <i>Tasmacetus shepherdi</i> (CAAB 41 120011)</p> <p>Curvier’s beaked whale, <i>Ziphius cavirostris</i> (CAAB 41 120012)</p> <p><u>Sharks</u></p> <p>Great White Shark, <i>Carcharodon carcharias</i> (CAAB 37 010003)</p> <p>Whale Shark, <i>Rhincodon typus</i> (CAAB 37 014001)</p> <p>Grey Nurse Shark, <i>Carcharias taurus</i> (CAAB 37 008001)</p> <p>Sandtiger shark, <i>Odontaspis ferox</i> (CAAB 37 008003)</p>

Ecological Component & Species

Sharks continued

Speartooth shark, *Glyphis glyphis* (CAAB 37 018041)
 Northern River Shark, *Glyphis garricki* (CAAB 37 018042)
 Porbeagle shark, *Lamna nasus* (CAAB 37 010004)
 Shortfin mako shark, *Isurus oxyrinchus* (CAAB 37 010001)
 Longfin mako shark, *Isurus paucus* (CAAB 37 01002)
 Great hammerhead shark, *Sphyrna mokarran* (CAAB 37 019002)
 Scalloped hammerhead shark, *Sphyrna lewini* (CAAB 37 019001)
 Smooth hammerhead shark, *Sphyrna zygaena* (CAAB 37 019004)
 Winghead shark, *Eusphyra blochii* (CAAB 37 019003)
 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 vulpuncus* (CAAB 37 012001)
 School shark, *Galeorhinus galeus* (CAAB 37 017008)
 Basking shark *Cetorhinus maximus* (CAAB 37 011001)
 Harrison's dogfish, *Centrophorus harrissoni* (CAAB 37 020010)
 Southern dogfish, *Centrophorus zeehaani* (CAAB 37 020011)
 Spiny dogfish, *Squalus acanthias* (CAAB 37 020008)
 Crested hornshark, *Heterodontidae galeatus* (CAAB 37 007003)

Rays / Batoids

Giant manta ray, *Mobula birostris* (CAAB 37 041004)
 Reef manta ray, *Mobula alfreidi* (CAAB 37 041005)
 Kuhl's devil ray, *Mobula kuhlii*, (CAAB 37 041001)
 Giant devilray, *Mobula mobular* (CAAB 37 041002)
 Bentfin deviray, *Mobula thurstoni* (CAAB 37 041003)
 Largetooth sawfish, *Pristis pristis* (CAAB 37 025003)
 Narrow sawfish, *Anoxypristis cuspidata* (CAAB 37 025002)
 Dwarf sawfish, *Pristis clavata* (CAAB 37 025004)
 Chilean devil ray, *Mobula tarapacana* (CAAB 37 041006)

Species of Conservation Concern Subgroups excluded during the Level 1 ERA analysis (Jacobsen et al., 2019)

- Whales
- Sea snakes
- Crocodiles
- Protected teleosts
- Syngnathids
- Seabirds
- Terrestrial mammals

Table B3—Detailed overview of the key consideration and justifications used as part of the SOCC Species Rationalisation Process.

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

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
Marine turtles				
Green turtle	<i>Chelonia mydas</i>	39 020002	Y	<p>Included—<i>Chelonia mydas</i>, <i>Caretta caretta</i> and <i>Eretmochelys imbricata</i>.</p> <p>Not included—<i>Natator depressus</i>, <i>Lepidochelys olivacea</i> and <i>Dermochelys coriacea</i>.</p> <p>Six species of marine turtle occur in Queensland waters. The known range of all six species cover the majority of the Queensland east coast and could theoretically interact with the Tunnel Net Fishery. However, a closer inspection of the preferred habitat and bathymetry ranges suggests that the majority (if not all) interactions would be with the green turtle (<i>C. mydas</i>), the loggerhead turtle (<i>C. caretta</i>) and the hawksbill turtle (<i>E. imbricata</i>) (<i>pers. comm.</i> C. Limpus, J. Meager). Green, loggerhead and hawksbill turtles frequently occur in shallow water environments in the Queensland east coast including in Moreton Bay and Hervey Bay. In comparison, the olive ridley turtle (<i>L. olivacea</i>) and the leatherback turtle (<i>D. coriacea</i>) inhabit deeper, pelagic waters (Department of the Environment, 2019k; l). While flatback turtles inhabit shallower inshore waters, their distribution has less overlap with central and southern Queensland where tunnel net operations operate exclusively.</p> <p>Given these considerations and the low probability that the other species will encounter or interact with a tunnel net, only the green, loggerhead and hawksbill turtle were included in the Tunnel Net Fishery Level 2 ERA. This decision was supported by <i>Species of Conservation Interest</i> (SOCI) data that shows all marine turtle interactions reported from this sector of the ECIF were with these three species (Appendix E).</p>
Loggerhead turtle	<i>Caretta caretta</i>	39 020001	Y	
Hawksbill turtle	<i>Eretmochelys imbricata</i>	39 020003	Y	
Flatback turtle	<i>Natator depressus</i>	39 020005	N	
Olive ridley turtle	<i>Lepidochelys olivacea</i>	39 020004	N	
Leatherback turtle	<i>Dermochelys coriacea</i>	39 021001	N	

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
Sirenia				
Dugong	<i>Dugong dugon</i>	41 206001	Y	Included —Tunnel nets operate in areas that a) contain high-value habitats for this species and b) support larger dugong populations that aggregate in higher densities e.g. Moreton Bay (Department of National Parks Sport and Racing, 2015b).
Dolphins (Odontocetes)				
Australian humpback dolphin	<i>Sousa sahalensis</i>	41 116014	N	<p>Not included—Five species of dolphin have a higher probability of interacting with the ECIF: the Australian humpback dolphin (<i>S. sahalensis</i>), the Australian snubfin dolphin (<i>O. heinsohni</i>), the common bottlenose dolphin (<i>T. truncatus</i>), the Indo-Pacific bottlenose dolphin (<i>T. aduncus</i>) and the common dolphin (<i>D. delphis</i>). Of these five, the known distributions and habitat preferences of the Australian humpback dolphin and the Indo-Pacific bottlenose dolphins make interactions with these two species more likely.</p> <p>The Australian humpback dolphin is an inshore species and has a resident population in Moreton Bay (Department of Environment and Science, 2018; Parra <i>et al.</i>, 2006). Indo-Pacific bottlenose dolphins are more often associated with shallow-water environments including inshore coastal waters, estuaries, bays and river mouths (Brown <i>et al.</i>, 2016; Cribb <i>et al.</i>, 2013; Fury & Harrison, 2008; Lukoschek & Chilvers, 2008). The species also has a resident population in Moreton Bay and is frequently identified as one of two dolphins that inhabit the area (Dolphin Research Australia, 2018; Lukoschek & Chilvers, 2008). If and when a dolphin interacts with this sector of the ECIF (including contact without capture events) it will most likely be with one of these two species.</p> <p>Of the remaining species:</p> <ul style="list-style-type: none"> - Snubfin dolphins have been reported as far south as Moreton Bay in south-east Queensland. However, the species is more prevalent in waters north of Keppel Bay and records south of this point are considered rare and extralimital (Parra <i>et al.</i>, 2017).
Australian snubfin dolphin	<i>Orcaella heinsohni</i>	41 116010	N	
Common bottlenose dolphin (synonym: offshore and Atlantic bottlenose dolphin)	<i>Tursiops truncatus</i>	41 116019	N	
Indo-Pacific bottlenose dolphin (synonyms: Indian, inshore, and spotted bottlenose dolphin)	<i>Tursiops aduncus</i>	41 116020	N	
Common dolphin	<i>Delphinus delphis</i>	41 116001	N	

ECIF— Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
				<ul style="list-style-type: none"> - The common bottlenose dolphins inhabit inshore waters but are regularly observed in larger groups or in aggregations in offshore waters (Bearzi <i>et al.</i>, 2009; Bilgmann <i>et al.</i>, 2019; Great Barrier Reef Marine Park Authority, 2013). Tunnel net interactions with this species, while possible, are less likely and (if applicable) will be lower than the Indo-Pacific bottlenose dolphin. - The common dolphin has a wide distribution and has been reported with some regularity in the Queensland <i>Shark Control Program</i> (Department of the Environment, 2019; Meager, 2013; 2016; Meager <i>et al.</i>, 2012; Queensland Government, 2019). However, the species prefers unwilling-modified waters, areas with steep sea floor relief and extensive shelf areas. As the Tunnel Net Fishery operates close to shore and in shallow water environments, interactions with this species are considered unlikely. In the unlikely event that <i>D. delphis</i> were to interact with the Tunnel Net Fishery the number of interactions and mortalities are not expected to pose a significant or long-term risk to the conservation status of this species. <p>Tunnel nets are set in comparatively shallow waters and the disturbance created during the net-setting process make the direct or immediate capture of a dolphin unlikely. This assessment is supported by an absence of data on tunnel net / dolphin interactions in the SOCI logbooks and ancillary programs like StrandNET (Department of Agriculture and Fisheries, 2019d; Department of Environment and Science, 2017). While noting this absence of data, there is anecdotal evidence that dolphins will interact infrequently with this sector of the ECIF (<i>pers. comm.</i> T. Ham; Thompson <i>et al.</i>, 2012). When a dolphin does interact with a tunnel net, a high percentage will be instigated by the animal and are unlikely to result in their capture <i>i.e.</i> contact without capture events. In the unlikely event that a dolphin is caught in the sweep of the net, current regulations reduce the risk of an interaction ending in mortality and the animal should be released with minimal intervention/handling.</p> <p>Due to this low interaction potential and high post-interaction survival rates, the Australian humpback dolphin, the Australian snubfin dolphin, the common bottlenose dolphin, the Indo-Pacific bottlenose dolphin and the common dolphin were excluded from the first iteration of the Tunnel Net Fishery Level 2 ERA. As the biology of these species will be the key driver of risk (<i>vs.</i> fisheries interactions), there is an increased probability that risk</p>

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
				ratings for these species will represent a false positive or a risk overestimation. When and where appropriate, these species will be considered for inclusion in subsequent ERAs involving this sector of the ECIF.
False killer whale	<i>Pseudorca crassidens</i>	41 116013	N	Not included —Research indicates that this species inhabits deeper water environments and it will not interact with the Tunnel Net Fishery (Baird, 2018; Department of the Environment, 2019c).
Fraser's dolphin	<i>Lagenodelphis hosei</i>	41 116006	N	Not Included —Research on the distribution and habitat preferences of this species indicates that it will not interact with the Tunnel Net Fishery (Department of the Environment, 2019b; Kiszka & Braulik, 2018).
Striped dolphin	<i>Stenella coeruleoalba</i>	41 116016	N	Not Included —The species is unlikely to interact with the ECIF and the key threats for this species largely occur in waters outside of Australia (Au & Perryman, 1985; Braulik, 2019; Department of the Environment, 2019v; Reeves <i>et al.</i> , 2003).
Spotted dolphin	<i>Stenella attenuata</i>	41 116015	N	Not included —Research indicates that this species inhabits deeper water environments and it will not interact with the Tunnel Net Fishery (Kiska & Braulik, 2018).
Risso's dolphin	<i>Grampus griseus</i>	41 116005	N	Not Included —Research on geographic distributions and habitat preferences suggest that it is highly unlikely that this species will interact with the Tunnel Net Fishery (Corkeron & Martin, 2004; Department of the Environment, 2019i).
Spinner dolphin	<i>Stenella longirostris</i>	41 116017	N	Not Included —Research on geographic distributions and habitat preferences suggest that it is highly unlikely that this species will interact with the Tunnel Net Fishery (Braulik, 2019; Department of the Environment, 2019e).
Rough toothed-dolphin	<i>Steno bredanensis</i>	41 116018	N	Not included —Research indicates that this species inhabits deeper water environments and it will not interact with the Tunnel Net Fishery (Department of the Environment, 2019d).

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
Melon headed whale	<i>Peponocephala electra</i>	41 116012	N	Not included —Research indicates that this species inhabits deeper water environments and it will not interact with the Tunnel Net Fishery (Department of the Environment, 2019a).
Short-finned pilot whale	<i>Globicephala macrorhynchus</i>	41 116003	N	Not Included —Species mostly associated with tropical and temperate oceanic waters. While the species has been reported in StrandNET (Department of the Environment, 2019y; Meager, 2016; Minton <i>et al.</i> , 2018a), it is highly unlikely that this species will interact with tunnel nets on the Queensland east coast.
Killer whale	<i>Orcinus orca</i>	41 116011	N	Not Included —Interactions with this species highly unlikely in the Tunnel Net Fishery (Department of the Environment, 2019w).
Pygmy killer whale	<i>Feresa attenuata</i>	41 116002	N	Not Included —Interactions with this species highly unlikely in the Tunnel Net Fishery (Department of the Environment, 2019u; Reeves <i>et al.</i> , 2003).
Pygmy sperm whale	<i>Kogia breviceps</i>	41 119001	N	Not Included —Deeper water species that will not interact with the Tunnel Net Fishery (Department of the Environment, 2019t).
Long-finned pilot whale	<i>Globicephala melas</i>	41 116004	N	Not Included —Species has a mostly southern distribution and it is unlikely to occur in high numbers in Queensland (Department of the Environment, 2019f; Minton <i>et al.</i> , 2018b).
Dusky dolphin	<i>Lagenorhynchus obscurus</i>	41 116008	N	Not Included —The northernmost point of the <i>L. obscurus</i> Australian distribution lies to the south of Queensland managed waters (Department of the Environment, 2019g).
Spectacled porpoise	<i>Phocoena dioptrica</i>	41 117001	N	Not Included —Species does not occur and/or is unlikely to occur in waters managed by Queensland (Department of the Environment, 2019h).
Commerson's dolphin	<i>Cephalorhynchus commersonii</i>	N/A	N	Not Included —Species does not occur in waters managed by Queensland (Crespo <i>et al.</i> , 2017).

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
Hourglass dolphins	<i>Lagenorhynchus cruciger</i>	41 116007	N	Not Included —Species does not occur and/or is unlikely to occur in waters managed by Queensland (Braulik, 2018b).
Southern right whale dolphin	<i>Lissodelphis peronii</i>	41 116009	N	Not Included —Species does not occur and/or is unlikely to occur in waters managed by Queensland (Braulik, 2018a).
Burrunan dolphin	<i>Tursiops australis</i>	41 116022	N	Not Included —Species does not occur in Queensland managed waters (Charlton-Robb <i>et al.</i> , 2011).
Irrawaddy dolphin	<i>Orcaella brevirostris</i>	n/a	N	Not Included — <i>Orcaella brevirostris</i> is now considered to be a south-east Asian species and it is not found in waters where tunnel net fishing occurs on the Queensland east coast (Minton <i>et al.</i> , 2017).
Indo-Pacific humpback dolphin	<i>Sousa chinensis</i>	n/a	N	Not Included —Similar profile to the Irrawaddy dolphin. Taxonomic reviews and further research has identified two distinct species, the Australian humpback dolphin (<i>Sousa sahulensis</i>) and the Indo-Pacific humpback dolphin (<i>S. chinensis</i>) (Department of the Environment, 2019m). The species will not inhabit waters where tunnel net fishing activities occur on the Queensland east coast.
Strap toothed whale	<i>Mesoplodon layardii</i>	41 120009	N	Not Included —While this species has StrandNET records (Meager, 2016) it is more frequently found in deeper water environments and it will not interact with the Tunnel Net Fishery.
Giant beaked whale (aka Arnoux's)	<i>Berardius arnuxii</i>	41 120001	N	Not Included —Species does not occur in Queensland managed waters (Department of the Environment, 2019n).
Dwarf sperm whale	<i>Kogia sima</i>	41 119002	N	Not Included —Dwarf sperm whales (<i>K. sima</i>) are not considered to be abundant in Australian waters and sightings/strandings for this species are limited (Department of the Environment, 2019o). In the unlikely event that a <i>K. sima</i> interacts with any of the ECIF sub-fisheries, the extent and impact of these interactions are expected to be low to negligible.

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
Southern bottlenose whale	<i>Hyperoodon planifrons</i>	41 120002	N	Not Included —Species does not occur in Queensland managed waters (Department of the Environment, 2019p).
Tropical bottlenose whale (aka Longman's)	<i>Indopacetus pacificus</i>	41 120003	N	Not Included —Species does not occur in Queensland managed waters (Department of the Environment, 2019q).
Andrew's beaked whale	<i>Mesoplodon bowdoini</i>	41 120004	N	Not Included —Species does not occur in Queensland managed waters (Department of the Environment, 2019r).
Blainville's beaked whale	<i>Mesoplodon densirostris</i>	41 120005	N	Not Included —A limited number of <i>M. densirostris</i> strandings have been reported in Queensland. The species though prefers tropical (22–32 °C) to temperate (10–20 °C) oceanic regions and inhabits waters ranging from 700–1000m deep, but often adjacent to much deeper waters of 5000m (Department of the Environment, 2019s). This species will not interact with the Tunnel Net Fishery.
Ginkgo-toothed beaked whale	<i>Mesoplodon ginkgodens</i>	41 120006	N	Not Included — <i>Mesoplodon ginkgodens</i> are not considered to be abundant and thought to primarily occur in deep, offshore waters (Department of the Environment, 2019z). This species will not interact with the Tunnel Net Fishery.
Gray's beaked whale	<i>Mesoplodon grayi</i>	41 120007	N	Not Included — <i>Mesoplodon grayi</i> is considered to be a southern species with low potential to interact with fisheries in Queensland (Taylor <i>et al.</i> , 2008a).
Hector's beaked whale	<i>Mesoplodon hectori</i>	41 120008	N	Not Included — <i>Mesoplodon hectori</i> is considered to be a southern species with low potential to interact with fisheries in Queensland (Taylor <i>et al.</i> , 2008b).
True's beaked whale	<i>Mesoplodon mirus</i>	41 120010	N	Not Included —Species does not occur in Queensland managed waters (Taylor <i>et al.</i> , 2008c).

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
Shepard's beaked whale	<i>Tasmacetus shepherdi</i>	41 120011	N	Not Included —Species does not occur in Queensland managed waters (Braulik, 2018c).
Curvier's beaked whale	<i>Ziphius cavirostris</i>	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 <i>et al.</i> , 2008d).
Sharks				
Whale shark	<i>Rhincodon typus</i>	37 014001	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Great white shark	<i>Carcharodon carcharias</i>	37 010003	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Grey nurse shark	<i>Carcharias taurus</i>	37 008001	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Speartooth shark	<i>Glyphis glyphis</i>	37 018041	N	Not Included —The distribution of <i>Glyphis glyphis</i> remains uncertain with research suggesting that speartooth sharks are extirpated from the majority (if not all) of the Queensland east coast (Compagno <i>et al.</i> , 2009; Last & Stevens, 2009; Peverell <i>et al.</i> , 2006). If <i>G. glyphis</i> had viable east coast populations, it would occur in far north Queensland where tunnel net fishing is not permitted (Department of Agriculture and Fisheries, 2019e; Peverell <i>et al.</i> , 2006).
Northern river shark	<i>Glyphis garricki</i>	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).
Porbeagle shark	<i>Lamna nasus</i>	37 010004	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
Sandtiger shark	<i>Odontaspis ferox</i>	37 008003	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Shortfin mako shark	<i>Isurus oxyrinchus</i>	37 010001	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Longfin mako shark	<i>Isurus paucus</i>	37 010002	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Great hammerhead	<i>Sphyrna mokarran</i>	37 019002	N	<p>Not Included—Tunnel net fishers retain a small amount of hammerhead with catch data showing that <0.5t is reported from the sector in most years. Two outliers occur in the catch data being 1.5t in 2008 and 5.0t in 2012. Reported catch from the fishery since 2013 has ranged from 0t to 0.01t and this portion of the catch will (more than likely) consist of smaller individuals.</p> <p>DAF notes that more hammerhead sharks may be caught in the Tunnel Net Fishery with unwanted product being discarded. Regulations for the fishery require the tunnel of the net to remain submerged for the duration of the fishing event. These measures will help to ensure that released hammerhead sharks have a high chance of survival.</p> <p>Due to their distribution and prevalence, tunnel net fishers have a higher probability of interacting with juvenile scalloped (<i>S. lewini</i>) and smooth hammerhead (<i>S. zygaena</i>) sharks. The extent of these interactions are not expected to have a significant or long-term impact on the conservation status of these species. These species will encounter greater fishing mortalities and fishing intensities in the Large Mesh Net Fishery (Department of Agriculture and Fisheries, 2019e; Jacobsen <i>et al.</i>, 2019). Accordingly, the risk posed to these species will be best addressed as part of the Large Mesh Net Level 2 ERA (Jacobsen <i>et al.</i>, 2021a; Pidd <i>et al.</i>, 2021).</p>
Scalloped hammerhead	<i>Sphyrna lewini</i>	37 019001	N	
Smooth hammerhead	<i>Sphyrna zygaena</i>	37 019004	N	
Winghead shark	<i>Eusphyra blochii</i>	37 019003	N	Not Included —When compared to the scalloped, great and smooth hammerhead shark, datasets for the winghead shark (<i>E. blochii</i>) are more limited. Distributional data for the species though indicates that this

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
				species is primarily found to the north of the Tunnel Net Fishery (Last & Stevens, 2009; Smart & Simpfendorfer, 2016).
Oceanic whitetip shark	<i>Carcharhinus longimanus</i>	37 018032	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Pelagic thresher	<i>Alopias pelagicus</i>	37 012003	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Bigeye thresher	<i>Alopias superciliosus</i>	37 012002	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Thresher shark	<i>Alopias vulpinus</i>	37 012001	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Basking shark	<i>Cetorhinus maximus</i>	37 011001	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Harrison's dogfish	<i>Centrophorus harrissoni</i>	37 020010	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Southern dogfish	<i>Centrophorus zeehaani</i>	37 020011	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
School shark	<i>Galeorhinus galeus</i>	37 017008	N*	Not included —The distribution of the school shark (<i>G. galeus</i>) has overlaps with this sector of ECIF (Last & Stevens, 2009). At a whole-of-fishery level, around 83t of school shark have been reported from the ECIF since 1993. The overwhelming majority of this catch (78t) was reported from the fishery before the introduction of the shark (S) fishery symbol. More than half of this catch was reported from 2004 with all but 3t retained by operators in the Large Mesh Net fishery.

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
				<p>Catch data for the Tunnel Net Fishery shows that less than 2t of school shark have been retained by the sector since 1993. This in part can be attributed to the footprint of the fishery which is confined to the Moreton Bay and Great Sandy Marine Parks. While school sharks may be discarded from this fishery, regulations require the tunnel of the net to remain submerged for the duration of the fishing event. These measures will help to ensure that school sharks that are released have a high chance of survival.</p> <p>The school shark was omitted from the first iteration of the Tunnel Net Fishery Level 2 ERA. Where and when appropriate, the species will be considered for inclusion in Level 2 ERAs for other sectors of the ECIF including the Large Mesh Net Fishery.</p>
Spiny dogfish	<i>Squalus acanthias</i>	37 020008	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Crested Hornshark	<i>Heterodontus galeatus</i>	37 007003	N	<p>Not Included—The crested hornshark (<i>H. galeatus</i>) was included on the preliminary list as it is afforded additional protections in Moreton Bay under the <i>Marine Parks (Moreton Bay) Zoning Plan 2008</i>. The majority of this species' distribution occurs outside of Queensland; although it 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 <i>Environment Protection and Biodiversity Conservation Act 1999</i> (EPBC Act).</p> <p>In the ECIF there is limited evidence to suggest that <i>H. galeatus</i> interacts with the tunnel net fishers and/or that regional populations are experiencing significant levels of fishing mortality. Due to these reasons <i>H. galeatus</i> was excluded from the Level 2 ERA.</p>

ECIF— Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
Batoids				
Manta Ray	<i>Mobula birostris</i> (synonym: <i>Manta birostris</i>)	37 041004	N	Not included —The likelihood of a manta ray or devilray interacting with a tunnel net is considered low. In the unlikely event that one or more of these species would interact with a tunnel net it would a) be more likely with the outside of the net vs. being caught in the tunnel of the net, b) is unlikely to result in the animal becoming enmeshed and c) is unlikely to result in the death of the animal over the short or long term. Overall, the extent and number of mobulid interactions in the Tunnel Net Fishery will not have a long-term or detrimental impact on the sustainability of regional stocks.
Reef manta Ray	<i>Mobula alfredi</i>	37 041005	N	
Kuhl's devil Ray	<i>Mobula kuhlii</i> (synonym: <i>Manta eregoodootenke</i> e)	37 041001	N	
Giant devil ray (synonym Japanese devil ray)	<i>Mobula mobular</i> (synonym: <i>M. japonica</i>)	37 041002	N	
Bentfin devil ray	<i>Mobula thurstoni</i>	37 041003	N	
Chilean devil ray	<i>Mobula tarapacana</i>	37 041006	N	Not Included —Species will not interact / unlikely to interact with this component of the ECIF.
Large-tooth sawfish (synonym: Freshwater sawfish)	<i>Pristis pristis</i>	37 025003	N	Not included —This subgroup of elasmobranchs have experienced notable population declines and their distribution has experienced a significant contraction (Last <i>et al.</i> , 2016). This includes in Queensland where there is a degree of uncertainty surrounding the extent of their distribution on the east coast (D'Anastasi <i>et al.</i> ,

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
Narrow sawfish	<i>Anoxypristis cuspidata</i>	37 025002	N	2013; Kyne <i>et al.</i> , 2013; <i>Simpfendorfer</i> , 2013). For at least three of these species <i>P. pristis</i> , <i>P. zijsron</i> and <i>P. clavata</i> their east coast distribution (if applicable) will be confined to far north Queensland where tunnel netting is not permitted. While the distribution of <i>A. cuspidata</i> extends further south, the southern extent of its range is unlikely to extend beyond central Queensland (<i>ECIF Bycatch Management Workshop, Townsville, 14-15 May 2019</i>). <i>Note</i> —The historic distribution of the green sawfish extends down to south-east Queensland and the species was caught (regionally) in commercial fishing nets. For this reason, consideration was given to including this species in the Level 2 ERA. However, evidence suggests that <i>P. zijsron</i> does not occur in areas where tunnel nets are being actively fished and it may not be regionally extirpated (<i>ECIF Bycatch Management Workshop, Townsville, 14–15 May 2019</i>). For example, the last reported record of a green sawfish being caught in Moreton Bay was back in the 1960s (Johnson, 1999; <i>Simpfendorfer</i> , 2013). In light of these consideration, the species was omitted from the Tunnel Net Level 2 ERA.
Green sawfish	<i>Pristis zijsron</i>	37 025001	N	
Dwarf sawfish	<i>Pristis clavata</i>	37 025004	N	
Bottlenose wedgefish (synonym: whitespotted guitarfish)	<i>Rhynchobatus australiae</i>	37 026005	Y*	Included —The species inhabits inshore waters down to around 60m and has a diet that consists of a wide range of bottom-dwelling fishes, crustaceans and molluscs (Last <i>et al.</i> , 2016). Given the area of operation, there is some potential for this species to interact with this sector of the ECIF. Since 2000 less than 5t of guitarfish have been retained in the Tunnel Net Fishery and no guitarfish catch has been reported/retained since 2015. Low retention rates are primarily due to current regulations that prevents a person taking or possessing more than 5 guitarfish (<i>Family Rhinidae</i>) and/or shovelnose rays (<i>Family Rhinobatidae</i>) for trade or commerce (total). Recreational fishers are limited to an in possession limit of 1. While retention rates for this species is low, there is limited information on the interaction rates and the composition of discards in the Tunnel Net Fishery. As larger bodied batoids, it is anticipated that post-release survival rates for discarded <i>R. australiae</i> will be high. However, further information is required on the extent of interactions with this species and the cohorts that are being caught. This species is not afforded additional protections under the EPBC Act; although <i>R. australiae</i> has been included in the <i>Convention on the Conservation of Migratory Species (CMS)</i> list. Further, the wedgefish

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
				<p>complex (<i>Family Rhinidae</i> inc. <i>Rhynchobatus</i> spp.) and Guitarfish (<i>Glaucostegus</i> spp.) have been listed under the <i>Convention on International Trade in Endangered Species of Wild Fauna and Flora</i> (CITES).</p> <p>Given these considerations and the potential for tunnel net operators to interact with <i>R. australiae</i>, the species was included in the Level 2 ERA. As the species has a comparatively low exploitation rate, the decision to include it in the Level 2 ERA is considered to be precautionary.</p> <p><i>Note—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.</i></p>
Eyebrow wedgefish	<i>Rhynchobatus palpebratus</i>	37 026004	N*	<p>Not Included—While the diet and morphology of the eyebrow wedgefish (<i>R. palpebratus</i>) is similar to the bottlenose wedgefish (<i>R. australiae</i>), the species has a more northern distribution (Last <i>et al.</i>, 2016). The species is not expected to interact with the Tunnel Net Fishery in significant quantities and the risk posed to this species will be lower when compared to the bottlenose wedgefish. The eyebrow wedgefish is more likely to be caught in gillnets and the risk posed to this species will be considered as part of the Large Mesh Net Level 2 ERA.</p>
Giant shovelnose ray	<i>Glaucostegus typus</i>	37 027010	Y	<p>Included—A mostly benthic species whose distribution extends along the entire Queensland coastline. The species is frequently caught in coastal waters and evidence suggests that adult specimens will move into shallow waters at night to avoid predators and target invertebrate prey (Last <i>et al.</i>, 2016). As with <i>R. australiae</i> the species will occur in areas where tunnel net fishing occurs and there is some potential for the species to be caught in this sector of the ECIF.</p> <p>The species is subject to the same management provisions as <i>R. australiae</i> and has the same limitations with respect to catch data. <i>Glaucostegus typus</i> is not afforded additional protections under the EPBC Act but has been listed in CITES. Given these considerations and the potential for tunnel net operators to interact with <i>G. typus</i>, the species was included in the Level 2 ERA. The inclusion of this species in the tunnel net PSA is</p>

ECIF—Tunnel Net Fishery (Moreton Bay & Great Sandy region)				
Common name	Species name	CAAB	Include	Considerations
				considered to be precautionary due to it having (comparatively) low exploitation rates and a higher probability of the animal surviving the fishing event.
Estuary stingray	<i>Hemirhynchus fluviorum</i>	37 035008	Y	<p>Included—The estuary stingray (<i>H. fluviorum</i>) was included on the preliminary species list due to its classification as <i>Near Threatened</i> under the Queensland <i>Nature Conservation Act 1992</i>. This classification prohibits the species retention in the <i>Moreton Bay</i> and <i>Great Sandy Marine Parks</i>; therefore are classified as a no-take species in the Tunnel Net Fishery. The species though can be retained for sale in areas of the ECIF that are not covered by the <i>Nature Conservation Act 1992</i>. As a consequence, it is not currently included in the list of <i>Species of Conservation Interest (SOI)</i></p> <p>The estuary stingray can be found in a range of environments from mangrove-fringed rivers/estuaries and in offshore waters down to at least 28m deep (Kyne <i>et al.</i>, 2016; Last <i>et al.</i>, 2016). While no records have been reported from the ECIF, there is potential for the species to interact with the Tunnel Net Fishery. The extent of <i>H. fluviorum</i> interactions in the Tunnel Net Fishery is largely unknown as batoid discards are not recorded and the species it is not subject to mandatory reporting requirements as it is not classified as a SOI. It is recognised though that the inclusion of this species in the tunnel net PSA may be precautionary.</p>

Appendix C—Residual Risk Analysis

The following provides an overview of the RRA of scores assigned to the species as part of the *Productivity & Susceptibility Analysis (PSA)*. As the study includes two distinct ecological components (Target & Byproduct Species and *Species of Conservation Concern*). The RRA for both groups were presented separately.

- *Table C1—Residual Risk Assessment for the Target & Byproduct Species*
- *Table C2—Residual Risk Analysis for the Species of Conservation Concern (SOCC).*

Table C1—Residual Risk Analysis (RRA) for the target & byproduct species included in the Level 2 ERA.

As the target & byproduct species RRA is comprehensive, species groupings (e.g. mullet, bream etc.) have been arranged in alphabetical order under broader teleost subheading. Information contained in this appendix provides a more detailed overview of the changes summarised in Table 7 of this report.

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
<u>Teleosts</u>				
<u>Bream</u>				
Yellowfin bream (<i>A. australis</i>)	<i>Management strategy (Susceptibility)</i>	3	2	<p>Yellowfin bream (<i>A. australis</i>) is managed through a MLS limit, combined in-possession limit (recreational fishing), and various other input controls (McGilvray <i>et al.</i>, 2018b). The MLS limit (25cm) is based on the size at maturity (19–21cm; Gray & Barnes, 2015) and increases the probability that a fish will spawn at least once before recruiting to the fishery. As the management regime does not include a mechanism to control catch the species was assigned a high (3) preliminary risk score for <i>management strategy</i>.</p> <p>While bream are one of the more prominent ECIF catch components, data for the complex has poor species resolution e.g. <i>Bream—unspecified</i> (Department of Agriculture and Fisheries, 2019e). A large proportion of this catch will consist of yellowfin bream; with secondary species like tarwhine (<i>R. sarba</i>) making varying contributions (<i>pers. comm.</i> T. Ham). While some bream catch is reported to species level, this occurs with less frequently and underestimates individual rates of harvest (e.g. <4t per year, 2001–2019, <i>Bream—yellowfanned</i>).</p> <p>In addition to the commercial fishing sector, yellowfin bream is a key target in the recreational fishing sector. Harvest rates in the recreational sector are comparable to that reported from the broader ECIF with recreational fishers accounting for around 46% of the total yellowfin bream catch (Leigh <i>et al.</i>, 2019). At this level, recreational fishing will make a significant contribution to the cumulative fishing pressures exerted on this species. These risks are primarily managed through in-possession limits and a MLS that is aligned with the size at sexual maturity.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>Sustainability of the yellowfin bream stock has been confirmed through a detailed stock assessment (Leigh <i>et al.</i>, 2019) and indicative sustainability evaluations (McGilvray <i>et al.</i>, 2018b). Of notable importance, these assessments considered fishing activities/harvest rates in both the commercial and recreational fishing sectors. Based on the available data, the stock assessment indicated that the yellowfin bream MSY sits at or around 420t. This compares to an annual harvest rate (commercial plus recreational) of 242t (2013–2017). Current biomass estimates place yellowfin bream stock health at around 33.8% of the unfished biomass with current harvest rates (e.g. <MSY) assisting with stock rebuilding. In terms of the <i>Queensland Sustainable Fisheries Strategy 2017–2027</i>, research suggests that the stock will need to be at 50.1% to reach the long-term objective of B_{60} (Department of Agriculture and Fisheries, 2017). The stock assessment notes that it will take (approximately) 25 years for the stock to reach B_{60} under the current rates of harvest.</p> <p>From an ERA perspective, confirmation of stock sustainability through qualitative assessments and a weight-of-evidence approach suggests that the risk posed to this species is being managed within the current fishing environment. The available data indicates that the fishery is being fished below MSY and stock health will improve under the current fishing conditions. This is being done without the use of a TACC limit and suggests that criteria used in the Level 2 ERA is less suited to this species. The notable caveat being that without a cap, catch and effort can increase and potentially exceed MSY under the current management regime.</p> <p>Key changes to the PSA scores</p> <p>While yellowfin bream are not managed under a TACC limit, a weight-of-evidence approach suggests that the over-exploitation risk is currently being managed. As a result, the risk score for the <i>management strategy</i> attribute was reduced from high (3) to medium (2). This change was done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i>, and <i>Guideline 5: effort and catch management arrangements for target and byproduct species</i>. As the fishery continues to operate without a cap on catch or effort, further reductions in the risk score were not supported. The score assigned to this attribute may need to be reviewed if or when harvest rates approach MSY limits. The need to review this score will reduce with the introduction of an ECIF-specific harvest strategy that relies more heavily on the use of management controls and output controls (Department of Agriculture and Fisheries, 2020b).</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
<p>Yellowfin bream (<i>A. australis</i>)</p> <p>Tarwhine (<i>R. sarba</i>)</p>	<p><i>Recreational desirability / other fisheries (Susceptibility)</i></p>	<p>1</p>	<p>2</p>	<p>Recreational bream catch on the east coast is dominated by yellowfin bream (<i>A. australis</i>), with tarwhine (<i>R. sarba</i>) targeted to a lesser extent. As both yellowfin bream and tarwhine have lower rates of retention (28% and 32% respectively) they were assigned low-risk ratings for the <i>recreational desirability / other fisheries</i> attribute (Department of Agriculture and Fisheries, 2021; Teixeira <i>et al.</i>, 2021).</p> <p>The popularity of bream in the recreational sector is reflected in the large catches of yellowfin bream and their sustained targeting across periods (2,589,224 caught in 2000–01; 1,006,386 caught in 2019–20). Tarwhine contributes less to the overall recreational bream harvest (24,000 fish caught in 2013–14), although legal sized fish are likely to be taken in conjunction with yellowfin bream. This is one of the reasons why the two are managed under a combined 30 fish in-possession limit (Department of Agriculture and Fisheries, 2018e). The MLS limit (23cm) for yellowfin bream is based on the size at maturity (McGilvray <i>et al.</i>, 2018b) and increases the probability that the species will spawn at least once before recruiting to the fishery.</p> <p>Though bream retention rates are comparatively low, these species are taken in larger numbers and discard mortality will be a risk for this complex (Broadhurst <i>et al.</i>, 2005). Research on recreational fishing activities recorded bream mortality rates up to 36.6%, with hook location shown to be a key predictor for survival (Broadhurst <i>et al.</i>, 2005). This risk will be of particular relevance to fish that fall below the MLS and will contribute to the total rate of fishing mortality.</p> <p>The majority of recreational data is obtained through voluntary localised collection of data (e.g. the boat ramp survey program, the Fisheries Monitoring Program) and a more expansive voluntary recreational fisher survey (Department of Agriculture and Fisheries, 2021; Teixeira <i>et al.</i>, 2021; Webley <i>et al.</i>, 2015). It can however be difficult to obtain accurate information on participation rates, regional catch trends and species assemblages for the recreational fishing sector. These limitations make it difficult to assess how recreational fishing pressures vary between and within years. From an ERA perspective, it increases a level of uncertainty that supports the adoption of a more conservative approach.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>Key changes to the PSA scores</p> <p>Based on the available information, preliminary scores assigned to the <i>recreational desirability / other fisheries</i> attribute were increased from low (1) to medium (2). The decision to increase risk scores assigned to this attribute was precautionary and takes into consideration the broader popularity of these species, and an inability to monitor catch/harvest rates effectively between and within years. While the increased score may represent a risk over-estimate, it aligns with the precautionary approach adopted for the Level 2 assessments. These changes were done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i>, and <i>Guideline 5: effort and catch management arrangements for target and byproduct species</i>.</p>
Tarwhine (<i>R. sarba</i>)	<i>Management strategy (Susceptibility)</i>	3	3	<p>Tarwhine (<i>R. sarba</i>) are primarily managed through a MLS limit and a combined in-possession limit (recreational fishing). The MLS limit (25cm) is based on the size at maturity (15–21cm; Hughes <i>et al.</i>, 2008) and increases the probability that a fish will spawn at least once before recruiting to the fishery. As the management regime does not include a mechanism to control catch or effort, tarwhine were assigned a high (3) preliminary risk score for <i>management strategy</i>.</p> <p>Information on the catch of bream species presents similar issues to whiting. At a species complex level, bream are one of the more prominent components of the ECIF. However, catch data for bream has poor species resolution and a considerable proportion is reported as <i>unspecified</i>. Catch reporting at the species level is less frequent and provides an incomplete account of individual harvest rates (e.g. <i>Bream—tarwhine</i> = <2t per year since 2000).</p> <p>While yellowfin bream has been the subject of a detailed stock assessment, tarwhine was not included in this evaluation. There is limited information on the sustainability of the stocks and/or how current harvest rates compare to key biological reference points. This makes it difficult to ascertain if the risk posed to this species is being managed effectively under the current management regime.</p> <p>Key changes to the PSA scores</p> <p>No changes were made to the PSA scores but it is recognised that a high-risk rating may be precautionary for this species. However, a score reduction could not be justified for tarwhine given the current absence of</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				output controls and information on how the take of the species compares to key sustainability reference points. These limitations are currently being addressed as part of the <i>Queensland Sustainable Fisheries Strategy 2017–2027</i> (Department of Agriculture and Fisheries, 2017). With the continued roll-out of the strategy there may be further avenues to review and (potentially) reduce this score.
<u>Flathead</u>				
Dusky flathead (<i>P. fuscus</i>)	<i>Management strategy (Susceptibility)</i>	3	2	<p>Dusky flathead (<i>P. fuscus</i>) are managed through minimum and maximum legal size (MLS) limits, in-possession limits (recreational fishing), and various other input controls (McGilvray <i>et al.</i>, 2018a). As the management regime for dusky flathead does not currently include a mechanism to control catch or effort, the species was assigned a high (3) preliminary risk score for <i>management strategy</i>.</p> <p>At a species complex level, flathead are one of the more prominent components of the ECIF catch (average 38.5t, 2010–18) (Department of Agriculture and Fisheries, 2019e; 2020a). Commercial catch data for the complex has poor resolution with all flathead reported as <i>unspecified</i>. While noting this deficiency, market demand is expected to favour larger fish with dusky flathead (<i>P. fuscus</i>) expected to dominate this catch (Leigh <i>et al.</i>, 2019). Outside of the commercial fishery, dusky flathead is viewed as a species of recreational significance and this sector makes a substantial contribution to the annual rate of fishing mortality (65% recreational, 35% commercial; Leigh <i>et al.</i>, 2019). For this reason, cumulative fishing pressures will be higher for this species.</p> <p>The sustainability of dusky flathead stocks on the Queensland east coast has been confirmed through a stock assessment (Leigh <i>et al.</i>, 2019) and indicative sustainability evaluations (McGilvray <i>et al.</i>, 2018a). These assessments considered fishing activities / harvest rates in both the commercial and recreational fishing sectors. The results of this assessment painted a more complicated picture in terms of regional sustainability with spawning biomass in the Moreton region estimated to be at 35.8% compared with an MSY of 34.6% (2017 data). This contrasts with more northern regions where spawning biomass was estimated at >60% (Leigh <i>et al.</i>, 2019). Based on the above outputs, the species is likely to achieve the long-term</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>Queensland Sustainable Fisheries Strategy 2017–2027 target of B_{60} in around eight years (Leigh <i>et al.</i>, 2019).</p> <p>From an ERA perspective, confirmation of stock sustainability through qualitative assessments and a weight-of-evidence indicates that the risk posed to this species is being managed within the current fishing environment. The available data indicates that the fishery is being fished below MSY and stocks will improve the current fishing conditions. This is being done without the use of a TACC limit and suggests that criteria used in the Level 2 ERA is less suited to this species. The notable caveat being that without a cap, catch and effort can increase and potentially exceed MSY under the current management regime. If this were to occur further review of the scores assigned to the <i>management strategy</i> would be warranted.</p> <p>Key changes to the PSA scores</p> <p>While dusky flathead are not managed under a TACC limit, a weight-of-evidence approach suggests that the over-exploitation risk is being managed on within the current fishing environment. Accordingly, the <i>management strategy</i> attribute score was reduced to medium (2). This change was done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i>, and <i>Guideline 5: effort and catch management arrangements for target and byproduct species</i>. As the fishery continues to operate without a cap on catch or effort, further reductions in the risk score were not supported. This is likely to change with the introduction of an ECIF-specific harvest strategy (Department of Agriculture and Fisheries, 2020b).</p>
Dusky flathead (<i>P. fuscus</i>)	<i>Recreational desirability / other fisheries (Susceptibility)</i>	2	2	<p>Recreational catch of flathead on the east coast is dominated by dusky flathead (<i>P. fuscus</i>) with the species tending to report large catches and lower rates of retention. Current estimates place the retention rates for this species at 33% which falls just within the medium (2) risk category for this attribute.</p> <p>Given their accessibility across environments, dusky flathead remain a top targeted teleost (Broadhurst <i>et al.</i>, 2003; Gray & Barnes, 2015). This popularity is reflected in the large catches and sustained targeting across survey periods. While recreational surveys suggest that catch has decreased slightly since 2010–11 (399,059 caught in 2010–11), harvest has remained stable over the same time-series (Webley <i>et al.</i>, 2015).</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>Key changes to the PSA scores</p> <p>No changes were made to the PSA scores but it is recognised that a medium (2) risk rating may be precautionary for this species. While catch rates for dusky flathead are larger, retention rates are at the lower limit of this risk rating. With additional information on fishing intentions and retention rates for legal-sized fished, the score assigned to this attribute could be reviewed.</p>
<p>Bartailed flathead (<i>P. australis</i>)</p> <p>Northern sand flathead (<i>P. endrachtensis</i>)</p> <p>Yellowtailed flathead (<i>P. westraliae</i>)</p>	<p><i>Management strategy (Susceptibility)</i></p>	3	3	<p>The management regime of the listed flathead is less developed and the take of these species is principally managed through MLS limits and combined in-possession limits (recreational sector, includes all flathead except dusky flathead). As their management does not include a mechanism to control catch or effort, all three species were assigned a high (3) preliminary risk score for <i>management strategy</i>.</p> <p>At a species complex level, flathead are one of the more prominent components of the ECIF catch (average 38.5t, 2010–18) (Department of Agriculture and Fisheries, 2019e). Flathead data has poor species resolution with all catch reported as <i>unspecified</i>. However, anecdotal evidence suggests that the majority of fishing effort is directed towards the dusky flathead (<i>P. fuscus</i>). While the bartailed flathead (<i>P. australis</i>), northern sand flathead (<i>P. endrachtensis</i>) and yellowtailed flathead (<i>P. westraliae</i>) will contribute to the <i>unspecified</i> catch, harvest rates for these species are likely to be lower (Department of Agriculture and Fisheries, 2019e; 2020a).</p> <p>At a whole-of-fishery level, there is limited information on the sustainability of secondary flathead stocks and/or how current harvest rates compare to key biological reference points. This makes it difficult to assess if sustainability risks posed to these species are being managed effectively under the current regime. Insight into the sustainability of these species though can be drawn from the dusky flathead stock assessment (Leigh <i>et al.</i>, 2019). This assessment indicated that the dusky flathead was being fished below MSY and that the current fishing environment was conducive to stock rebuilding.</p> <p>Given that a) dusky flathead accounts for the majority of the catch/effort and b) the <i>Platycephalidae</i> family share similar biological characteristics, it is likely that the secondary species are also being fished</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>sustainably. This inference though has yet to be fully tested and cannot be confirmed at this point in time due to an absence of information on individual rates of harvest and key sustainability reference points.</p> <p>Key changes to the PSA scores</p> <p>No changes were made to the PSA scores but it is recognised that a high (3) risk rating may be an overestimate for some of these species. A score reduction could not be justified for these species given the current absence of output controls and information on how the take of the species compares to key sustainability reference points. These limitations are currently being addressed as part of the <i>Queensland Sustainable Fisheries Strategy 2017–2027</i> (Department of Agriculture and Fisheries, 2017) and will likely result in a risk score reduction in future Level 2 ERAs involving the Tunnel Net Fishery.</p>
<p>Bartailed flathead (<i>P. australis</i>)</p> <p>Yellowtailed flathead (<i>P. westraliae</i>)</p>	<p><i>Recreational desirability / other fisheries (Susceptibility)</i></p>	<p>3</p>	<p>2</p>	<p>While the listed species were included in the <i>Statewide Recreational Fishing Survey</i>, recreational catch and harvest estimates could not be used in the Level 2 ERA due to high error margins and a low confidence in the available data (Webley <i>et al.</i>, 2015). As accurate recreational data was unavailable, bartailed flathead (<i>P. australis</i>) and yellowtailed flathead (<i>P. westraliae</i>) were assigned a precautionary high-risk score (3) for <i>recreational desirability / other fisheries</i>.</p> <p>The listed species are more likely to be caught by fishers targeting dusky flathead (<i>P. fuscus</i>). The dusky flathead arguably has more appeal in this sector and a large proportion of the recreational effort will be targeted at this species. As noted, recreational data for these secondary species is of low quality and morphological similarities may see some species (e.g. bartailed and yellowtail) included in the dusky flathead data. However, recreational catch and harvest of all flathead species has decreased over time and this trend is expected to extend to the lesser targeted species. For these reasons, a high-risk (3) score for the <i>recreational desirability / other fisheries</i> attribute was considered to be an overestimate for these species.</p> <p>Key changes to the PSA scores</p> <p>The default high (3) risk scores assigned to <i>recreational desirability / other fisheries</i> for bartailed and yellowtailed flathead was reduced to medium (2). While data is limited for these species, a weight-of-evidence approach suggests that the recreational desirability score should be equal to or lower than dusky</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				flathead. Due to the precautionary nature of the assessment, a medium (2) risk rating was applied to these species. With additional information, this risk score could be reduced further. These changes were done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i> .
Northern sand flathead (<i>P. endrachtensis</i>)	<i>Recreational desirability / other fisheries (Susceptibility)</i>	2	2	<p>Northern sand flathead (<i>P. endrachtensis</i>) are not heavily targeted in the recreational sector and the species is caught and harvested in low quantities. As the species registered a retention rate of 35% (Webley <i>et al.</i>, 2015) it was assigned a medium (2) preliminary risk score for the <i>recreational desirability / other fisheries</i> attribute.</p> <p>Recreational catch and harvest of the species have decreased over time (30,192 harvested 2010–11, 19,000 harvested 2013–14) (Taylor <i>et al.</i>, 2012; Webley <i>et al.</i>, 2015) with retention rates remaining proportionally stable across survey periods (40% 2010–11, 35% 2013–14). This data suggests that cumulative fishing pressures exerted on the northern sand flathead are lower than that observed in other species. The extent of this risk differential though is difficult to quantify given uncertainty in the data and catch compositions.</p> <p>Key changes to the PSA scores</p> <p>While no change was made to the PSA score, additional information on recreational catch compositions and fisher intentions may facilitate a score reduction in future ERAs.</p>
Bartailed flathead (<i>P. australis</i>) Northern sand flathead (<i>P. endrachtensis</i>) Yellowtailed flathead (<i>P. westraliae</i>)	<i>Age at maturity (Productivity)</i>	3	1	<p>In the PSA, the three secondary flathead species were all assigned a precautionary high-risk score (3) for the <i>age at maturity</i> attribute due to data deficiencies. While data deficiencies make it difficult to assess the consistency of <i>age at maturity</i> across flathead species, a high-risk rating is considered an overestimate for this attribute. Accordingly, the <i>age at maturity</i> for the dusky flathead was used as a proxy for the bartailed (<i>P. australis</i>), northern sand (<i>P. endrachtensis</i>) and yellowtailed (<i>P. westraliae</i>) flathead.</p> <p>Key changes to the PSA scores</p> <p>Default high (3) risk score was reduced to low (1) and now align with the dusky flathead. These changes were made in accordance with <i>Guideline 2: additional scientific assessment & consultation</i>.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Bartailed Flathead (<i>P. australis</i>) Northern sand flathead (<i>P. endrachtensis</i>) Yellowtailed flathead (<i>P. westraliae</i>)	<i>Maximum age</i> <i>(Productivity)</i>	3	2	<p>The situation surrounding the <i>maximum age</i> attribute shared similarities with the <i>age at maturity</i>. For this attribute, all three species were assigned a precautionary high-risk score (3) due to data deficiencies. In the RRA, the use of proxies allowed this score to be reduced. These revised scores are considered to be more representative of their biological constraints.</p> <p>Key changes to the PSA scores</p> <p>Default high (3) risk scores assigned to <i>maximum age</i> was reduced to medium (2). This score is now consistent with what was assigned to the dusky flathead. These changes were made in accordance with <i>Guideline 1: risk rating due to missing, incorrect or out of date information.</i></p>
Bartailed flathead (<i>P. australis</i>) Northern sand flathead (<i>P. endrachtensis</i>)	<i>Size at maturity</i> <i>(Productivity)</i>	3	2	<p>Size at maturity data were not available for two of the secondary flathead species: the bartailed flathead (<i>P. australis</i>) and the northern sand flathead (<i>P. endrachtensis</i>). Based on their <i>maximum size</i> (50cm and 46cm, respectively) it is likely that the <i>size at maturity</i> for both species falls within the low-risk category (<40cm). In-keeping with the precautionary nature of ERAs, data for dusky flathead (<i>P. fuscus</i>) was used as a proxy for these species.</p> <p>Key changes to the PSA scores</p> <p>Default high (3) risk scores assigned to the <i>size at maturity</i> attribute was reduced to medium (2). Given their maximum size, a medium rating may still represent a risk overestimation for this species. The decision to adopt a more precautionary score though was considered to be appropriate and in-line with the broader approach adopted as part of the Level 2 ERA. These changes were made in accordance with <i>Guideline 1: risk rating due to missing, incorrect or out of date.</i></p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
<u>Garfish</u>				
Snubnose garfish (<i>A. sclerolepis</i>) Three-by-two garfish (<i>H. robustus</i>)	<i>Management strategy (Susceptibility)</i>	3	1	<p>The garfish complex is not managed under a quota or a minimum legal size limit and it has a recreational in-possession limit of 50 fish. Due to these factors, the snubnose (<i>A. sclerolepis</i>) and three-by-two (<i>H. robustus</i>) garfish were assigned a high (3) preliminary risk score for <i>management strategy</i>.</p> <p>At a species complex level, garfish are one of the more prominent components of the ECIF catch (Department of Agriculture and Fisheries, 2019e). However, data for garfish has poor species resolution with all catch since 2010 classified as <i>unspecified</i>. It is anticipated that snubnose garfish and three-by-two garfish make up a considerable portion of the unspecified catch.</p> <p>While these species are not managed under a TACC limit, there are fewer concerns surrounding the sustainability of these species on the Queensland east coast. Research suggests that <i>Hemiramphidae</i> are fast-growing, serial spawners that are more resilient to regional fishing pressures (Department of Agriculture and Fisheries, 2018f). These factors suggest garfish are a) less-susceptible to over-exploitation and b) are being managed effectively under a broader management framework.</p> <p>Key changes to the PSA scores</p> <p>Available data suggests that the management regime for these species, while less developed, is well-suited to their biology and commensurate with the over-exploitation risk. Accordingly, the risk score for <i>management strategy</i> was reduced to a low (1). The above changes were done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i>, and <i>Guideline 5: effort and catch management arrangements for target and byproduct species</i>.</p>
Snubnose garfish (<i>A. sclerolepis</i>) Three-by-two garfish (<i>H. robustus</i>)	<i>Recreational desirability / other fisheries (Susceptibility)</i>	3	3	<p>While garfish were included in the <i>Statewide Recreational Fishing Survey</i>, they were assessed as part of a broader species grouping (Webley <i>et al.</i>, 2015). This grouping recorded a 90% retention rate and they were assigned a high (3) risk rating for the <i>recreational desirability / other fisheries</i> attribute. The popularity of garfish in the recreational sector is reflected in the moderate to large catches and increased targeting across periods. Recreational catch of <i>Garfish—unspecified</i> has increased across the last two survey periods (65,492</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>caught in 2010–11, 104,000 caught in 2013–14; Taylor <i>et al.</i>, 2012; Webley <i>et al.</i>, 2015). This data though has poor species resolution and could not be assigned to a particular species.</p> <p>Key changes to the PSA scores</p> <p>No changes were made to the PSA scores but it is recognised that a high (3) risk rating may be precautionary given their ability to sustain increased fishing mortality. With improved information on catch compositions and fisher intentions, the risk rating for one or both species could be reduced. At present, a risk score reduction could not be justified for these species given the broader popularity of these species, increased recreational interest across periods, and an inability to monitor species-specific catch/harvest rates effectively between and within years.</p>
Three-by-two Garfish (<i>H. robustus</i>)	<p><i>Age at maturity</i> (Productivity)</p> <p><i>Maximum age</i> (Productivity)</p> <p><i>Size at maturity</i> (Productivity)</p>	3	1	<p>There is limited information on the secondary species like the three-by-two garfish (<i>H. robustus</i>). This was reflected in the PSA where a number of the attributes were assigned precautionary high-risk scores (3). While some inter-specific variability will exist, it is unlikely that the <i>age at maturity</i>, <i>maximum age</i> and <i>size at maturity</i> for the three-by-two garfish falls within the medium (2) or high (3) risk categories. To this extent, preliminary scores assigned to these three productivity attributes are considered to be an overestimate.</p> <p>Key changes to the PSA scores</p> <p>Default high (3) risk scores assigned to the <i>age at maturity</i>, <i>maximum age</i> and <i>size at maturity</i> attributes were reduced to low (1). While this represents a notable score reduction, it is unlikely that these amendments will lead to a false-negative result. These changes were made in accordance with <i>Guideline 1: risk rating due to missing, incorrect or out of date information</i> and <i>Guideline 2: additional scientific assessment & consultation</i>.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
<u>Mullet</u>				
Sea mullet (<i>M. cephalus</i>)	<i>Management strategy (Susceptibility)</i>	3	1	<p>Sea mullet (<i>M. cephalus</i>) are managed through a MLS limit, in-possession limits (recreational fishing), limited licencing and various other input controls (Stewart <i>et al.</i>, 2018). The MLS limit (30cm) is based on the size at maturity (25–45cm; Smith & Deguara, 2002) and increases the probability that a fish will spawn at least once before recruiting to the fishery. As the management regime for sea mullet does not include a mechanism to control catch or effort it was assigned a high (3) preliminary risk score for <i>management strategy</i>.</p> <p>East coast mullet stocks are targeted by commercial fisheries in Queensland and New South Wales, however state-wise comparisons highlight significant differences in commercial catch and effort between the two jurisdictions (65% and 35%, respectively) (Stewart <i>et al.</i>, 2018). On the Queensland east coast, the majority of the sea mullet catch is reported from the Ocean Beach Fishery. This sector of the ECIF utilises a beach seine to target schools of mullet and it will be the key driver of risk for this species. When compared, mullet are retained in smaller quantities in the Tunnel Net Fishery. Similarly, recreational fishers retain smaller quantities of mullet for bait that is caught using small mesh nets / cast nets (Lovett <i>et al.</i>, 2018).</p> <p>The sustainability of the entire east coast stock has been confirmed through stock assessments (Lovett <i>et al.</i>, 2018) and indicative sustainability evaluations (Stewart <i>et al.</i>, 2018). The species has a long catch history in Queensland and reductions in nominal effort coupled with favourable biomass estimates (50%, 2016) has the fishery meeting key targets under the <i>Queensland Sustainable Fisheries Strategy 2017–2027</i> (Lovett <i>et al.</i>, 2018; Stewart <i>et al.</i>, 2018). While further reductions in catch and effort may be required to achieve the long-term objective of 60% biomass, this target aligns more closely with Maximum Economic Yield (MEY).</p> <p>Key changes to the PSA scores</p> <p>While sea mullet are not managed under a TACC limit, a weight-of-evidence approach suggests that the over-exploitation risk is being managed on the Queensland east coast. As a result, the risk score for the <i>management strategy</i> attribute was reduced to a low (1). This change was done in accordance with <i>Guideline</i></p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>2: additional scientific assessment & consultation, and Guideline 5: effort and catch management arrangements for target and byproduct species.</p> <p>Note—Under the proposed harvest strategy, the ECIF will be subject to regional management and greater use of output controls. As a Tier 2 species, the management of regional sea mullet stocks will likely move to output controls e.g. a TACC limit.</p>
<p>Fantail mullet (<i>P. georgii</i>)</p> <p>Diamondscale mullet (<i>L. vaigiensis</i>)</p>	<p>Management strategy (Susceptibility)</p>	3	1	<p>The majority of fishing effort for <i>Mugilidae</i> is directed at sea mullet with the fantail (<i>P. georgii</i>) and diamondscale (<i>L. vaigiensis</i>) mullet making smaller contributions to the total mullet catch. Catch of these secondary species is largely listed as part of the <i>Mullet—unspecified</i> catch category. As with sea mullet (<i>M. cephalus</i>), these species are not subject to commercial catch or effort limits and they were assigned a high (3) preliminary risk score for <i>management strategy</i>.</p> <p>Given their morphological and biological similarities, sea mullet is considered a good indicator species for this complex. Sea mullet attracts the majority of the catch/effort and stock sustainability has been confirmed through a variety of mechanisms (Lovett <i>et al.</i>, 2018; Stewart <i>et al.</i>, 2018). As secondary mullet species make a lower contribution to the total catch it is likely that regional stocks will display the same resilience to fishing pressures.</p> <p>Key changes to the PSA scores</p> <p>Following consultation with Fisheries Management, preliminary risk scores for the <i>management strategy</i> attribute were reduced to low (1) for all secondary mullet species. This change was done in accordance with <i>Guideline 2: additional scientific assessment & consultation, Guideline 5: effort and catch management arrangements for target and byproduct species, and Guideline 7: management arrangements relating to seasonal spatial and depth closures.</i></p>
<p>Sea mullet (<i>M. cephalus</i>)</p>	<p>Recreational desirability /</p>	3	2	<p>While the listed species were included in the <i>Statewide Recreational Fishing Survey 2013–14</i>, all mullet species were assessed as a species grouping (57% retention, moderate confidence)(Webley <i>et al.</i>, 2015). This absence of species specific data resulted in all four species being assigned a high-risk score (3) for the</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Fantail mullet (<i>P. georgii</i>) Diamondscale mullet (<i>L. vaigiensis</i>)	<i>other fisheries (Susceptibility)</i>			<p><i>recreational desirability / other fisheries</i> attribute. Further investigation of recreational surveys and charter fishery data indicated that the listed species were less likely to be at risk from cumulative fishing pressures. The adjusted scores were based on a combination of the following factors:</p> <ul style="list-style-type: none"> • MLS limits that are aligned reasonably well with the biology of these species; • The most recent recreational survey data indicates that the species or species complex are caught and retained in fewer numbers; • Charter data for the most recent three calendar years indicated that the species or species complex are retained in lesser amounts; • Consultation with Fisheries Monitoring scientists indicates that secondary mullet species are caught and retained in fewer numbers; and • These species are more inclined to be caught and used as bait. <p>Key changes to the PSA scores</p> <p>Default high (3) risk scores assigned to the <i>recreational desirability / other fisheries</i> attribute for the listed species were reduced to medium (2). The revised score is based on the recreational fishing data which shows retention rates for the complex sit at around 57% (Webley <i>et al.</i>, 2015). It is recognised that this score may still represent an overestimate for some species and that individual retention rates are likely to be <33%. This however is difficult to confirm without additional information on recreational catch compositions. These changes were done in accordance with <i>Guideline 1: risk rating due to missing, incorrect or out of date information</i> and <i>Guideline 2: additional scientific assessment & consultation</i>.</p>
Fantail mullet (<i>P. georgii</i>) Diamondscale mullet (<i>L. vaigiensis</i>)	<i>Sustainability assessments (Susceptibility)</i>	3	1	<p>As noted, the majority of effort is targeted at sea mullet (<i>M. cephalus</i>). Sea mullet has been the subject of numerous stock assessments and indicative sustainability evaluations (Department of Primary Industries, Undated; Lovett <i>et al.</i>, 2018; Stewart <i>et al.</i>, 2018; Virgona <i>et al.</i>, 1998). These studies have shown that sea mullet has been sustainably fished over an extended period of time. In the RRA, some consideration was given to the suitability and applicability of the <i>sustainability assessment</i> scores assigned to the fantail mullet</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>(<i>P. georgii</i>) and the diamonds scale mullet (<i>L. vaigiensis</i>). The premise being that if sea mullet is being fished sustainably then there is a high probability that the two remaining species are also being fished sustainably.</p> <p>The challenge with the secondary mullet species is that they are unlikely to be caught in quantities that make them stock assessment priorities and/or in need of an indicative sustainability evaluation. This situation is unlikely to change in the short-to-medium term unless there is a shift in species compositions and a reduction in the dominance of sea mullet. While the sustainability of secondary mullet stocks is difficult to quantify, productivity scores for this complex suggest that they can withstand higher rates of fishing mortality. To this extent, they are likely to display a similar resilience to regional fishing pressures.</p> <p>Key changes to the PSA scores</p> <p>Default high (3) risk scores assigned to the <i>sustainability assessment</i> attribute were reduced to low (1) based on recommendations made during expert consultation and the current understanding of sea mullet resilience. These changes were done in accordance with <i>Guideline 1: risk rating due to missing, incorrect or out of date information</i> and <i>Guideline 2: additional scientific assessment & consultation</i>. While the decision to reduce this attribute score was qualitative in nature, it is not expected to result in a false-negative result.</p>
Sea mullet (<i>M. cephalus</i>)	<i>Maximum size (Productivity)</i>	2	1	<p>Reports on the <i>maximum size</i> for sea mullet (<i>M. cephalus</i>) varied, with some estimating it to be as high as 120cm (Froese & Pauly, 2019). In the PSA, the highest reported estimate was used as the basis of the <i>maximum size</i> attribute assessment. In the RRA, further consideration was given to the suitability of this score and its relevance to the fishery on the Queensland east coast. As part of this process, consideration was given to <i>maximum size</i> estimates reported across the two jurisdictions that harvest sea mullet: NSW = approx. 75cm total length; QLD = 91cm total length (Department of Primary Industries, Undated; Queensland Government, 2018). These estimates align more closely with what is known about the east coast sea mullet stocks (Lovett <i>et al.</i>, 2018; Smith & Deguara, 2002; Stewart <i>et al.</i>, 2018).</p> <p>Key changes to the PSA scores</p> <p>The score assigned to the <i>maximum size</i> attribute was reduced from medium (2) to low (1). This score better reflects what is known about the stocks on the Queensland east coast and it was viewed as a more</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				appropriate estimate for this attribute. Changes were done in accordance with <i>Guideline 1: rating due to missing, incorrect or out of date information</i> and <i>Guideline 2: additional scientific assessment & consultation</i> .
Fantail mullet (<i>P. georgii</i>) Diamondscale mullet (<i>L. vaigiensis</i>)	<i>Age at maturity (Productivity)</i>	3	1	<p>A number of the mullet species included in the Level 2 ERA are secondary targets and, when compared to sea mullet (<i>M. cephalus</i>), are harvested in smaller quantities. The dominance of sea mullet in the catch is reflected in the amount of information that is available for this species. Conversely, biological information on the remaining species is more limited. Due to these data deficiencies, two of the mullet species were assigned a precautionary high-risk score (3) for <i>age at maturity</i>. As age of maturity is not expected to vary significantly between mullet species, preliminary scores assigned to this attribute were viewed as a risk overestimate.</p> <p>Key changes to the PSA scores</p> <p>Age at maturity estimates for sea mullet were used as a proxy for the fantail mullet (<i>P. georgii</i>) and the diamondscale mullet (<i>L. vaigiensis</i>). Based on the best available information, sea mullet attains sexual maturity in 2–4 years (Lovett <i>et al.</i>, 2018; Smith & Deguara, 2002). When this information was incorporated into the risk profiles of both species, scores assigned to this attribute were lowered from high (3) to low (1). These changes were largely done in accordance with <i>Guideline 1: rating due to missing, incorrect or out of date information</i> and <i>Guideline 2: additional scientific assessment & consultation</i>.</p>
Fantail mullet (<i>P. georgii</i>) Diamondscale mullet (<i>L. vaigiensis</i>)	<i>Maximum age (Productivity)</i>	3	2	<p>The situation surrounding <i>maximum age</i> is similar to <i>age at maturity</i> in that the fantail (<i>P. georgii</i>) and diamondscale (<i>L. vaigiensis</i>) mullet were assigned a precautionary high-risk score (3) due to data deficiencies. Anecdotal evidence suggests that the biology of these species will not differ markedly from the sea mullet (<i>M. cephalus</i>) and that maximum age will be lower than 25 years. Accordingly, the maximum age reported for sea mullet (16 years) was used as a proxy for these two species.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>Key changes to the PSA scores</p> <p>With sea mullet used as a proxy for <i>maximum age</i>, scores assigned to this attribute were reduced from high (3) to medium (2). These changes were largely done in accordance with <i>Guideline 1: rating due to missing, incorrect or out of date information</i> and <i>Guideline 2: additional scientific assessment & consultation</i>.</p>
<p>Fantail mullet (<i>P. georgii</i>)</p> <p>Diamondscale mullet (<i>L. vaigiensis</i>)</p>	<p><i>Size at maturity (Productivity)</i></p>	3	2	<p>The fantail (<i>P. georgii</i>) and diamondscale (<i>L. vaigiensis</i>) received a precautionary high-risk score (3) for <i>size at maturity</i> in the PSA due to data deficiencies. In the RRA, this attribute was reassessed using data on the size at sexual maturity for sea mullet (<i>M. cephalus</i>).</p> <p>Key changes to the PSA scores</p> <p>Scores assigned to the <i>size at maturity</i> attribute were reduced from high (3) to medium (2). These changes were largely done in accordance with <i>Guideline 1: rating due to missing, incorrect or out of date information</i>. In this instance, sea mullet was used as the proxy.</p>
<u>Rabbitfish</u>				
<p>Scribbled rabbitfish (<i>S. spinus</i>)</p>	<p><i>Management strategy (Susceptibility)</i></p>	3	3	<p>The commercial take of scribbled rabbitfish (<i>S. spinus</i>) is managed at a whole-of-fishery level (e.g. spatial closures, mesh size restrictions etc.) with the recreational take principally managed through a general in-possession limit ($n = 20$) (<i>Fisheries Declaration 2019</i>). The management regime for this species does not include a minimum legal size limit or a mechanism to control catch and effort. This was reflected in the preliminary score assigned to the <i>management strategy</i> attribute.</p> <p>Scribbled rabbitfish are considered to be a byproduct species with operators reporting low but fluctuating catches across the entire ECIF (Department of Agriculture and Fisheries, 2019e; 2020a). The species was retained in higher quantities in the pre-2000 period where the average annual catch was closer to 60t. While difficult to quantify, this trend is likely to be the result of management and reporting changes <i>versus</i> declining catch. As the Tunnel Net Fishery retains a comparatively high proportion of scribbled rabbitfish, this sector would be responsible for a notable portion of the pre-2000 catch.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>Current catch rates make the scribbled rabbitfish a low priority in terms of their transition to output controls and the development of a detailed stock assessments. A weight-of-evidence approach suggests that, at current harvest rates, the risk posed to this species is being managed. It is important to note though that there is limited information on how current harvest rates compare to key biological reference points and this inference has yet to be fully tested.</p> <p>Key changes to the PSA scores</p> <p>No changes were made to the PSA scores but it is recognised that a high-risk rating may be too precautionary for this species. With further information on catch compositions, harvest rates and discards, the score assigned to this attribute could be reduced in future ERAs. This process would also benefit from additional information on the status of regional stocks. Given the low priority of the species, an indicative sustainability evaluation should be prioritised over a quantitative stock assessment.</p>
Scribbled rabbitfish (<i>S. spinus</i>)	Recreational desirability / other fisheries (Susceptibility)	3	1	<p>While scribbled rabbitfish were included in the <i>Statewide Recreational Fishing Survey</i> (<i>S. spinus</i>), they were done so as part of a broader <i>Siganus</i> complex (Webley <i>et al.</i>, 2015). As no species-specific data were available, it was assigned a precautionary high-risk score (3) for the <i>recreational desirability / other fisheries</i> attribute. There is currently limited information on the recreational catch of scribbled rabbitfish, however, the available data suggests very low catches and negligible harvests (Taylor <i>et al.</i>, 2012; Webley <i>et al.</i>, 2015). This may be partly due to the fact that the spines of the scribbled rabbitfish are poisonous. Catch and retention rates for the <i>Siganus</i> complex suggest that the PSA overestimates the cumulative risk posed to this species.</p> <p>Key changes to the PSA scores</p> <p>The preliminary score assigned to the <i>recreational desirability / other fisheries</i> attribute was considered an over-estimate and was reduced to low (1). This decision was based on the species having low catches and low retention rates. This change was done in accordance with <i>Guideline 2: additional scientific assessment &</i></p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<i>consultation</i> . While the decision to reduce the <i>recreational desirability / other fisheries</i> score was qualitative, it is unlikely to result in a false-negative result.
Scribbled rabbitfish (<i>S. spinus</i>)	Maximum age (Productivity)	3	1	<p>While there is limited information on the age and growth of the scribbled rabbitfish (<i>S. spinus</i>), the biology of this species is expected to be similar to other species in the genus. Research on the forktail rabbitfish (<i>S. argenteus</i>) suggests that these species are relatively fast growing and have a maximum age of less than 10 years (Shakman <i>et al.</i>, 2008; Taylor <i>et al.</i>, 2016). Based on this data, a precautionary high-risk score (3) was considered an overestimate.</p> <p>Key changes to the PSA scores</p> <p>Default high (3) risk scores assigned to the <i>maximum age</i> attribute was reduced to a low (1). This reduction considered maximum age estimates for other species in the genus and the likelihood that the scribbled rabbitfish would differ significantly with what is already known about their age and growth. These changes were made in accordance with <i>Guideline 1: risk rating due to missing, incorrect or out of date information</i>.</p>
Scribbled rabbitfish (<i>S. spinus</i>)	Size at maturity (Productivity)	3	1	<p>As with the <i>age at maturity</i> attribute, <i>size at maturity</i> received a preliminary high (3) risk rating due to data deficiencies. However, the maximum size for this species is estimated to be less than 40cm. This by extension indicates that a high rating overestimates the risk associated with this attribute.</p> <p>Key changes to the PSA scores</p> <p>The default high (3) risk score assigned to <i>size at maturity</i> was reduced to low (1). This was based on the understanding that the maximum size for this species is comparatively small; meaning there is a high probability that the size at sexual maturity is less than 40cm. This change was made in accordance with <i>Guideline 2: additional scientific assessment & consultation</i>.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
<u>Trevally</u>				
Giant trevally (<i>C. ignobilis</i>) Golden trevally (<i>G. speciosus</i>)	<i>Management strategy (Susceptibility)</i>	3	3	<p>The trevally complex is not managed under minimum or maximum legal size limits and the recreational catch is principally managed through a combined <i>Carangidae</i> 20 fish limit (Fisheries Declaration 2019). As management of these species does not include a mechanism to control catch or effort; they were all assigned a high (3) preliminary risk score for <i>management strategy</i>.</p> <p>Trevally are often retained as byproduct and reported at a higher taxonomic level <i>e.g. Trevally—unspecified</i>. Likely reasons for this include a high probability of various species being caught in a single fishing event and the difficulty in differentiating between individual species in an active fishing environment. While some trevally have species-specific data, this information does not provide a true indication of their total catch <i>e.g. 1–6t</i> per year since 2000.</p> <p>The multi-species nature of the trevally catch combined with identification issues has inhibited management's ability to conduct stock assessments and/or compile indicative sustainability evaluations (Department of Agriculture and Fisheries, 2018f). As a consequence, there is limited information on the sustainability of trevally stocks and/or how current harvest rates compare to key biological reference points. This makes it difficult to evaluate the suitability, applicability and effectiveness of the current management regime.</p> <p>Key changes to the PSA scores</p> <p>No changes were made to the PSA scores but it is recognised that a high-risk rating may be precautionary for some or all of these species. Score reductions could not be justified given the current absence of output controls, monitoring and assessment information, and information on how the take of the species compares to key sustainability reference points. With the continued roll-out of the <i>Queensland Sustainable Fisheries Strategy 2017–2027</i> (Department of Agriculture and Fisheries, 2017) there may be further avenues to review and (potentially) reduce this score for one or more of the species assessed.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Golden trevally (<i>G. speciosus</i>)	<i>Recreational desirability / other fisheries (Susceptibility)</i>	1	2	<p>Recreational data for golden trevally (<i>G. speciosus</i>) estimates that around 32% of the catch from this sector is retained (Department of Agriculture and Fisheries, 2018f; Webley <i>et al.</i>, 2015). As this percentage is below the medium-risk threshold, giant trevally were assigned a low (1) risk rating for <i>recreational desirability / other fisheries</i>.</p> <p>The recreational catch of golden trevally decreased markedly across survey periods from 117,000 (2000–01) to 72,947 (2010–11) and 28,000 (2013–14). This decline was reflected in the retention rates which reduced from 50% in 2010–11 to 32% in 2013–14. Research on post-capture mortality of trevally have found varied results, with some trevally species experiencing a high discard mortality and a delayed mortality of up to four days (Broadhurst <i>et al.</i>, 2005). From an ERA perspective, there is an increased risk that a portion of the discarded golden trevally will die as a result of their interaction. This by extension suggests that total fishing mortality (retained plus post-release) in the recreational fishing sector is higher than what is estimated.</p> <p>Key changes to the PSA scores</p> <p>While retention rates for golden trevally were less than 33%, the decision was made to increase the score from low (1) to medium (2). This increase recognises a) that retention rates were on the border of the low and medium-risk category and b) the rate of fishing mortality for this sector will be higher due to post release mortalities. The decision to increase this score is considered precautionary and could be reversed with improved information on recreational catch compositions, effort and discard fates. This changes were done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i> with consideration given to <i>Guideline 1: rating due to missing, incorrect or out of date information</i> with consideration given to <i>Guideline 1: rating due to missing, incorrect or out of date information</i>.</p>
<u>Whiting</u>				
Sand whiting (<i>S. ciliata</i>)	<i>Management strategy (Susceptibility)</i>	3	2	<p>Sand whiting (<i>S. ciliata</i>) is managed through a MLS limit, combined in-possession limits (recreational fishing), and various other input controls (McGilvray <i>et al.</i>, 2018a). The MLS limit (23cm) is based on size at sexual maturity (17–24cm; McGilvray <i>et al.</i>, 2018a) and increases the probability that fish will spawn at least once</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>before recruiting to the fishery. As the management regime for sand whiting does not include a mechanism to control catch or effort it was assigned a high (3) preliminary risk score for <i>management strategy</i>.</p> <p>While the majority of the sand whiting catch is reported from the commercial fishery, the recreational fishing sector makes a notable contribution to annual harvest rates. At a complex level, whiting are one of the more prominent components of the ECIF catch. Data for this complex has poor resolution and almost all of the catch is reported as <i>unspecified</i>. While some of the sand whiting catch is reported to species level, this occurs with less frequency and provides an inaccurate account of the total harvest e.g. <23t per year from 2000–2005 (Department of Agriculture and Fisheries, 2019e; 2020a).</p> <p>The sustainability of the sand whiting stocks on the Queensland east coast has been confirmed through a detailed stock assessment (Leigh <i>et al.</i>, 2019) and indicative sustainability evaluations (McGilvray <i>et al.</i>, 2018a). These assessments considered fishing activities/harvest rates in both the commercial and recreational fishing sectors. The outputs of the stock assessment indicate that the equilibrium MSY for the sand whiting stock sits at or around 452t which compares to annual harvest rates (commercial plus recreational) of 272t (Leigh <i>et al.</i>, 2019). Based on these outputs, the species is likely to achieve the long-term <i>Queensland Sustainable Fisheries Strategy 2017–2027</i> target of B_{60} in around 7 years (Department of Agriculture and Fisheries, 2017).</p> <p>From an ERA perspective, the above is significant as it shows a) that current harvest levels (if maintained) will facilitate stock rebuilding and b) the risk posed to this species are being managed effectively within the current fishing environment. The notable caveat being that that without an effective cap, catch and effort levels can still increase under the current management regime.</p> <p>Key changes to the PSA scores</p> <p>While sand whiting are not managed under a TACC limit, a weight-of-evidence approach suggests that the over-exploitation risk is being managed within the current fishing environment. Therefore, the risk score for the <i>management strategy</i> attribute was reduced to medium (2). A further reduction in the risk score could not be justified due to the current absence of output controls and the potential for catch and effort to increase</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				under the current management regime. These limitations are currently being addressed as part of the <i>Queensland Sustainable Fisheries Strategy 2017–2027</i> and the harvest strategy development process (Department of Agriculture and Fisheries, 2017; 2020b). This change was done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i> , and <i>Guideline 5: effort and catch management arrangements for target and byproduct species</i> .
Trumpeter whiting (<i>S. maculata</i>)	<i>Management strategy (Susceptibility)</i>	3	2	<p>The management regime for the trumpeter whiting (<i>S. maculata</i>) is less developed and reflects its status as a secondary target species. In the PSA, the use of less-stringent management controls resulted in the species receiving a high-risk (3) rating for the <i>management strategy</i> attribute. In the RRA, further consideration was given to the suitability of this score, how it relates to commercial fishing pressures exerted on key stocks and current sustainability concerns.</p> <p>When compared to sand whiting (<i>S. ciliata</i>), the commercial pressures exerted on trumpeter whiting are expected to be smaller. Anecdotal evidence also suggests that this species will be retained more readily in the recreational fishing sector (<i>pers. comm.</i> T. Ham). For this reason, this species is unlikely to experience the same levels of fishing pressure. This suggests that there is less need to implement a highly prescriptive set of management arrangements.</p> <p>Key changes to the PSA scores</p> <p>While the management regime for trumpeter whiting is less developed, a weight-of-evidence approach suggests that the management regime is commensurate with the current over-exploitation risk. Given this, the risk score for the <i>management strategy</i> attribute was reduced to a medium (2). A further reduction in the risk score could not be justified due to the current absence of output controls and the potential for catch and effort to increase under the current management regime. These limitations are currently being addressed as part of the <i>Queensland Sustainable Fisheries Strategy 2017–2027</i> (Department of Agriculture and Fisheries, 2017). This change was done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i>, and <i>Guideline 5: effort and catch management arrangements for target and byproduct species</i>.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Sand whiting (<i>S. ciliata</i>)	<i>Recreational desirability / other fisheries (Susceptibility)</i>	3	2	<p>While sand whiting were included in the <i>Statewide Recreational Fishing Survey</i>, they were assessed as part of a broader species grouping and they were assigned a precautionary high-risk score (3) for the <i>recreational desirability / other fisheries</i> attribute.</p> <p>The popularity of whiting in the recreational sector is reflected in large catches and the sustained high retention rates. The last two surveys though suggest that catch has decreased markedly across the last two periods (1,090,121 caught in 2013–14, 766,822 caught in 2019–20) (<i>pers. comm.</i> J. Webley; Webley <i>et al.</i>, 2015). While species-specific data is not available, retention rates for the broader complex sit at around 49%. If assessed on these values, the <i>recreational desirability / other fisheries</i> attribute for sand whiting would be assigned a medium (2) risk score.</p> <p>The MLS limit for sand whiting (23cm) is based on the size at sexual maturity (17–24cm; McGilvray <i>et al.</i>, 2018a) and increases the probability that fish will spawn at least once before recruiting to the fishery. It is however recognised that a proportion of whiting (including undersized fish) will be discarded in a dead or moribund state and that cryptic mortalities will contribute to the total rates of fishing mortality. Current knowledge on discard mortality of sand whiting is limited to southern New South Wales and suggests that discard mortalities originating from the recreational fishing sector are relatively low (Butcher <i>et al.</i>, 2006; Kendall & Gray, 2009) .</p> <p>Key changes to the PSA scores</p> <p>The default high (3) risk scores assigned to <i>recreational desirability / other fisheries</i> was considered an overestimate and reduced to medium (2). The principal drivers behind this reduction include marked reductions in catch and effort over time, moderate retention rates at the species complex level, and research suggesting low discard mortality. Further reductions in risk scores could not be justified given the sustained recreational interest in the species over time, and the absence of species-specific catch and harvest estimates. These changes were done in accordance with <i>Guideline 1: risk rating due to missing, incorrect or out of data information</i> and <i>Guideline 2: additional scientific assessment & consultation</i>.</p>

Table C2—Residual Risk Analysis (RRA) for the Species of Conservation Concern (SOCC) included in the Tunnel Net Fishery Level 2 ERA

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
<p><u>Marine turtles</u> Loggerhead turtle (<i>C. caretta</i>)</p>	<p><i>Fecundity</i> (<i>Productivity</i>)</p>	3	2	<p>The precautionary nature of the PSA meant that preliminary scores for the <i>fecundity</i> 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 to be an unrealistic account of the species fecundity. To address this discrepancy, 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.</p> <p>Key changes to the PSA scores</p> <p>As a result of the above amendments, the score assigned to <i>fecundity</i> for the loggerhead turtle (<i>C. caretta</i>) was reduced from a high (3) to medium (2). This was done in consultation with members from the scientific community (<i>pers. comm.</i> C. Limpus & J. Meager) and in accordance with <i>Guideline 1: rating due to missing, incorrect or out of date information</i> and <i>Guideline 2: additional scientific assessment & consultation</i>.</p>
<p><u>Marine turtles</u> Loggerhead turtle (<i>C. caretta</i>)</p>	<p><i>Maximum size</i> (<i>Productivity</i>)</p>	1	2	<p>The loggerhead turtle (<i>C. caretta</i>) was initially assigned a low (1) risk score for this attribute. During the consultation process, it was advised that this score should be increased (<i>pers. comm.</i> C. Limpus).</p> <p>Key changes to the PSA scores</p> <p>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 <i>Guideline 1: rating due to missing, incorrect or out of date information</i> and <i>Guideline 2: additional scientific assessment & consultation</i>.</p>
<p><u>Sirenia</u> <i>Dugong</i> (<i>D. Dugon</i>)</p>	<p><i>Encounterability</i> (<i>Susceptibility</i>)</p>	3	1	<p>Criteria used to assess <i>encounterability</i> are based on a broad evaluation of the overlap between the preferred habitats/bathymetries and fishing effort. In the PSA, the species was assigned the highest risk rating as tunnel nets tend to operate in shallower, inshore environments with clearer waters.</p> <p>Dugongs inhabit shallow water environments and their known distribution/preferences overlap with a number of the ECIF sub-fisheries. In the Tunnel Net Fishery, the encounterability potential is reduced significantly by</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>the size of the fishery and the area of operation. With an operating potential of 22, the Tunnel Net Fishery is one of the smallest sub-fisheries in the ECIF (Department of Agriculture and Fisheries, 2019e). Of those licences, all but five are attached to licences with multiple fishing symbols. This suggests that not all of the 22 licences are in active operation and/or they are used in conjunction with other fishing symbols as part of a multi-endorsed fishing operation. These factors would help reduce the footprint of the fishery in key habitats.</p> <p>While noting the above, the location of the fishery is arguably of more significance in terms of risk management. As noted, the Tunnel Net Fishery operates exclusively within the confines of the <i>Moreton Bay Marine Park</i> and the <i>Great Sandy Marine Park</i>. 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, 2015b). In a number of instances, closures have been specifically implemented to protect areas of significant importance to dugongs or protect areas where dugongs are found in higher densities. While dugongs are found outside these areas, they are more likely to be found/encountered in areas where tunnel net fishing is not permitted.</p> <p><i>Note—Dugongs are afforded additional protections through Fisheries legislation via the Dugong Protection Areas (DPA). All areas classified as DPA Zone A and DPA Zone B are situated outside the prescribed tunnel net fishing area.</i></p> <p>Key changes to the PSA scores</p> <p>The score assigned to the <i>encounterability</i> attribute was downgraded from high (3) to low (1). This decision recognises that comparatively small footprint of the Tunnel Net Fishery and protections (general and species-specific) already in place that reduce interactions in the <i>Moreton Bay</i> and <i>Great Sandy</i> marine parks. The above changes were done in accordance with <i>Guideline 6: Management arrangements to mitigate against the level of bycatch</i> with consideration given to <i>Guideline 3: at risk with spatial assumptions</i> and <i>Guideline 4: at risk in regards to level of interaction/capture with a zero or negligible level of susceptibility</i>.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
<p><u>Sirenia</u> <i>Dugong (D. Dugon)</i></p>	<p><i>Post-capture mortality (Susceptibility)</i></p>	<p>3</p>	<p>1</p>	<p>While the SOCI data does not contain any dugong / tunnel net interactions (Department of Agriculture and Fisheries, 2019e), StrandNET attributes one dugong mortality to tunnel net fishing in 2005 (Greenland & Limpus, 2005). There is limited information on the circumstances surrounding this interaction besides the location; Moreton Bay. This area of the Tunnel Net Fishery now operates under a voluntary code of practice that, among other things, establishes measures to minimise the risk to marine megafauna. This includes the use of a of an exclusion grid with bar spaces no larger than 25cm (Thompson <i>et al.</i>, 2012). These measures are designed to prevent marine megafauna from entering the tunnel of the net where the mesh size is higher and there is an elevated potential for entanglements.</p> <p>While noting the previous mortality, dugong interactions in the Tunnel Net Fishery will be infrequent (see RRA for <i>encounterability</i>) and there is a high probability that the animal will survive the fishing event. Dugongs that interact with a tunnel net are less likely to become entangled in the net (<i>i.e.</i> when compared to gillnets) with the most likely interaction being contact without capture events <i>i.e.</i> swimming into the (outside) of the net. As bycatch reduction devices are not (currently) mandatory across the fishery, these animals could still enter the tunnel of the net. This however will not restrict the movement of the animal or impede their capacity to access the surface. The probability that an animal will survive is further improved by provisions that require the tunnel of the net to be submerged for the duration of the fishing event and the use of smaller mesh sizes in the wings of the net.</p> <p>In the unlikely event that a dugong is caught in the tunnel of the net, the operators will be on hand to release the animal. This is usually done by lifting up the net to release the animal or creating an opening for it to escape. While the animal may experience some stress and superficial injuries, there is a high probability that the animal will survive the fishing event.</p> <p>Key changes to the PSA scores</p> <p>Due to the above considerations, scores assigned to this attribute were downgraded from high (3) to low (1). This score is considered to be more representative of the likelihood that a tunnel net interaction will end in the death of the animal. It also reflects the sector’s ability to release the animal without landing the animal,</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				bringing it to the side of the vessel and/or handling it excessively. This amendment was done in accordance with <i>Guideline 6: Management arrangements to mitigate against the level of bycatch.</i>
<u>Batoids</u> <i>Bottlenose wedgefish</i> (<i>R. australiae</i>)	<i>Age at maturity</i> (<i>Productivity</i>)	3	2	<p>There is limited information on the age and growth of <i>R. australiae</i> including on their age of sexual maturity. This was reflected in the preliminary scores assigned as part of the PSA.</p> <p>A limited study on the age and growth of a broader <i>Rhynchobatus</i> 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; Simpfordorfer <i>et al.</i>, 2019; White <i>et al.</i>, 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 <i>et al.</i>, 2016; Smith <i>et al.</i>, 2007; White <i>et al.</i>, 2014; White & Dharmadi, 2007; White <i>et al.</i>, 2006).</p> <p>Key changes to the PSA scores</p> <p>To accommodate the above considerations, PSA scores assigned to the <i>age at maturity</i> 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. Further reductions <i>i.e.</i> to low risk (1) were not considered to be an option in this ERA given a) uncertainty surrounding the age at sexual maturity for females and b) an absence of species-specific data. Changes made as part of the RRA were done in accordance with <i>Guideline 2: additional scientific assessment & consultation.</i></p>
<u>Batoids</u> <i>Bottlenose wedgefish</i> (<i>R. australiae</i>) <i>Giant shovelnose ray</i> (<i>G. typus</i>)	<i>Management strategy</i> (<i>Susceptibility</i>)	3	2	<p>Unlike other SOCC, both shovelnose rays and guitarfish can be retained for sale in the Tunnel Net Fishery. As shovelnose and guitarfish are not managed under species-specific TACCs, they were assigned a high (3) risk rating for the <i>management strategy</i> attribute. While noting the reasoning behind this decision, this subgroup is subject to a number of significant catch restrictions. This includes management under a maximum size limit of 1.5m and a combined in possession limit of five individuals (Department of Agriculture and Fisheries, 2019e). The recreational fishing sector is also limited by a one shark or ray in-possession limit.</p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>These restrictions combined with a high probability that discarded shovelnose rays / guitarfish will survive a tunnel net event suggests that scores assigned in the PSA represent a risk overestimation.</p> <p>Key changes to the PSA scores</p> <p>Based on the above considerations, preliminary score assigned to the <i>post-capture mortality</i> attribute in the PSA were reduced from high (3) to medium (2) for both species. These changes were done in accordance with <i>Guideline 5: effort and catch management arrangements for target and byproduct species</i>. It is recognised that a medium-risk rating may still be too high for these species in this sector of the ECIF. With further information on total interaction rates (retained plus discards) and fisher intentions, there may be additional avenues to reduce this score.</p>
<p><u>Batoids</u></p> <p><i>Bottlenose wedgefish (R. australiae)</i></p> <p><i>Giant shovelnose ray (G. typus)</i></p>	<p><i>Post-capture mortality (Susceptibility)</i></p>	<p>3</p>	<p>1</p>	<p>Under the current regulations, the bottlenose wedgefish (<i>R. australiae</i>) and the giant shovelnose ray (<i>G. typus</i>) can be retained for commercial sale. However, both are managed under a maximum size limit of 1.5m and the catch of guitarfish and shovelnose rays is further restricted by a combined in possession limit of five individuals (Department of Agriculture and Fisheries, 2019e).</p> <p>Under the PSA criteria all species that can be retained for sale are assigned the highest score for the <i>post-capture mortality</i> attribute. While noting the reasons behind this assessment (Australian Fisheries Management Authority, 2018; Hobday <i>et al.</i>, 2007), this criterion is less suited to the Tunnel Net Fishery. The main reasons for this are:</p> <ol style="list-style-type: none"> 1) The species are taken in comparatively small amounts across the entire ECIF; 2) This catch will include the Large Mesh Net Fishery which has a large footprint and accounts for the majority of the ECIF catch and effort; 3) There are significant limits already imposed on the number of shovelnose rays / guitarfish that can be retained for sale in the Tunnel Net Fishery; 4) While discards will be a factor, these animals are expected to have high post-interaction survival rates due to the nature of the apparatus, the (comparatively) low entanglement potential, the use of

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>bycatch reduction devices in key areas (<i>i.e.</i> Moreton Bay) and regulations that require the tunnel of the net to be submerged at all times during a fishing event.</p> <p>Key changes to the PSA scores</p> <p>Based on the above considerations, preliminary score assigned to the <i>post-capture mortality</i> attribute in the PSA were reduced from high (3) to low (1) for both species. These changes were done in accordance with <i>Guideline 5: effort and catch management arrangements for target and byproduct species.</i></p>
<p><u>Batoids</u></p> <p><i>Bottlenose wedgefish (R. australiae)</i></p> <p><i>Giant shovelnose ray (G. typus)</i></p>	<p><i>Recreational desirability / Other fisheries (Susceptibility)</i></p>	<p>3</p>	<p>1</p>	<p>While elasmobranchs can be retained in the recreational fishing sector, there is limited information on interaction rates, release fates and harvest levels. As a consequence, the bottlenose wedgefish (<i>R. australiae</i>) and the giant shovelnose ray (<i>G. typus</i>) were assigned a precautionary high-risk score (3) for the <i>recreational desirability / other fisheries</i> attribute.</p> <p>Elasmobranchs (sharks & rays) are not highly targeted within the recreational sector, with complex registering low retention rates across survey periods (Taylor <i>et al.</i>, 2012; Webley <i>et al.</i>, 2015). This in part can be attributed to the restriction imposed on this sector <i>i.e.</i> 1.5m maximum size limit and a 1 shark or ray in-possession limit. Hammerhead sharks are also classified as a no-take in the recreational fishing sector. These restrictions make a significant contribution to the lowering of cumulative fishing pressures.</p> <p>Key changes to the PSA scores</p> <p>Based on the available information, the preliminary score assigned to the <i>recreational desirability / other fisheries</i> attribute in the PSA was reduced to a low (1). The decision was based on the low and decreasing recreational interest of sharks, high release rates and management provisions that are already in place for this sector. While discard mortality remains unknown across species groupings, survival rates for recreational line-caught sharks/rays are expected to be moderate or high. This change was done in accordance with <i>Guideline 1: risk rating due to missing, incorrect or out of date information</i> and <i>Guideline 5: effort and catch management arrangements for target and byproduct species.</i></p>

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
<u>Batoids</u> <i>Estuary stingray (H. fluviorum)</i>	<i>Availability (Susceptibility)</i>	3	1	<p>Distributional data for the estuary stingray (<i>H. fluviorum</i>) 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 <i>availability</i> (Hobday <i>et al.</i>, 2007). In the RRA, <i>availability</i> was reassessed using IUCN species distribution map (Kyne <i>et al.</i>, 2016). In this instance, the full boundary of the two marine parks was used as a) there is limited capacity to assess the fine-scale distribution of tunnel net effort and b) it provides a more conservative estimate of the affected area. Even with the adoption of a more precautionary approach the total overlap percentage was less than 10%. This value is consistent with what is known about the distribution of the species and the size of the fishery and the area of operation.</p> <p>Key Changes to the PSA scores</p> <p>The preliminary score assigned to the <i>encounterability</i> attribute as part PSA was reduced from high (3) to low (1). Changes made as part of the RRA were done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i>.</p>
<u>Batoids</u> <i>Estuary stingray (H. fluviorum)</i>	<i>Encounterability (Susceptibility)</i>	3	2	<p>While the estuary stingray is largely associated with mangrove swamps, estuarine and riverine systems (Last <i>et al.</i>, 2016), the species has been reported to depths of 20m. This was reflected in the <i>encounterability</i> attribute where it was assigned a high (3) risk score. 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. The interaction potential for this species will arguably be higher in the Large Mesh Net Fishery; particularly for operations targeting key species like barramundi, threadfin or shallow-water species. While not universal, these two species tend to be targeted with more frequency in central and northern Queensland <i>i.e.</i> in areas where tunnel net fishing does not occur:</p> <ul style="list-style-type: none"> - Barramundi catch distributions (Qfish: http://qfish.fisheries.qld.gov.au/query/5b3efd8c-0b8a-40c9-9192-ffce3ffbc71a/map) - Combined threadfin catch distribution (Qfish: http://qfish.fisheries.qld.gov.au/query/50e84889-250e-4aee-b18c-7df71898a0ce/map)

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				<p>In addition to the above, tunnel nets are less likely to be set in habitats preferred by the estuary stingray <i>i.e.</i> on mangrove lined banks, estuaries and within waterways. While these factors cannot completely rule out the species being caught in this fishery, it does suggest that the score assigned to the <i>encounterability</i> attribute was an overestimate.</p> <p>Key changes to the PSA scores</p> <p>Based on the available information, the preliminary score assigned to the <i>encounterability</i> attribute in the PSA was reduced from high (3) to medium (2). This decision was based on the fact the species prefers habitats where Tunnel Net Fishery is less likely to occur <i>i.e.</i> mangrove lined banks and estuaries. It is noted that this score may still represent an overestimate for this species. However, there is limited information on catch rates for this species in the Tunnel Net Fishery. Changes made as part of the RRA were done in accordance with <i>Guideline 2: additional scientific assessment & consultation</i>; specifically on the dynamics and operational constraints of the fishery.</p>

Appendix D—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 *i.e.* 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 positives are 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 to be of particular importance when identifying priority risks for this fishery.

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

2. Methods

The LCA was constructed using a simplified version of the *National ESD Reporting Framework for Australian Fisheries* (Fletcher, 2014; Fletcher *et al.*, 2002; Fletcher *et al.*, 2005) and focused specifically on the *Risk Analysis* component. It is recognised that the *National ESD Reporting Framework* incorporates additional steps including ones that establish the context of the assessment and identifies key risks. As these steps were fulfilled with the completion of a *Scoping Study* (Department of Agriculture and Fisheries, 2019e) and whole-of-fishery (Level 1) assessment (Jacobsen *et al.*, 2019), 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 D1) and b) the likelihood of a particularly adverse consequence occurring due to these activities or events (Table D2). Central to this is the establishment of a *Likelihood x Consequence* matrix that estimates the risk based on scores assigned to each component (Table D3).

Table D1. 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 / harvest levels or mortalities at, near or approaching maximum yields (or equivalent).
Severe	3	Species assessed as high risk through the PSA / harvest or mortalities at 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 / harvest levels or 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 D2. Criteria used to assign indicative scores of the likelihood that fishing activities in the Tunnel Net Fishery 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 D3. 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				
		Negligible	Minor	Moderate	Severe	Major
Likelihood		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 D2), criteria used to assign scores (0–4) were based on the outputs of the semi-quantitative assessment (e.g. PSA/RRA results outlined in section 4, Table 7). In the likelihood assessment (Table D1), scores reflect the likelihood of the fishery causing or making a significant contribution to the occurrence of the most hazardous consequence (Fletcher *et al.* 2002). Once scores are assigned to each aspect of the LCA, they are used to calculate an overall risk value ($Risk = Likelihood \times Consequence$) for each species (Table D3).

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 D1 and D2 respectively. The *Likelihood x Consequence* matrix used to assign risk ratings is provided as Table D3.

3. Results & Considerations

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

Teleosts

LCA risk estimates for the 16 teleost species were all low; although matrix scores for dusky flathead, trumpeter whiting, and tarwhine were at the higher end of the spectrum (Table D4). All mullet species, yellowfin bream and sand whiting had LCA estimates that aligned with the PSA/RRA. The remainder were below that recorded as part of the PSA/RRA.

The results of the LCA reflect the small-scale nature of the Tunnel Net Fishery, the size of the fished area and the number of active licences (Department of Agriculture and Fisheries, 2019e). These results support the broader outcomes of the PSA/RRA and suggest that ratings assigned to a number of the flathead species, trevally and garfish were overly cautious.

Marine turtles

All LCA risk estimates for the marine turtle complex were lower than that recorded through the PSA/RRA (Table 7; Table D4). Of the species assessed, the Tunnel Net Fishery is more likely to interact with the green turtle. Green turtles have higher population numbers on the Queensland east coast and are found in higher densities in the *Moreton Bay Marine Park* and *Great Sandy Marine Park*. This increases the probability that the Tunnel Net Fishery will encounter this species with more frequency. Interactions with the loggerhead turtle and hawksbill turtle are less likely and the LCA supports the assignment of *precautionary* risk ratings for these two species.

Dugong

The LCA supports the assignment of a *precautionary* risk rating for dugongs (Table D4). While tunnel net operations occur adjacent to preferred dugong habitats, these areas are protected and closed to fishing. These measures will limit a) the extent of the overlap between the Tunnel Net Fishery and their preferred habitats and b) the number of interactions. These protections are complimented by

fisheries-specific measures that reduce the risk of an interaction ending in mortality. This includes provisions that require the tunnel of the net to be submerged for the duration of the fishing event and net-attendance provisions.

Batoids

The LCA for batoids supported the assignment of precautionary high-risk ratings for two of the three species assessed: the giant shovelnose ray and the bottlenose wedgefish (Table D4). 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.

The estuary ray was found to be at lower risk in the PSA (Table 7); a value that was partially supported by the LCA (Table D4). When compared to the shovelnose ray and guitarfish, sustainability concerns for the estuary ray are higher and more immediate. These concerns relate to their take as bycatch in inshore fisheries (e.g. nets and trawl fishing) and external factors including habitat loss / regional degradation. Due to these concerns, the final risk rating for the estuary ray was retained.

Table D4. Results of the Likelihood & Consequence Analysis for species assessed as part of the Tunnel Net Fishery Level 2 ERA.

Common name	Species name	Likelihood	Consequence	Matrix score	Risk category
Teleosts					
Sea mullet	<i>Mugil cephalus</i>	2	1	2	Low
Fantail mullet	<i>Paramugil georgii</i>	1	1	1	Low
Diamondscale mullet	<i>Liza vaigiensis</i>	1	1	1	Low
Dusky flathead	<i>Platycephalus fuscus</i>	2	2	4	Low
Bartailed flathead	<i>Platycephalus australis</i>	2	2	4	Low
Northern sand flathead	<i>Platycephalus endrachtensis</i>	1	2	2	Low
Yellowtailed flathead	<i>Platycephalus westraliae</i>	1	2	2	Low
Trumpeter whiting	<i>Sillago maculata</i>	2	2	4	Low
Sand whiting	<i>Sillago ciliata</i>	2	1	2	Low
Yellowfin bream	<i>Acanthopagrus australis</i>	2	1	2	Low
Tarwhine	<i>Rhabdosargus sarba</i>	2	2	4	Low
Snubnose garfish	<i>Arrhamphus sclerolepis</i>	1	2	2	Low

Common name	Species name	Likelihood	Consequence	Matrix score	Risk category
Three-by-two garfish	<i>Hemiramphus robustus</i>	1	2	2	Low
Giant trevally	<i>Caranx ignobilis</i>	1	2	2	Low
Golden trevally	<i>Gnathanodon speciosus</i>	1	2	2	Low
Scribbled rabbitfish	<i>Siganus spinus</i>	2	2	4	Low
Marine turtles					
Green turtle	<i>Chelonia mydas</i>	2	2	4	Low
Loggerhead turtle	<i>Caretta caretta</i>	1	2	2	Low
Hawksbill turtle	<i>Eretmochelys imbricata</i>	1	2	2	Low
Dugong					
Dugong	<i>Dugong dugon</i>	2	2	4	Low
Batoids					
Bottlenose wedgefish	<i>Rhynchobatus australiae</i>	2	3	6	Medium
Giant shovelnose ray	<i>Glaucostegus typus</i>	2	2	4	Low
Estuary stingray	<i>Hemitrygon fluviorum</i>	2	2	4	Low

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.

<i>All marine turtle records</i>										
	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

<i>Green turtles (Chelonia mydas)</i>										
	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 turtles (<i>Caretta caretta</i>)										
	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 (<i>Eretmochelys imbricata</i>)										
	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 (SOI) logbook. Data separated by species, fishing method and release state.

<i>Flatback turtle (Natator depressus)</i>										
	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

<i>Leatherback turtle (Dermochelys coriacea)</i>										
	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 (SOI) logbook. Data separated by species, fishing method and release state.

<i>Olive ridley turtle (Lepidochelys olivacea)</i>										
	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

<i>Species unknown / Not specified</i>										
	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