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East Coast Otter Trawl Fishery Ecological Risk Assessment

Species of Conservation Concern

Queensland Government

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Species of Conservation Concern

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Executive Summary

On 17 December 2021, the *East Coast Otter Trawl Fishery* (ECOTF) was accredited as a Wildlife Trade Operation (WTO) under Part 13A of the *Environment Protection and Biodiversity Conservation Act 1999* (Department of Climate Change Energy the Environment and Water, 2021). Condition 8(b) of this approval requires an updated Ecological Risk Assessment (ERA) to be published for the fishery by 30 November 2023. This condition also requires the ERA to be developed using protocols outlined in the *Queensland Ecological Risk Assessment Guidelines* (Department of Agriculture and Fisheries, 2018b). An updated species-specific ERA has now been completed for the ECOTF in accordance with Condition 8(b) of the WTO accreditation.

The updated ERA for the ECOTF was completed using a *Productivity & Susceptibility Analysis* (PSA). The PSA is a semi-quantitative risk assessment method and it differs from that used in the two previous qualitative ERAs (Astles *et al.*, 2006; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). It identifies aspects of a species biology and fishery impact profile that make it more vulnerable/susceptible to trawl fishing activities. The primary objective of the study being to inform management of the species that are exposed to higher levels of risk within the ECOTF.

The PSA takes into consideration a range of biological (*age at sexual maturity*, *maximum age*, *fecundity*, *maximum size*, *size at sexual maturity*, *reproductive strategy*, and *trophic level*) and fisheries-specific attributes (*availability*, *encounterability*, *selectivity, post-interaction mortality* and *conservation status*). As the PSA can over-estimate risk for some species (Zhou *et al.,* 2016), the 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. The primary purpose of the RRA is to minimise the number of false positives or instances where the risk level has been overestimated.

As fishing-related risks for target and byproduct species are managed through regionally-specific harvest strategies (Department of Agriculture and Fisheries, 2021d; h; f; g; e), the ERA prioritised assessments for non-target species, specifically species with ongoing conservation concerns (herein referred to as *Species of Conservation Concern* or SOCC). A review of relevant legislation and international instruments produced a preliminary list of 161 species that were considered for inclusion in the ECOTF SOCC ERA. This list was rationalised to 62 species consisting of six marine turtles, 13 sea snakes, nine syngnathids, 12 sharks and 22 batoids. The remaining species were excluded from the analysis as they had a low interaction potential with the ECOTF or had a geographical distribution that had minimal overlap with the trawl effort footprint.

When the outputs of the PSA and RRA were taken into consideration,12 species were categorised as being at high risk from fishing activities in the ECOTF. Final risk ratings for a number of the species were heavily influenced by life-history and biological constraints, with attributes based on reproduction and trophic levels identified as the key drivers of risk. *Susceptibility* scores displayed more interspecific variability; although *encounterability* and *post-interaction mortality* were scored highly across most subgroups. While not uniform, data deficiencies were a factor of influence in a number of the risk profiles. In the *productivity* component, data deficiencies were most evident in *age at maturity* and *maximum age* attributes. Conversely, *selectivity* and *post-interaction mortality* registered the highest number of data deficiencies within the *susceptibility* component.

Of notable importance, nine of the 12 high-risk ratings were classified as '*precautionary*' as they are more representative of the potential risk. Precautionary ratings were assigned when a species risk level may have been overestimated due to data deficiencies, the conservative nature of the ERA methodology and/or when the risk is being managed within the current fishing environment. Precautionary ratings may also be assigned to species that have fewer conservation concerns but were assigned a higher risk rating due (*e.g.*) to their biological constraints. Precautionary risk ratings are best addressed through improved monitoring and data collection. These risk elements are already being addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* and the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a; Queensland Government, Undated-a). **Species assigned *precautionary* risk ratings are viewed as lower priorities for risk management intervention.**

The remaining high-risk ratings (n = 3) are viewed as higher priorities. The drivers of risk for these species need further consideration and may require a more formal management response *e.g.* longer-term monitoring to determine a species interaction and mortality rate, research on alternate bycatch mitigation strategies (*e.g.* sawfish), additional industry support (*e.g.* identification guides) and reporting refinements. For these species, management will need to consider risk at both a whole-of-fishery and regional level. The outputs of the ECOTF SOCC ERA will assist in this process.

As the ECOTF SOCC ERA is based at a whole-of-fishery level, ratings assigned to some species may not accurately account for variations at a management region level. Evidently, some of the species included in this assessment will only interact with a subset of the five trawl management regions *e.g.* stingarees in the southern Queensland trawl regions (Last *et al.*, 2016b; Department of Agriculture and Fisheries, 2021h; g; Kyne *et al.*, 2021). This regional context and the distributions of the species assessed need to be considered when reviewing the outputs of this report and their applicability to the *Northern*, *Central*, *Southern Inshore, Southern Offshore* and the *Moreton Bay* trawl regions (Department of Agriculture and Fisheries, 2021e; d; f; g; h). Regional risk variations will be explored further in an additional risk assessment involving the ECOTF.

More broadly, a number of the ratings contained in this report differ from that reported by Pears *et al.* (2012b) and Jacobsen *et al.* (2015). While the outputs of all three assessments are similar, there are notable differences in terms of the methodology used, the quantification of risk and the treatment of data deficiencies and uncertainty. Given these methodological differences, risk ratings for individual species <u>should not be directly compared</u> across studies. Similarly, it is not recommended that cross-study comparisons be used to draw inferences/conclusions on long-term risk trends for individual species.

While noting these caveats, the outputs of the current ERA, combined with recent management reforms and a decline in annual effort levels (~4,000 effort days less per year), indicate that there has been an overall improvement in the management of risk in this fishery. Going forward, QDAF anticipates that further refinements and (likely) risk score reductions can be achieved through the harvest strategy program and the *Data Validation Plan e.g.* Independent Data Validation (IDV) / catch monitoring.

The following recommendations have been identified as areas where risk profiles can be refined and the level of risk reduced within the ECOTF. These recommendations complement risk management strategies already employed in this fishery including the use of bycatch reduction devices, the introduction of regional management arrangements / harvest strategies, the establishment of regional effort caps and a reduction in annual effort levels. Recommendations relating to the improvement of catch compositions and interaction rate data should be progressed as a priority. The remaining recommendations are viewed as lower priorities and timeframes for their potential completion may be more resource dependent.

Whole-of-fishery recommendations are supported within the report by complex-specific recommendations aimed at reducing risk or improving the accuracy of the assessments involving individual species. A number of the recommendations are already being addressed and progressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027*.

General recommendations

1. *Identify mechanisms to monitor interactions with key bycatch species (preferably in real or near-real time), validate data submitted through the logbook program, and minimise the risk of non-compliance with Threatened, Endangered and Protected Animal (TEPA) reporting requirements.*

2. *Identify mechanisms to improve the level of information on species compositions, interaction rates and landing fates (i.e. alive, moribund, dead) for species with increased conservation concerns.*

3. *When appropriate, undertake a more detailed assessment of risk at a regional level considering a) the distribution of each species in relation to the five harvest strategies and b) the likelihood of the risk coming to fruition within each management region over the short to medium term.*

4. *Explore the benefits of assessing the risk posed to key subgroups, namely sharks and batoids, using a quantitative ERA method such as a base Sustainability Assessment for Fishing Effects (where applicable).*

5. *Identify avenues to improve the efficacy of the current logbook reporting systems (e.g. electronic logbooks) and review nomenclature used in fisheries legislation / logbook reporting systems to ensure that it reflects the best available data.*

6. *Undertake a review of the resources made available to licence holders to assist in the identification of TEP species and avenues to better integrate data collected through the TEPA logbook program with ancillary programs like the Marine Wildlife Stranding and Mortality Database (StrandNET).*

7. *Explore avenues to improve research on the distribution and biology of key subgroups through engagement with industry and third-party representatives (e.g. the Queensland Museum and regional universities).*

Summary of the outputs from the Ecological Risk Assessment for Species of Conservation Concern (SOCC) that interact with the East Coast Otter Trawl Fishery (ECOTF).

Species with '' were assigned precautionary ratings, in part, because they have more restrictive distributions in Queensland, primarily stingarees (Family Urolophidae) and skates (Family Rajidae).*

Common name	Species name	Productivity	Susceptibility	Final risk rating
Marine Turtles				
Loggerhead turtle	*Caretta caretta*	2.43	1.78	Prec. medium
Green turtle	*Chelonia mydas*	2.29	1.78	Medium
Leatherback turtle	*Dermochelys coriacea*	2.43	1.78	Prec. medium
Hawksbill turtle	*Eretmochelys imbricata*	2.29	1.78	Medium
Olive ridley turtle	*Lepidochelys olivacea*	2.14	1.78	Prec. medium
Flatback turtle	*Natator depressus*	2.43	1.78	Medium
Syngnathids				
Tiger pipefish	*Filicampus tigris*	1.71	2.41	Medium
Spiny seahorse	*Hippocampus spinosissimus*	1.71	2.55	Medium
Great seahorse	*Hippocampus kelloggi*	1.71	2.55	Medium
White's seahorse	*Hippocampus whitei*	1.71	2.55	Medium
Duncker's pipehorse	*Solegnathus dunckeri*	1.86	3.00	High
Pallid pipehorse	*Solegnathus hardwickii*	2.00	2.41	Medium
Bentstick pipefish	*Trachyrhamphus bicoarctatus*	1.71	2.05	Medium
Straightstick pipefish	*Trachyrhamphus longirostris*	1.71	1.93	Low
Ribboned pipefish	*Haliichthys taeniophorus*	1.71	1.55	Low
Sea snakes				
Reef shallows sea snake	*Aipysurus duboisii*	2.14	1.78	Medium
Mosaic sea snake	*Aipysurus mosaicus*	2.00	1.64	Low
Olive sea snake	*Aipysurus laevis*	2.43	1.64	Medium
Spine-bellied sea snake	*Hydrophis curtus*	2.14	1.64	Medium
Elegant sea snake	*Hydrophis elegans*	2.29	1.78	Medium
Spectacled sea snake	*Hydrophis kingii*	2.29	1.89	Medium
Turtle-headed sea snake	*Emydocephalus annulatus*	2.29	1.52	Prec. medium
Olive-headed sea snake	*Hydrophis major*	2.14	1.64	Medium
Small-headed sea snake	*Hydrophis macdowelli*	2.14	1.89	Medium
Spotted sea snake	*Hydrophis ocellatus*	2.14	1.89	Medium
Horned sea snake	*Hydrophis peronii*	2.14	1.64	Medium
Beaked sea snake	*Hydrophis zweifeli*	2.14	2.05	Medium
Stoke's sea snake	*Hydrophis stokesii*	2.29	1.78	Medium
Sharks				
Collar carpetshark	*Parascyllium collare*	2.14	1.64	Prec. medium
Brownbanded bambooshark	*Chiloscyllium punctatum*	2.00	1.52	Low
Colclough's shark	*Brachaelurus colcloughi*	2.29	2.55	High

Common name	Species name	Productivity	Susceptibility	Final risk rating
Crested hornshark	*Heterodontus galeatus*	2.29	1.15	Low
Eastern angelshark	*Squatina albipunctata*	2.57	2.35	Prec. high
Eastern banded catshark	*Atelomycterus marnkalha*	2.14	1.89	Prec. medium
Zebra shark	*Stegostoma tigrinum*	2.29	1.78	Prec. medium
Piked spurdog	*Squalus megalops*	2.57	1.78	Medium
Australian weasel shark	*Hemigaleus australiensis*	2.29	2.05	Prec. medium
Pale Spotted catshark	*Asymbolus pallidus*	2.00	1.55	Low
Grey spotted catshark	*Asymbolus analis*	2.29	1.78	Prec. medium
Orange spotted catshark	*Asymbolus rubiginosus*	2.00	1.55	Low
Batoids				
Australian butterfly ray	*Gymnura australis*	2.57	2.05	Prec. high
Yellowback stingaree	*Urolophus sufflavus*	2.00	2.77	Prec. high*
Patchwork stingaree	*Urolophus flavomosaicus*	2.00	2.05	Prec. medium
Sandyback stingaree	*Urolophus bucculentus*	2.29	2.22	Prec. high*
Kapala stingaree	*Urolophus kapalensis*	2.00	2.55	Prec. high*
Greenback stingaree	*Urolophus viridis*	2.00	2.77	Prec. high*
Common stingaree	*Trygonoptera testacea*	2.14	2.05	Medium
Australian whipray	*Himantura australis*	2.71	1.52	Medium
Blackspotted whipray	*Maculabatis astra*	2.57	1.89	Prec. high
Brown whipray	*Maculabatis toshi*	2.57	1.89	Prec. high
Estuary stingray	*Hemitrygon fluviorum*	2.43	1.89	Medium
Coral sea maskray	*Neotrygon trigonoides*	2.14	2.22	Medium
Speckled maskray	*Neotrygon picta*	2.00	2.22	Prec. medium
Bottlenose wedgefish	*Rhynchobatus australiae*	2.57	1.64	Prec. medium
Eyebrow wedgefish	*Rhynchobatus palpebratus*	2.57	1.32	Prec. medium
Eastern shovelnose ray	*Aptychotrema rostrata*	2.43	1.89	Prec. medium
Giant guitarfish	*Glaucostegus typus*	2.43	1.52	Prec. medium
Sydney skate	*Dentiraja australis*	2.14	2.22	Medium
Endeavour skate	*Dentiraja endeavouri*	2.00	2.55	Prec. high*
Argus skate	*Dentiraja polyommata*	2.00	2.22	Medium
Narrow sawfish	*Anoxypristis cuspidata*	2.43	1.89	Medium
Green sawfish	*Pristis zijsron*	2.86	2.35	High

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Definitions & Abbreviations

AFMA	–	*Australian Fisheries Management Authority.*
BMP	–	Bycatch Management Plan.
BRD	–	Bycatch Reduction Device.
bSAFE	–	*base Sustainability Assessment for Fishing Effects*. The *Sustainability Assessment for Fishing Effects,* or SAFE, is one of the two ERA methodologies that can be used as part of the ECOTF SOCC assessment. This method can be separated into a base SAFE (bSAFE) and enhanced SAFE (eSAFE). The data requirements for eSAFE are higher than for a bSAFE, which aligns more closely to a PSA.
CAAB	–	*Codes for Australian Aquatic Biota.*
CCL	–	Curved carapace length. Body-size measurement used for marine turtles.
CMS	–	*Convention on the Conservation of Migratory Species of Wild Animals.*
CITES	–	*Convention on International Trade in Endangered Species of Wild Fauna and Flora.*
CSIRO	–	*Commonwealth Scientific and Industrial Research Organisation.*
DW	–	Disc Width.
ECOTF	–	*East Coast Otter Trawl Fishery*.
EPBC Act	–	*Environment Protection and Biodiversity Conservation Act 1999.*
ERA	–	Ecological Risk Assessment.
ERAEF	–	*Ecological Risk Assessment for the Effects of Fishing*. A risk assessment strategy established by Hobday *et al.* (2011) and employed by the AFMA.
False positive	–	The situation where a species at low risk is incorrectly assigned a higher risk rating due to the method being used, data limitation *etc*. In the context of an ERA, false positives are preferred over false negatives.
False negative	–	The situation where a species at high risk is assigned a lower risk rating. When compared, false-negative results are considered to be of more concern as the impacts/consequences can be more significant.

HT	–	Height. Body-size measurement used for syngnathids (sea horses and pipefish).
IUCN Red List	–	Refers to the IUCN Red List extinction risk assessments. For the purpose of this ERA, both IUCN extinction risk classifications and conservation listings (*e.g.* under the *EPBC Act or Nature Conservation Act 1992*) were used and referenced as the 'conservation status' of a species.
LCA	–	*Likelihood & Consequence Analysis.*
NDF	–	*Non-Detriment Finding*. A NDF is required for all CITES species that are exported for sale and provides an assessment of the current management arrangements and exploitation status.
NPF	–	*Northern Prawn Fishery.*
PSA	–	*Productivity & Susceptibility Analysis.* One of the two ERA methodologies that can be used as part of the Level 2 assessments.
RIBTF	–	*River & Inshore Beam Trawl Fishery*.
RRA	–	*Residual Risk Analysis*.
QDAF	–	*Queensland Department of Agriculture and Fisheries*.
SAFE	–	*Sustainability Assessment for Fishing Effects*. One of the two ERA methodologies that can be used as part of the Level 2 assessments. This method can be separated into a base SAFE (bSAFE) and enhanced SAFE (eSAFE). Data requirements for eSAFE are higher than a bSAFE which aligns more closely to a PSA.
SAFS	–	The National *Status of Australian Fish Stocks*. Refer to www.fish.gov.au for more information.
SOCC	–	*Species of Conservation Concern*. Term used in the ECOTF SOCC ERA to categorise the list of species with ongoing concern. The SOCC includes both no-take species and species that are targeted within the ECOTF.
SOCI	–	*Species of Conservation Interest.* A historical term formally applied to no-take species that were subject to additional reporting requirements. This was primarily done through the *Species of Conservation Interest* (SOCI) logbook. The SOCI logbook was superseded in 2021 by the *Threatened, Endangered & Protected Animals* logbook.
StrandNET	–	Reporting system used by the *Department of Environment and Science* (DES) to complete the *Marine Wildlife Stranding and Mortality Database*. StrandNET summarises all records of sick, inured or dead marine wildlife reported through DES and annual

		reports can be accessed at: https://environment.des.qld.gov.au/wildlife/animals/caring-for-wildlife/marine-strandings/data-reports/annual-reports#document_availability .
SVL	–	Snout-vent length. Body-size measurement used for sea snakes.
TACC	–	Total Allowable Commercial Catch Limit.
TED	–	Turtle Excluder Device.
TEP	–	Threatened, Endangered and Protected.
TEPA logbook	–	Threatened, Endangered, and Protected Animals logbook is used to monitor interactions with non-target species that are subject to mandatory reporting requirements. The TEPA logbook replaced the Conservation Interest (SOCI) logbook in 2021.
TL	–	Total Length.

1 Introduction

The *East Coast Otter Trawl Fishery* (ECOTF) operates in tidal waters extending from the tip of Cape York through to the Queensland—New South Wales border. It is one of the largest commercial fisheries operating in Queensland (e.g. by annual catch and effort, Gross Value of Production; Department of Agriculture and Fisheries, 2022c; *BDO EconSearch*, 2023) and it incorporates a diverse range of fishing operations targeting prawns, scallops, bugs and squid. However, the fishery displays a high degree of regional variability in terms of the species being targeted and areas of operation. This variability is reflected within the ECOTF harvest strategy program and in legislative requirements surrounding gear configurations, vessel restrictions and spatial/temporal closures (Department of Agriculture and Fisheries, 2021e; d; f; g; h).

The ECOTF has been the subject of three previous, comprehensive Ecological Risk Assessments (ERA). The first ERA was completed in 2012 and examined the risk posed by trawl fishing activities within the Great Barrier Reef Marine Park (GBRMP; Pears *et al.*, 2012b). This assessment was followed by a complementary ERA examining the risk posed by trawl fishing in southern Queensland and the *River and Inshore Beam Trawl Fishery* (Jacobsen *et al.*, 2015). Both assessments were based on a more conservative qualitative ERA methodology (Astles *et al.*, 2006; Astles *et al.*, 2009). The third trawl ERA examined the risk posed to elasmobranchs in southern Queensland using the quantitative *Sustainability Assessment for Fishing Effects* (SAFE; Zhou & Griffiths, 2008; Zhou *et al.*, 2011; Campbell *et al.*, 2017). As they were all regionally specific, none of the three previous assessments considered risk across the entire ECOTF.

On 17 December 2021, the ECOTF was accredited as a Wildlife Trade Operation (WTO) under Part 13A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; Department of Climate Change Energy the Environment and Water, 2021). Condition 8 of this approval requires an ERA to be completed for the ECOTF and for it to be published by 30 November 2023. This condition requires the assessment to consider risk at both a whole-of-fishery and regional level.

The completion of this report and the supporting Scoping Study (Department of Agriculture and Fisheries, 2023) fulfills key aspects of Condition 8 of the ECOTF WTO (Department of Climate Change Energy the Environment and Water, 2021). It also sets out a new, more adaptive risk assessment strategy for the ECOTF. This strategy prioritised assessments for species that have ongoing conservation concerns and establishes an ERA framework that can be built on through time to include additional species and new assessment priorities.

2 Objective

The objective of the ECOTF SOCC ERA is to establish a baseline of risk assessments for a range of non-target species (Department of Agriculture and Fisheries, 2018b). It identifies aspects within each species' biological and fishery impact profile that make it more vulnerable to trawl fishing activities. The aim of this report being to translate these vulnerabilities into a rating that can be used to inform management on the risks posed by trawl fishing activities (Hobday *et al.*, 2007).

The outputs of this assessment provide insight into a) species that are exposed to higher levels of risk from trawl fishing activities and b) the key drivers of risk.[1] For some species, risk ratings assigned in this assessment will be more relevant to the current fishing environment (*i.e.* real risks). For others, this risk may not come to fruition unless there is a notable change or divergence from the current fishing environment (*i.e.* potential risks). Similarly, the ERA may result in species being assigned higher risk ratings due to biological constraints despite fisheries-related risks being managed within the current fishing environment. Therefore, it should not be automatically assumed that all vulnerabilities/risks can or need to be addressed through a fisheries management framework. The above factors increase the importance of understanding the key drivers of risk for each species, how they are managed within the current fishing environment and the need/necessity of implementing additional risk-management strategies.

As it considers risk across the entire ECOTF, the outputs of this assessment may not fully reflect what is occurring at a regional level (Department of Agriculture and Fisheries, 2021d; h; f; g; e). To address these deficiencies, the ECOTF SOCC ERA will be supported by an additional report examining inter-regional risk variability. This secondary assessment, separate to this report, will examine the likelihood of the risk eventuating within each of the management regions, considering the distribution of each species under the current fishing environment (e.g. effort distributions, regional management etc.; Department of Agriculture and Fisheries, 2021d; h; f; g; e).

3 Scope

3.1 ERA framework

In Queensland, ERAs have previously been developed on an as-needs basis and often employed alternate methodologies. This process has now been formalised as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* and risk assessments are being completed in accordance with the *Queensland Ecological Risk Assessment Guideline* (the Guideline; Department of Agriculture and Fisheries, 2017a; Department of Agriculture and Fisheries, 2018b). The Guideline was released in March 2018 and provides the framework to transition a fishery through a series of ERAs with increasingly progressive data requirements. This framework includes a qualitative whole-of-fishery (Level 1) assessment, a semi-quantitative species-specific (Level 2) assessment and a fully quantitative (Level 3) assessment (Department of Agriculture and Fisheries, 2018b).

A Level 1 ERA provides a broad-scale assessment of the key drivers of risk for each fishery and the ecological components most likely to experience an undesirable event. The primary purpose of a Level 1 assessment is to identify the key fishing activities in each fishery (*e.g. harvesting*, *discarding*, *contact without capture etc.*) and the risk they pose to broader ecological components (*e.g. target species*, *bycatch*, *marine habitats* and *ecological processes*). In the ECOTF, these broader risks are well understood and documented across various large-scale research projects (e.g. Wassenberg & Hill, 1989; Hill & Wassenberg, 1990; Poiner *et al.*, 1998; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Pitcher *et al.*, 2017; Pitcher *et al.*, 2022). This research negates the need to undertake a Level 1 ERA

[1] *A key caveat of this assessment being that the assignment of a high-risk rating does not automatically indicate that a species is experiencing an unsustainable level of interactions. It does, however, indicate that a species has an element or elements within its risk profile which elevate its risk within the ECOTF. In terms of mitigating against this, specific species may benefit from further monitoring or management intervention.*

and, accordingly, the ECOTF was progressed directly to a species-specific or Level 2 assessment (Department of Agriculture and Fisheries, 2018b).

Due to the complexity of the fishery, the ECOTF ERA update will be developed using a staged assessment approach. A staged ERA approach has been used to great effect in other fisheries (Department of Agriculture and Fisheries, 2022a) and prioritises assessments for key species or species complexes. Phase 1 of the ECOTF ERA (this report) focuses specifically on species classified as *Threatened, Endangered and Protected* (TEP) and a range of non-target sharks, stingrays, stingarees and skates. Herein referred to as '*Species of Conservation Concern'* or SOCC, these species are often the focus of discussions surrounding the impact of the fishery on non-target species (Department of Agriculture and Fisheries, 2020c).

The ECOTF SOCC ERA will be built on through subsequent assessments examining the risk posed to other bycatch species and, where and when appropriate, species retained as key targets and byproduct. The scope and extent of these future assessments will depend on a range of factors including risk mitigation strategies implemented as part of the harvest strategy program (Department of Agriculture and Fisheries, 2021d; h; f; g; e) and the outputs of initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018a; 2020c; Queensland Government, Undated-a).

3.2 Fishery context

The ECOTF SOCC ERA considered all otter trawl fishing activities conducted under the T1, T2, M1 and M2 fishery symbols (Department of Agriculture and Fisheries, 2023).[2] Unlike previous assessments (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017), this ERA takes into consideration the entire (combined) ECOTF effort footprint. Of the four symbols being considered, most otter trawl catch and effort is recorded against the T1 and T2 fishery symbols. As M1 and M2 symbols are restricted to Moreton Bay, these operations make up a smaller portion of the annual ECOTF catch and effort.

The management regime for the ECOTF has undergone considerable reform since the completion of the three previous ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). The most significant change being the introduction of regional management arrangements underpinned by harvest strategies for the *Northern; Central*; *Southern Inshore*; *Southern Offshore (A and B)*; and *Moreton Bay* regions (Department of Agriculture and Fisheries, 2021e; d; f; g; h). These harvest strategies, among other things, establish regional effort limits, define decision rules/trigger limits for the sustainable management of harvested species and mechanisms for the ongoing monitoring and management of ecological risk.

A key objective of the ECOTF harvest strategy program is to provide an evidence-based approach to the long-term management of target and byproduct species. While the five harvest strategies include provisions to address broader ecological risks, the benefits for non-target species will be more varied and indirect. The distribution of many non-target species also transcends the prescribed boundaries of the five management regions (Department of Agriculture and Fisheries, 2021d; h; f; g; e). From a risk

[2] *The broader East Coast Trawl Fishery incorporates the ECOTF, the River and Inshore Beam Trawl Fishery (RIBTF) and the Fin Fish (Stout Whiting) Fishery. Level 1 ERAs were completed for the RIBTF and the Stout Whiting Fishery in 2019. Neither of the Level 1 ERAs recommended that the fishery be progressed to a species-specific (Level 2) ERA (Department of Agriculture and Fisheries, 2018b; 2019d; c; Walton & Jacobsen, 2019; Walton et al., 2019). The RIBTF and stout whiting fishery were not considered as part of this assessment.*

management perspective, this increases the probability of a species experiencing cumulative fishing pressures and highlights the importance of undertaking a whole-of-fishery assessment.

When and where appropriate, reforms instigated as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* were considered as part of the risk profiles for non-target species. This ensured that assessments retained relevance to the current fishing environment *e.g.* identifying the management region/s where the risk rating is most applicable. As noted, regional risk variability will be given further consideration in a second, stand-alone risk assessment for this fishery. This secondary assessment will take into consideration the outputs of the ECOTF SOCC ERA (this report) and determine the likelihood or probability of the risk coming to fruition within each management region over the short to medium term.

3.3 Species Rationalisation Processes

The ECOTF SOCC ERA focused specifically on species classified as *Threatened*, *Endangered* or *Protected* (TEP) and a subgroup of sharks, skates, stingrays and stingarees (*Class Chondrichthyes, Subclass Elasmobranchii*). The following provides a brief overview of how the preliminary list of species was compiled and rationalised. Refer to Appendices A & B for a more detailed overview of the species rationalisation process including detailed justifications as to why a species was included or omitted from the analysis.

A preliminary list of species was initially compiled and considered for inclusion in the ECOTF SOCC ERA. The framework of the preliminary list was based on the *Threatened, Endangered, Protected Animals* (TEPA) logbook and the former *Species of Conservation Interest* (SOCI) logbook. The TEPA logbook is used by commercial fishers to report interactions with a limited number of non-target species that are subject to mandatory reporting requirements (Queensland Government, 2022a). The TEPA logbook replaced the SOCI logbook in 2021.

This preliminary list of TEP species was expanded through a review of Commonwealth and State legislation (*e.g.* the *Environment Protection and Biodiversity Conservation Act 1999, Fisheries Declaration 2019*, the *Nature Conservation Act 1992*) and international conventions with the potential to influence fishing activities in Queensland (*e.g.* 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]). Additional information for the elasmobranch complex was sourced from the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021) and key reference material such as *Rays of the World* (Last *et al*., 2016b) and *Sharks and Rays of Australia* (Last & Stevens, 2009). For completeness the preliminary species list was cross-referenced with ERAs compiled for the Great Barrier Reef Marine Park (Pears *et al.*, 2012b) and southern Queensland (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). This ensured that all species with previous risk assessments were considered for inclusion in the updated ECOTF ERA.

Once compiled, the preliminary species list was subject to a final rationalisation process. The full detail of the rationalisation steps used has been provided in Appendix A. However, key considerations of this process included the extent of the overlap between the species distribution and the trawl effort footprint, the interaction/encounterability potential, the level of concern surrounding the species / species complex, and the effectiveness of bycatch mitigation strategies already implemented in the fishery *e.g.* Turtle Excluder Device (TED) effectiveness (Appendix B). When and where appropriate, targeted consultation was undertaken with experts to further refine the list of species to be included in the ECOTF SOCC ERA (Appendix B).

3.4 Information sources / baseline references

Where possible, baseline information on the life history constraints and habitat preferences for each species was obtained from peer-reviewed articles and literature. In the absence of peer-reviewed data, additional information was sourced from grey literature and publicly accessible databases such as *FishBase* (https://www.fishbase.org.au/v4), *Fishes of Australia* (https://fishesofaustralia.net.au/), *Atlas of Living Australia* (https://www.ala.org.au/), and the *IUCN Red List of Threatened Species* (https://www.iucnredlist.org/). Additional information including the distribution of endangered species was obtained through the *Species Profile and Threats Database* (Department of Climate Change, Energy, Environment and Water [DCCEEW], https://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl) and resources associated with the management and regulation of marine national parks *e.g.* the *Great Barrier Reef Marine Park*, *Moreton Bay Marine Park* and *Great Sandy Marine Park.* Where possible regional distribution maps were sourced for direct comparisons with effort distribution data (Whiteway, 2009).

For the elasmobranch complex, additional core references included *Rays of the World (Last et al., 2016b)*, *Sharks and Rays of Australia* (Last & Stevens, 2009), *Sharks of the World: A Complete Guide* (Ebert *et al.*, 2021) and the *Action Plan of Australian Sharks and Rays* (Kyne *et al.*, 2021). For marine turtles, core references included detailed biological reviews (Limpus, 2007b; a; 2008b; c; a; 2009), the *Queensland Marine Turtle Conservation Strategy 2021–2031* (Department of Environment and Science, 2021) and associated recovery plans (Department of the Environment and Energy, 2017). Fewer information sources were available for syngnathids (*e.g.* Seahorses: A Life-Size Guide to Every Species; Lourie, 2016) and were more limited for Australian sea snakes.

Fisheries data was obtained through the fisheries logbook program (including the *Threatened, Endangered, Protected Animals* or TEPA logbook, previously known as the *Species of Conservation Interest* or SOCI logbook), a previous *Fisheries Observer Program* (FOP), the *Fishery Monitoring Program* (FMP)[3] and the *Statewide Recreational Fishing Survey* (Webley *et al.*, 2015; Department of Agriculture and Fisheries, 2021a; Teixeira *et al.*, 2021).

4 Methodology

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

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

In the PSA, the level of risk (low, medium or high) is defined through a finer scale assessment of the life-history constraints of a species (*Productivity*), the potential for a species to interact with the fishery and the associated consequences (*Susceptibility*). The alternative, SAFE, 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.*, 2011; Zhou *et al.*, 2016). As SAFE is a quantitative assessment, the method provides an absolute measure of risk or a continuum of values that can be compared directly to the above reference points (Hobday *et al.,* 2011). This contrasts with the PSA which provides an indicative measure (low, medium, high) of the potential risk (Hobday *et al.,* 2007).

While research has shown that SAFE produces fewer false-positives, data thresholds for this method tend to be higher (Zhou *et al.*, 2009; Hobday *et al.*, 2011). For this reason, the PSA is the preferred method for species with insufficient data and/or species with biological characteristics (*e.g.* colonial breeders) that are not suited to SAFE (Australian Fisheries Management Authority, 2017). While not universal, this has typically been the case for protected species (especially mammals, reptiles and seabirds) and marine invertebrates (Australian Fisheries Management Authority, 2017). SAFE has been used with more effect as a risk assessment tool for teleosts and elasmobranchs, including within the ECOTF (e.g. Zhou & Griffiths, 2008; Campbell *et al.*, 2017; Sporcic *et al.*, 2021; Australian Fisheries Management Authority, 2023a).

In the ECOTF, one of the challenges of undertaking a whole-of-fishery ERA relates to the diversity of the species being assessed and the suitability of the method being applied. The PSA is the most appropriate method for assessing trawl-related risks for marine turtles, sea snakes and syngnathids (Hobday *et al.*, 2007; Scandol *et al.*, 2009; Department of Agriculture and Fisheries, 2018b). However, the SAFE method can and has been applied effectively to elasmobranch species caught as prawn trawl bycatch in southern Queensland (Campbell *et al.*, 2017).

To address the above differential, some consideration was given to applying a composited assessment model to the ECOTF. Under this scenario, elasmobranchs would be assessed using SAFE with all remaining complexes assessed using the PSA. While applying a composite ERA approach had merit, the decision was made to first assess all species using the PSA. This maintains a level of consistency across the ERA and ensures all species were assessed using a standardised set of criteria. This was considered to be of particular importance in the ECOTF as the methodology applied under the ERA Guidelines differs from that previously used in this fishery (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). Once completed, the outcomes of the PSA will be used to determine the need to undertake further assessment using SAFE.

4.1 Productivity & Susceptibility Analysis (PSA)

The PSA was largely aligned with the ERAEF approach employed for Commonwealth fisheries (Hobday *et al.*, 2011; Australian Fisheries Management Authority, 2017). 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 at sexual maturity, age at sexual maturity*, *maximum size, maximum age*, *fecundity*, *reproductive strateg*y and *trophic level* (Table 1). As the ECOTF interacts with a diverse array of species / species complexes, criteria used to assess *maximum size* and *reproductive strategy* incorporated slight nuances or variations. For *maximum size*, the applied variations accounted for differences in methods used to measure the size of batoids (disc width, DW), sea snakes (snout-vent length, SVL), syngnathids (height, HT) and turtles (curved carapace length, CCL). Similarly, criteria used to assess *reproductive strategy* was amended to include the addition of brooders (Table 1). Criteria used to assign each attribute a score of low (1), medium (2) or high (3) risk are outlined in Table 1.

Table 1. *Scoring criteria and cut-off scores for the productivity component of the Productivity & Susceptibility Analysis (PSA) utilised as part of the ECOTF SOCC ERA. Attributes and scores/criteria were mostly aligned with the national (ERAEF) approach (Hobday et al., 2011).*

Attribute	**High Productivity (Low risk, score = 1)**	**Medium Productivity (Medium risk, score = 2)**	**Low Productivity (High risk, score = 3)**
Age at sexual maturity	<5 years	5–15 years	>15 years
Maximum age*	<10 years	10–25 years	>25 years
Fecundity**	>20,000 eggs per year	100–20,000 eggs per year	<100 eggs per year
Maximum size*			
Sharks, skates, turtles, sawfish and sea snakes (TL/CCL/SVL)	<100 cm	100–300 cm	>300 cm
Batoids and syngnathids (DW or Ht)	<50 cm	50–100 cm	>100 cm
Size at sexual maturity*	<40 cm	40–200 cm	>200 cm
Reproductive strategy	Broadcast spawner	Demersal egg layer	Live bearer (& birds) / brooders
Trophic Level	<2.75	2.75–3.25	>3.25

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

For the *susceptibility* component of the PSA, ERAEF attributes were used as the baseline of the assessment and included *availability*, *encounterability, selectivity* and *post-interaction mortality* (Hobday *et al.*, 2007; Hobday *et al.*, 2011).[4] In the ECOTF, *sustainability / conservation status* was included as a fifth *susceptibility* attribute to reduce the potential influence of false-positive results. The inclusion of this attribute was done in consultation with the *Trawl Fishery Working Group* (Department of Agriculture and Fisheries, 2020c). The following provides an overview of the *susceptibility* attributes used in the PSA with Table 2 outlining 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 jurisdiction of the

[4] *In previous assessments and the ERAEF framework, this attribute is referred to as post-capture mortality. In the ECOTF SOCC ERA, the name of the attribute was changed to post-interaction mortality as it provides a better representation of the interactions that occur between SOCC and the ECOTF operations.*

fishery. To account for inter-annual variability and potential effort anomalies (*e.g.* disruptions due to the COVID-19 pandemic), percentage overlaps were calculated for five seasons (2017 to 2021 inclusive). The highest overlap percentage value was then used as the basis of the *availability* assessment.

Regional distribution maps were sourced from the *Atlas of Living Australia* (Atlas of Living Australia, 2022), the *IUCN Red List of Threatened Species* (International Union for Conservation of Nature's Red List of Threatened Species, 2022) and the *CAAB–Codes for Australian Aquatic Biota* (Commonwealth Scientific and Industrial Research Organisation, 2022). As elasmobranch and syngnathid distributions varied, the collated data was cross-referenced with principal information sources to ensure consistency with the most up-to-date information (Lourie, 2016; Kyne *et al.*, 2021). Information on the distributions of the six marine turtles was more extensive and regional maps sourced from the *Atlas of Living Australia* were accepted as current. Similarly, maps contained in the *IUCN Red List of Threatened Species* database were adopted as baseline references for sea snake distributions (International Union for Conservation of Nature's Red List of Threatened Species, 2022).

Where possible, uncertainty surrounding the distribution of a species / species complex was addressed through external consultation. In instances where a reliable distribution map was unavailable or when the map did not adequately match the principal information source, *availability* scores were based on the broader geographic distribution assessment described in Table 2 (Hobday *et al.*, 2007; Hobday *et al.*, 2011). A full summary of the overlap percentages used to assess *availability* has been provided in Appendix C.

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

- **Selectivity**—*Selectivity* is effectively a measure of the likelihood that a species will get caught in the apparatus if encountered. Factors that will influence *selectivity* include the fishing method, the apparatus used and the body size of the species in relation to the gear. In the ECOTF, *selectivity* criteria were based on Turtle Excluder Device (TED) and Bycatch Reduction Device (BRD) effectiveness. Susceptibility to capture correlates directly with species morphology, and individuals are more likely to experience contact without capture events if there is a high level of TED and/or BRD effectiveness (Brewer *et al.*, 2006; Griffiths *et al.*, 2006; Campbell *et al.*, 2020).

  To account for the vast difference in morphology among species, *selectivity* criteria were applied at a complex level. For elasmobranchs, assessments were refined using information on their morphology and TED effectiveness (Brewer *et al.*, 2006; Griffiths *et al.*, 2006; Campbell *et al.*, 2020). A second, more-generalised definition was required for turtles, sea snakes and syngnathids (Table 2). In each instance, assessments considered information on TED/BRD effectiveness in the ECOTF and adjacent jurisdictions, namely the *Northern Prawn Fishery* (NPF).

Table 2. *Scoring criteria and cut-off scores for the susceptibility component of the Productivity & Susceptibility Analysis (PSA). Where possible, attributes and the corresponding scores/criteria were aligned with national (ERAEF) approach (Hobday et al., 2011).*

Attribute	**Low susceptibility (Low risk, score = 1)**	**Medium susceptibility (Medium risk, score = 2)**	**High susceptibility (High risk, score = 3)**
Availability			
Option 1. Overlap of species range with fishery.	<10% overlap.	10–30% overlap.	>30% overlap.
Option 2. Global distribution & stock proxy considerations.	Globally distributed.	Restricted to same hemisphere / ocean basin as fishery.	Restricted to same country as fishery.
Encounterability			
Option 1. Habitat type	Low overlap with fishery area.	Medium overlap with fishery area.	High overlap with fishery area.
Option 2. Depth check	Low overlap with fishery area.	Medium overlap with fishery area.	High overlap with fishery area.
Selectivity			
Selectivity (sharks and batoids)	Species *size at maturity* (>100 cm TL/DW)	Species *size at maturity* (36–100 cm DW or 50–100 cm TL)	Species *size at maturity* (<36 cm DW or <50 cm TL)
Selectivity (sea snakes, turtles and syngnathids)	Species demonstrates high TED/BRD effectiveness	Species demonstrates moderate TED/BRD effectiveness	Species demonstrates low TED/BRD effectiveness
Post-interaction mortality	Evidence of good post-interaction survival. *E.g.* low mortality	Evidence of moderate post-interaction survival.	Retained species or data deficient or evidence of poor post-interaction survival. *E.g.* high mortality
Sustainability / Conservation assessment	A species assigned a status of *Least Concern*	A species assigned a status of *Near Threatened*	Negative sustainability trend and/or assessed as *Vulnerable, Endangered, Critically Endangered or Data Deficient*

- **Post-interaction mortality**—*Post-interaction mortality* (PIM) is one of the more difficult attributes to assess in a marine environment; particularly for species that are discarded as bycatch. This situation is compounded by the fact that some species will experience 'contact without capture' events where individuals are a) excluded from entering the codend of the net via the TED or b) are able to escape the codend through the BRD. These types of interactions often go unobserved, are difficult to quantify and account for in a broader risk assessment. These factors are less of an issue for retained species (target and byproduct) as the ERAEF assumes that all are retained for sale *i.e.* PIM = 100 per cent (Hobday *et al.*, 2007; Hobday *et al.*, 2011).

  In the ECOTF, assessments of *post-interaction mortality* needed to consider the available data and confounding factors such as the (current) inability to validate data collected through the TEPA logbook (Queensland Government, 2022a). This was reflected in the assessment criteria for *post-interaction mortality* (Table 2). Where possible, the assessment used data on the PIM of released animals. If not available, the PSA considered data and information on landing fates or the state of the animal when released/discarded (*e.g.* alive, moribund or dead).

- **Sustainability/Conservation assessment**—*Sustainability* considers the various assessments conducted on the conservation status or sustainability of a species. Where possible stock assessments and indicative sustainability evaluations (*e.g. National Status of Australian Fish Stocks*) were prioritised (Simpfendorfer *et al.*, 2019a; Department of Agriculture and Fisheries, 2020b; Fisheries Research and Development Corporation, 2021b; a). In the absence of a stock assessment or analogous study, the conservation status and extinction risk classifications were taken into consideration.[5]

  Conservation status assessments involving elasmobranchs were sourced from the *Action Plan for Australian Sharks and Rays* (Kyne *et al.*, 2021). The *IUCN Red List of Threatened Species* and the *Species Profile and Threats Database* (SPRAT) were used for the remaining subgroups (Department of Climate Change, Energy, the Environment, and Water, International Union for Conservation of Nature's Red List of Threatened Species, 2022; Undated). When and where appropriate, sustainability and conservation status assessments considered species-specific listings under the EPBC Act (Cth) and the *Nature Conservation Act 1992* (Qld).

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 1 and Table 2 (Patrick *et al.*, 2010; Hobday *et al.*, 2011; Brown *et al.*, 2013). 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 results. The inherent trade off with this approach is that the ERA outputs can be conservative and may include a number of false positives (Zhou *et al.,* 2016). Issues associated with false positives and the overestimation of risk will be examined further as part of the *Residual Risk Analysis* (RRA).

[5] *The IUCN Red List assessment provides a classification of the extinction risk for each species. Categories applied under IUCN Red List assessment criteria are similar to that used under the EPBC Act (International Union for Conservation of Nature's Red List of Threatened Species, 2022).* For the purpose of this ERA, both IUCN extinction risk classifications and conservation listings (*e.g.* under the *EPBC Act or Nature Conservation Act 1992*) were used and referenced as the 'conservation status' of a species.

Risk ratings (*R*) were based on a two-dimensional graphical representation of the average *productivity* (*x*-axis) and *susceptibility* (*y*-axis) scores (Fig. 1). Cross-referencing the *productivity* (additive) and *susceptibility* (multiplicative/geometric) 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 PSAs 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 (Hobday *et al.*, 2007; Brown *et al.*, 2013; Department of Agriculture and Fisheries, 2022a).

As the PSA includes an *uncertainty* assessment and RRA (refer to section *4.3 Uncertainty* and *4.4 Residual Risk Analysis*), attribute scores assigned at this stage of the assessment are subject to change. To this extent, scores assigned as part of the initial PSA can be viewed as a measure of the potential risk with the final risk score determined at the completion of the RRA.

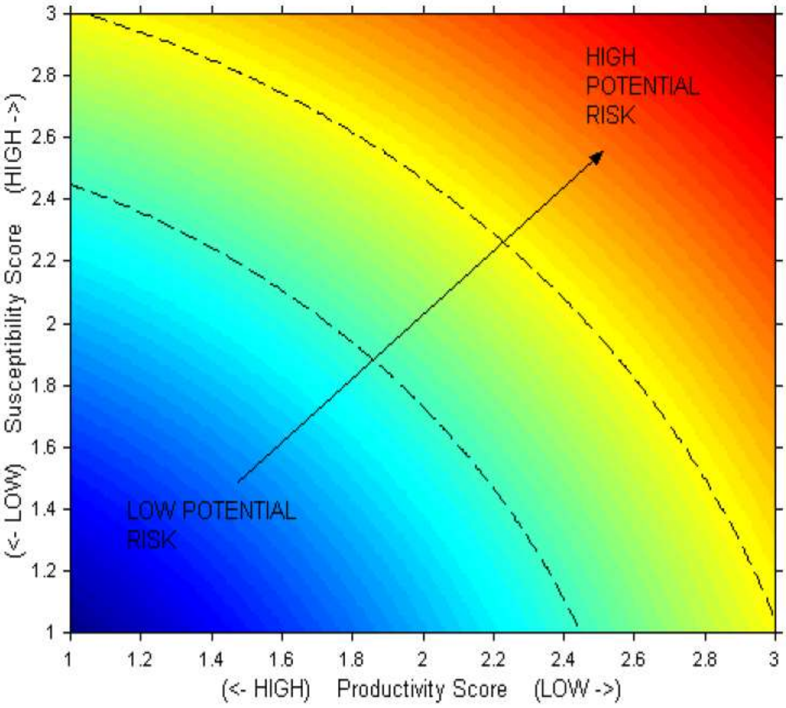

Figure 1. *Productivity & Susceptibility Analysis (PSA) plot demonstrating the two-dimensional space on which species units are plotted. PSA scores for species units represent the Euclidean distance or the distance between the origin and the productivity (x axis), susceptibility (y axis) intercept (excerpt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

4.3 Uncertainty

A number of factors increase the level of uncertainty within a risk assessment including the use of imprecise estimates, missing data, averages and proxies. The PSA methodology also includes precautionary elements that have the potential to increase uncertainty *e.g.* assigning a default high-risk score for any attributes with missing data (Hobday *et al.,* 2011). In the ECOTF SOCC ERA (Department of Agriculture and Fisheries, 2018b), uncertainty is examined through a baseline assessment of each risk profile to determine the proportion of attributes assigned precautionary risk ratings. The premise being that the risk profiles of species with greater data deficiencies are more likely to fall on the conservative side of the spectrum. In these instances, it may be more appropriate to address these risks through additional monitoring, research and initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a).

4.4 Residual Risk Analysis

Precautionary elements in the PSA combined with an undervaluation of some management arrangements can result in more conservative risk assessments and a higher number of false positives. Similarly, the effectiveness of some attributes may be exaggerated and subsequent risks could be underestimated (false negatives). To address these issues, PSA results were subjected to a *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). The RRA is specifically designed to account for data deficiencies and false-positive results; two of the key challenges encountered in the previous qualitative ERAs (pers. comm. I. Jacobsen; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). This provides management with greater capacity to differentiate between potential and actual risks (Department of Agriculture and Fisheries, 2018b).

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. 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, 2018b).

In instances where the RRA resulted in an amendment to the preliminary score, full justifications were provided (Appendix D) and included the guidelines in which the amendments were considered. A brief summary of each guideline and the RRA considerations is provided in Table 3.

Table 3. *Guidelines used to assess residual risk and a brief overview of factors taken into consideration. 'Summary' represents a modified excerpt from the revised AFMA Ecological Risk Assessment, RRA Guidelines (Australian Fisheries Management Authority, 2018).*

Guidelines	Summary
Guideline 1*: Risk rating due to missing, incorrect or out of date information.*	Considers if *susceptibility* and/or *productivity* attribute data for a species is missing or incorrect for the fishery assessment and is correct using data from a trusted source or another fishery.
Guideline 2*: Additional Scientific assessment & consultation.*	Considers any additional scientific assessments on the biology or distribution of the species and the impact of the fishery. This may include verifiable accounts and data raised through key consultative processes, including but not limited to, targeted consultation with key experts and oversight committees established as part of the *Queensland Sustainable Fisheries Strategy 2017–2027 e.g. Fisheries Working Groups* and the *Sustainable Fisheries Expert Panel*.
Guideline 3*: At risk with spatial assumptions.*	Provides further consideration to the spatial distribution data, habitat data and any assumptions underpinning the assessment.

Guidelines	Summary
Guideline 4*: At risk in regards to level of interaction / capture with a zero or negligible level of susceptibility.*	Considers observer or expert information to better calculate susceptibility for those species known to have a low likelihood or no record of interaction nor capture with the fishery.
Guideline 5*: Effort and catch management arrangements for Target & Byproduct species.*	Considers current management arrangements based on effort and catch limits set using a scientific assessment for key species.
Guideline 6*: Management arrangements to mitigate against the level of bycatch.*	Considers management arrangements 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.

5 Results

5.1 PSA

Cross-referencing the expanded SOCC list (*n* = 161 species) with the ECOTF effort footprint produced a list of 62 species that were included in Phase 1 of the ECOTF SOCC ERA (Appendices A & B). Of the subgroups identified for inclusion in the ECOTF SOCC ERA, batoids (stingrays, skates, stingarees, guitarfish, sawfish) had the highest representation (*n* = 22 species), followed by sea snakes (*n* = 13 species), sharks (*n* = 12 species), syngnathids (*n* = 9 species) and marine turtles (*n* = 6 species; Appendix B). Some of these species may have low or infrequent interactions with the ECOTF and were included in the assessment as a precautionary measure (Appendix B).

Based on the prescribed criteria, all but one of the SOCC registered *productivity* scores greater than, or equal to 2.00 (*average* = 2.40). When compared, the White's seahorse (*Hippocampus whitei*, 1.71) had the lowest *productivity* score while the Australian whipray (*Himantura australis*) and the green sawfish (*Pristis zijsron*) registered an assessment high score of 2.86 (Table 4). Of the six *productivity* attributes assessed, *trophic level* (*average* = 2.93), *fecundity* (*average* = 2.90) and *reproductive strategy* (*average* = 2.72) had the highest overall average score. Conversely, *maximum size* and *size at sexual maturity* had the lowest average at 1.56 and 1.73 respectively (Table 4). In the *susceptibility* analysis, all SOCC registered scores of between 1.43 and 3.00 at an average of 2.17 (Table 4). Five species were assigned the maximum score across all five *susceptibility* attributes; two stingarees, one skate and two syngnathids (Table 4). One attribute, *encounterability*, was assigned the highest risk rating (3.00) across all 62 species. The *sustainability* attribute showed the highest degree of variability (*average* = 1.77, *range* = 1:00–3:00; Table 4).

When the *productivity* and *susceptibility* scores were taken into consideration, syngnathids (*average* = 3.47) had the highest preliminary risk score, followed by batoids (*average* = 3.33), sharks (*average* = 3.24), sea snakes (*average* = 3.11) and turtles (*average* = 2.94). Based on these results 31 species had preliminary PSA scores that fell within the high-risk category, 30 species in the medium-risk category and one in the low-risk category (Table 4).

Table 4. *Preliminary risk ratings compiled as part of the Productivity & Susceptibility Analysis (PSA) and the scores assigned to each attribute used in the assessment. Final PSA values are calculated using the scores assigned to each attribute and in accordance with the methods outlined in Hobday et al. (2007). Pink boxes with '*' represent attributes that were assigned precautionary scores due to an absence of species-specific data.*

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity (additive)	Availability	Encounterability	Selectivity	Post-interaction mortality	Sustainability / Conservation	Susceptibility (multiplicative)	*PSA score*
Marine Turtles																
Loggerhead turtle	*Caretta caretta*	3	3	2	2	2	2	3	2.43	2	3	1	1	3	1.78	**3.01**
Green turtle	*Chelonia mydas*	3	3	3	2	2	2	1	2.29	2	3	1	1	3	1.78	**2.90**
Leatherback turtle	*Dermochelys coriacea*	3	3	2	2	2	2	3	2.43	2	3	1	1	3	1.78	**3.01**
Hawksbill turtle	*Eretmochelys imbricata*	3	3	3	1	2	2	2	2.29	2	3	1	1	3	1.78	**2.90**
Olive ridley turtle	*Lepidochelys olivacea*	2	3	2	1	2	2	3	2.14	2	3	1	1	3	1.78	**2.79**
Flatback turtle	*Natator depressus*	3	3	3	1	2	2	3	2.43	2	3	1	1	3	1.78	**3.01**
Syngnathids																
Tiger pipefish	*Filicampus tigris*	3*	3*	2	1	1	3	3	2.29	3	3	3*	3*	1	2.41	**3.32**
Spiny seahorse	*Hippocampus spinosissimus*	3*	3*	3*	1	1	3	3	2.43	2	3	3*	3*	3	2.77	**3.68**
Great seahorse	*Hippocampus kelloggi*	3*	3*	3*	1	1	3	3	2.43	2	3	3*	3*	3	2.77	**3.68**
White's seahorse	*Hippocampus whitei*	1	1	2	1	1	3	3	1.71	3	3	3*	3*	3	3.00	**3.46**
Duncker's pipehorse	*Solegnathus dunckeri*	3*	3*	3	2	1	3	3	2.57	3	3	3*	3	3	3.00	**3.95**
Pallid pipehorse	*Solegnathus hardwickii*	3*	3*	3	2	2	3	3	2.71	1	3	3*	3	3	2.41	**3.63**

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity (additive)	Availability	Encounterability	Selectivity	Post-interaction mortality	Sustainability / Conservation	Susceptibility (multiplicative)	*PSA score*
Bentstick pipefish	*Trachyrhamphus bicoarctatus*	3*	3*	3*	1	1	3	3	2.43	2	3	3*	3*	1	2.22	**3.29**
Straightstick pipefish	*Trachyrhamphus longirostris*	3*	3*	3*	1	1	3	3	2.43	1	3	3*	3*	1	1.93	**3.10**
Ribboned pipefish	*Haliichthys taeniophorus*	3*	3*	3*	1	1	3	3	2.43	1	3	3*	3	1	1.93	**3.10**
Sea snakes																
Reef shallows sea snake	*Aipysurus duboisii*	1	1	3	2	2	3	3*	2.14	3	3	3*	2	1	2.22	**3.09**
Mosaic sea snake	*Aipysurus mosaicus*	1	2	3	1	2	3	3*	2.14	2	3	3*	2	1	2.05	**2.96**
Olive sea snake	*Aipysurus laevis*	2	2	3	2	2	3	3*	2.43	2	3	3*	2	1	2.05	**3.18**
Spine-bellied sea snake	*Hydrophis curtus*	1	1	3	2	2	3	3*	2.14	2	3	3*	1	1	1.78	**2.79**
Elegant sea snake	*Hydrophis elegans*	1	2	3	2	2	3	3*	2.29	3	3	3*	2	1	2.22	**3.19**
Spectacled sea snake	*Hydrophis kingii*	3*	3*	3	2	2	3	3*	2.71	2	3	3*	3	1	2.22	**3.51**
Turtle-headed sea snake	*Emydocephalus annulatus*	1	2	3	2	2	3	3*	2.29	2	3	3*	1	1	1.78	**2.90**
Olive-headed sea snake	*Hydrophis major*	1	2	3	2	2	3	3*	2.29	2	3	3*	2	1	2.05	**3.07**
Small-headed sea snake	*Hydrophis macdowelli*	3*	3*	3	1	2	3	3*	2.57	2	3	3*	2	1	2.05	**3.29**
Spotted sea snake	*Hydrophis ocellatus*	1	2	3	2	2	3	3*	2.29	2	3	3*	2	1	2.05	**3.07**
Horned sea snake	*Hydrophis peronii*	1	1	3	2	2	3	3*	2.14	2	3	3*	1	1	1.78	**2.79**
Beaked sea snake	*Hydrophis zweifeli*	1	3*	3	2	2	3	3*	2.43	2	3	3*	1	3	2.22	**3.29**
Stoke's sea snake	*Hydrophis stokesii*	1	2	3	2	2	3	3*	2.29	3	3	3*	3	1	2.41	**3.32**
Sharks																

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity (additive)	Availability	Encounterability	Selectivity	Post-interaction mortality	Sustainability / Conservation	Susceptibility (multiplicative)	*PSA score*
Collar carpetshark	*Parascyllium collare*	3*	3*	3*	1	2	2	3	2.43	3	3	2	3*	1	2.22	**3.29**
Brownbanded bambooshark	*Chiloscyllium punctatum*	1	2	2	2	2	2	3	2.00	2	3	2	1	1	1.64	**2.59**
Colclough's shark	*Brachaelurus colcloughi*	3*	3*	3	1	2	3	3	2.57	3	3	2	3*	3	2.77	**3.78**
Crested hornshark	*Heterodontus galeatus*	3*	2	3	2	2	2	3	2.43	3	3	2	1	1	1.78	**3.01**
Eastern angelshark	*Squatina albipunctata*	3*	3*	3	2	2	3	3	2.71	2	3	2	3*	3	2.55	**3.72**
Eastern banded catshark	*Atelomycterus marnkalha*	3*	3*	3*	1	1	2	3	2.29	2	3	3	2	1	2.05	**3.07**
Zebra shark	*Stegostoma tigrinum*	3*	3*	3	2	2	2	2	2.43	2	3	1	3	1	1.78	**3.01**
Piked spurdog	*Squalus megalops*	3	3	3	1	2	3	3	2.57	2	3	3	3*	1	2.22	**3.40**
Australian weasel shark	*Hemigaleus australiensis*	3*	3*	3	2	2	3	3	2.71	2	3	2	3	1	2.05	**3.40**
Pale Spotted Catshark	*Asymbolus pallidus*	3*	3*	3*	1	1	2	3	2.29	1	3	3	3*	1	1.93	**2.99**
Grey spotted catshark	*Asymbolus analis*	3*	3*	3*	1	2	2	3	2.43	3	3	3	2	1	2.22	**3.29**
Orange spotted catshark	*Asymbolus rubiginosus*	3*	3*	3*	1	1	2	3	2.29	3	3	3	3	1	2.41	**3.32**
Batoids																
Australian butterfly ray	*Gymnura australis*	3*	3*	3	2	2	3	3	2.71	2	3	2	3	1	2.05	**3.40**
Yellowback stingaree	*Urolophus sufflavus*	3*	3*	3	1	1	3	3	2.43	3	3	3	1	3	2.41	**3.42**
Patchwork stingaree	*Urolophus flavomosaicus*	3*	3*	3	1	1	3	3	2.43	2	3	3	3*	1	2.22	**3.29**
Sandyback stingaree	*Urolophus bucculentus*	2	2	3	1	2	3	3	2.29	3	3	3	3*	3	3.00	**3.77**
Kapala stingaree	*Urolophus kapalensis*	3*	3*	3	1	1	3	3	2.43	3	3	3	1	2	2.22	**3.29**

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity (additive)	Availability	Encounterability	Selectivity	Post-interaction mortality	Sustainability / Conservation	Susceptibility (multiplicative)	*PSA score*
Greenback stingaree	*Urolophus viridis*	3*	3*	3	1	1	3	3	2.43	3	3	3	3*	3	3.00	**3.86**
Common stingaree	*Trygonoptera testacea*	3*	3*	3	1	2	3	3	2.57	3	3	3	3	2	2.77	**3.78**
Australian whipray	*Himantura australis*	3*	3*	3	3	2	3	3	2.86	2	3	2	3	1	2.05	**3.52**
Blackspotted whipray	*Maculabatis astra*	2	3	3	2	2	3	3	2.57	2	3	2	1	1	1.64	**3.05**
Brown whipray	*Maculabatis toshi*	3*	3*	3	2	2	3	3	2.71	2	3	2	2	1	1.89	**3.31**
Estuary stingray	*Hemitrygon fluviorum*	2	2	3	2	2	3	3	2.43	2	3	2	1	3	2.05	**3.18**
Coral sea maskray	*Neotrygon trigonoides*	2	2	3	1	1	3	3	2.14	2	3	3	3*	1	2.22	**3.09**
Speckled maskray	*Neotrygon picta*	1	2	3	1	1	3	3	2.00	2	3	3	3	1	2.22	**2.99**
Bottlenose wedgefish	*Rhynchobatus australiae*	2	3	3	2	2	3	3	2.57	2	3	1	1	2	1.64	**3.05**
Eyebrow wedgefish	*Rhynchobatus palpebratus*	2	3	3	2	2	3	3	2.57	1	3	1	1	2	1.43	**2.94**
Eastern shovelnose ray	*Aptychotrema rostrata*	2	2	3	2	2	3	3	2.43	2	3	2	1	2	1.89	**3.08**
Giant guitarfish	*Glaucostegus typus*	2	2	3	2	2	3	3	2.43	2	3	1	3	1	1.78	**3.01**
Sydney skate	*Dentiraja australis*	3*	3*	3*	1	2	2	3	2.43	3	3	3	3	3	3.00	**3.86**
Endeavour skate	*Dentiraja endeavouri*	3*	3*	3*	1	1	2	3	2.29	3	3	3	3*	2	2.77	**3.59**
Argus skate	*Dentiraja polyommata*	2	2	3*	1	1	2	3	2.00	3	3	3	3	1	2.41	**3.13**
Narrow sawfish	*Anoxypristis cuspidata*	1	1	3	3	3	3	3	2.43	1	3	1	3	3	1.93	**3.10**
Green sawfish	*Pristis zijsron*	2	3	3	3	3	3	3	2.86	2	3	1	3	3	2.22	**3.62**

5.2 Uncertainty

Productivity assessments for marine turtles, syngnathids, sea snakes, batoids and sharks were all largely supported by scientific evidence. Of the *productivity* attributes assessed, *age at sexual maturity* and *maximum* age had the largest number of data deficiencies (Table 5). These deficiencies can be linked to the challenges of undertaking biological assessments for species with small populations or geographical ranges *e.g.* defining age and growth through non-lethal methods.

Data deficiencies were most prevalent in risk assessments involving the syngnathids, batoids and sharks; particularly for *maximum age*, *age at sexual maturity* and *fecundity* (Table 4 & 5). While research is limited, syngnathid species with known age and growth information indicate that species can mature within as little as 210 days (Harasti *et al.*, 2012). This suggests that a precautionary high (3) score for *age at sexual maturity* overestimates the risk for these species. The situation surrounding *maximum age* is equally as complicated as *Syngnathidae* longevity estimates fall either side of the five-year limit (Foster & Vincent, 2004). Overall, research on syngnathid biology is limited and this was reflected in the PSA results (Table 4).

While not universal, research on shark and ray age and growth indicates that a high proportion will reach sexual maturity before 15 years (e.g. Cortés, 2000; White & Dharmadi, 2007; Jacobsen & Bennett, 2011; Geraghty *et al.*, 2013; White *et al.*, 2014). This, again, suggests that a precautionary high (3) score overestimates the attribute risk for this subgroup. The situation surrounding *maximum age* is more complex as shark and ray longevity estimates fall either side of the 25-year limit (Table 1). For this attribute, the extent of any (potential) risk overestimation will be dependent on the species in question. Research has shown that elasmobranch *fecundity* levels are typically low with individuals often producing fewer than 20 offspring per year (White *et al.*, 2006; Jacobsen, 2007; Last & Stevens, 2009; White *et al.*, 2014; Last *et al.*, 2016b; Parra *et al.*, 2017a; Parra *et al.*, 2017b; Wells *et al.*, 2019). As this is well below the 100 eggs/offspring criteria limit (Table 1), the use of precautionary scores will not have a significant impact on the risk profiles of the affected species.

Table 5. *Summary of the number of attributes that were assigned a precautionary high (3) score as part of the Productivity & Susceptibility Analysis (PSA) due to data deficiencies.*

	Productivity							Susceptibility				
	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Availability	Encounterability	Selectivity	Post-interaction mortality	Sustainability / Cons. assessment
Species with data	32	32	49	62	62	62	49	62	62	40	46	62
Species missing attribute data	30	30	13	0	0	0	13	0	0	22	16	0
Percentage of unknown information	48%	48%	21%	0%	0%	0%	21%	0%	0%	35%	26%	0%

Of the remaining subgroups, *productivity* assessments involving sea snakes returned a high number of precautionary risk scores (Table 4). Within this subgroup, most of these deficiencies related to an absence of data on trophic levels. However, gaps in the information on sea snake age and growth development also limited the scope of these preliminary assessments (Table 4).

In the *susceptibility* analysis, precautionary ratings were only applied to two attributes across all five subgroups (Table 4). These included *selectivity* and *post-interaction mortality*, with precautionary high-risk ratings applied to 35 per cent and 26 per cent of species respectively (Table 5). These deficiencies were intimately linked with the absence of an effective mechanism to monitor interaction rates, catch compositions and release fates of non-target species. All other scores assigned in the *susceptibility* component were supported by available information (Table 4 & 5).

5.3 Residual Risk Analysis

The ECOTF SOCC ERA covers a wide array of species with varying life-history traits, habitat preferences and information gaps. This complexity can be difficult to account for in the PSA which provides a more rudimentary assessment of risk (Table 4). In the RRA, a number of the risk profiles were refined using additional information and input from key stakeholders (Table 6). In some instances, this information was considered as part of the PSA but could not be explicitly accounted for within the assessment criteria (Table 1 & 2).

The following provides an overview of the changes that were adopted as part of the RRA (Table 6). A full overview of the RRA including the key considerations for each species has been provided in Appendix D.

5.3.1 Marine turtles

Risk profiles for the six marine turtle species were not amended as part of the RRA process (Table 6). Information sets for this complex are reasonably well developed and risk profiles for this subgroup benefited from refinements undertaken in previous ERAs *e.g.* targeted consultation on the suitability and applicability of the biological parameters (Department of Agriculture and Fisheries, 2022a).

5.3.2 Syngnathids

A number of the syngnathids lacked biological data and, as a consequence, were assigned precautionary risk ratings in the *productivity* attribute assessment (Table 4). In the RRA, scores assigned to these attributes were refined with additional input from experts more familiar with Australian populations. These changes resulted in a reduction of the *productivity* score for eight of the nine species (Table 6; Appendix D).

While amendments to the *susceptibility* scores were less substantive, five of the nine species had at least one score amended as part of the RRA (Table 6). As part of the RRA, further consideration was given to the habitats preferred by syngnathid species. This review indicated that the spiny seahorse (*Hippocampus spinosissimus*), great seahorse (*H. kelloggi*), bentstick pipefish (*Trachyrhamphus bicoarctatus*), ribboned pipefish (*Haliichthys taeniophorus*) and White's seahorse (*H. whitei*) are afforded a degree of natural protection. At a whole-of-fishery level, this natural protection was considered sufficient to reduce the score assigned to the *encounterability* attribute (Table 6). The other notable amendment involved *H. whitei* and the availability attribute. Further consultation on the distribution of this species supported a reduction in the score assigned to the *availability* attribute (Table 6; Appendix D).

Risk score reductions implemented as part of the RRA were sufficient to reduce the risk rating of six species from high to medium. A further two species, the straightstick pipefish (*T. longirostris*) and the ribboned pipefish (*H. taeniophorus*) had their risk classification downgraded from medium to low (Table 6).

5.3.3 Sea snakes

The RRA of sea snake risk profiles resulted in all 13 species having at least one attribute score amended (Table 6). While not universal, the majority of these amendments involved attributes that were assigned a precautionary high (3) risk score (Table 4).

Three sea snakes received precautionary ratings for *maximum age* and/or *age at sexual maturity* (Table 4). Consultation undertaken as part of the RRA indicated that these values overestimated the attribute risk. As an alternative, it was recommended that natural rates of mortality be used to assess sea snake age and growth development for all included species (*pers. comm.* A. Courtney; V. Udyawer). In line with this recommendation, the RRA reassessed *maximum age* based on an estimate of the natural mortality rate of each sea snake species. Under this estimate, *maximum age* was assumed to be the age, by which, 95 per cent of the population has died from natural causes (*i.e.* in the absence of fishing mortality) (pers. comm. A. Courtney; Courtney *et al.*, 2010). Applying the revised assessment criteria reduced the *maximum age* attribute scores for six species. The revised assessment methods also allowed for further refinement of the *age at sexual maturity* score for the spectacled sea snake (*Hydrophis kingii*) and the small-headed sea snake (*H. macdowelli*). The remainder of the *productivity* RRA involved revisions that improved the accuracy of the assessment but did not alter the score assigned to that attribute (*i.e.* trophic level; Table 6; Appendix D).

In the *susceptibility* component, most amendments involved the *selectivity* and *post-interaction mortality* attribute. For this complex, a lack of species-specific data on Turtle Excluder Device (TED) effectiveness restricted the initial *selectivity* assessment (Table 4).[6] In the RRA, further consideration was given to risk mitigation measures currently implemented in the fishery (*e.g.* regional BRD design mandates) and research that demonstrates BRD effectiveness within this complex (Courtney *et al.*, 2010). Based on these considerations, *selectivity* scores for all sea snakes were reduced from precautionary high to medium (Table 6; Appendix D).

In the PSA, the lowest reported survival rate was used to assess *post-interaction mortality* (Table 4). This approach aligns with the precautionary nature of the PSA and minimised the risk of a false-negative result. In the RRA, it was determined that the PSA overestimated the *post-interaction mortality* risk for some species (Table 6). To address this issue, the key findings of each study were reviewed and scores recalibrated using estimates from studies with larger sample sizes (Milton, 2001; Wassenberg *et al.*, 2001; Milton *et al.*, 2009; Courtney *et al.*, 2010). As a result of this change, nine of the *post-interaction mortality* scores were amended (Table 6; Appendix D).

Amendments made as part of the RRA reduced the total risk score for all sea snakes. For five of these species, the score reduction was sufficient to downgrade their overall risk rating from high to medium. The risk score for the mosaic sea snake (*Aipysurus mosaicus*) was reduced from medium to low (Table 6).

[6] *Data on TED/BRD effectiveness for sea snakes is generally based at the complex level. Finer-scale assessments of TED/BRD effectiveness at the species level is still limited.*

Table 6. *Residual Risk Analysis (RRA) of the preliminary scores assigned as part of the Productivity & Susceptibility Analysis (PSA). Pink shaded squares represent attribute scores that were amended as part of the RRA. Refer to Appendix D for a full account of the RRA including key justifications.*

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability (additive)	Encounterability	Selectivity	Post-interaction mortality	Sustainability / Conservation	Susceptibility (multiplicative)	*PSA score*
Marine Turtles																
Loggerhead turtle	*Caretta caretta*	3	3	2	2	2	2	3	2.43	2	3	1	1	3	1.78	**3.01**
Green turtle	*Chelonia mydas*	3	3	3	2	2	2	1	2.29	2	3	1	1	3	1.78	**2.90**
Leatherback turtle	*Dermochelys coriacea*	3	3	2	2	2	2	3	2.43	2	3	1	1	3	1.78	**3.01**
Hawksbill turtle	*Eretmochelys imbricata*	3	3	3	1	2	2	2	2.29	2	3	1	1	3	1.78	**2.90**
Olive ridley turtle	*Lepidochelys olivacea*	2	3	2	1	2	2	3	2.14	2	3	1	1	3	1.78	**2.79**
Flatback turtle	*Natator depressus*	3	3	3	1	2	2	3	2.43	2	3	1	1	3	1.78	**3.01**
Syngnathids																
Tiger pipefish	*Filicampus tigris*	1	1	2	1	1	3	3	1.71	3	3	3	3	1	2.41	**2.96**
Spiny seahorse	*Hippocampus spinosissimus*	1	1	2	1	1	3	3	1.71	2	2	3	3	3	2.55	**3.07**
Great seahorse	*Hippocampus kelloggi*	1	1	2	1	1	3	3	1.71	2	2	3	3	3	2.55	**3.07**
White's seahorse	*Hippocampus whitei*	1	1	2	1	1	3	3	1.71	2	2	3	3	3	2.55	**3.07**
Duncker's pipehorse	*Solegnathus dunckeri*	1	1	2	2	1	3	3	1.86	3	3	3	3	3	3.00	**3.53**
Pallid pipehorse	*Solegnathus hardwickii*	1	1	2	2	2	3	3	2.00	1	3	3	3	3	2.41	**3.13**
Bentstick pipefish	*Trachyrhamphus bicoarctatus*	1	1	2	1	1	3	3	1.71	2	2	3	3	1	2.05	**2.67**

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability (additive)	Encounterability	Selectivity	Post-interaction mortality	Sustainability / Conservation	Susceptibility (multiplicative)	*PSA score*
Straightstick pipefish	*Trachyrhamphus longirostris*	1	1	2	1	1	3	3	1.71	1	3	3	3	1	1.93	**2.58**
Ribboned pipefish	*Haliichthys taeniophorus*	1	1	2	1	1	3	3	1.71	1	1	3	3	1	1.55	**2.31**
Sea snakes																
Reef shallows sea snake	*Aipysurus duboisii*	1	1	3	2	2	3	3	2.14	3	3	2	1	1	1.78	**2.79**
Mosaic sea snake	*Aipysurus mosaicus*	1	1	3	1	2	3	3	2.00	2	3	2	1	1	1.64	**2.59**
Olive sea snake	*Aipysurus laevis*	2	2	3	2	2	3	3	2.43	2	3	2	1	1	1.64	**2.93**
Spine-bellied sea snake	*Hydrophis curtus*	1	1	3	2	2	3	3	2.14	2	3	2	1	1	1.64	**2.70**
Elegant sea snake	*Hydrophis elegans*	1	2	3	2	2	3	3	2.29	3	3	2	1	1	1.78	**2.90**
Spectacled sea snake	*Hydrophis kingii*	2	1	3	2	2	3	3	2.29	2	3	2	2	1	1.89	**2.96**
Turtle-headed sea snake	*Emydocephalus annulatus*	1	2	3	2	2	3	3	2.29	2	1	2	2	1	1.52	**2.74**
Olive-headed sea snake	*Hydrophis major*	1	1	3	2	2	3	3	2.14	2	3	2	1	1	1.64	**2.70**
Small-headed sea snake	*Hydrophis macdowelli*	2	1	3	1	2	3	3	2.14	2	3	2	2	1	1.89	**2.86**
Spotted sea snake	*Hydrophis ocellatus*	1	1	3	2	2	3	3	2.14	2	3	2	2	1	1.89	**2.86**
Horned sea snake	*Hydrophis peronii*	1	1	3	2	2	3	3	2.14	2	3	2	1	1	1.64	**2.70**
Beaked sea snake	*Hydrophis zweifeli*	1	1	3	2	2	3	3	2.14	2	3	2	1	3	2.05	**2.96**
Stoke's sea snake	*Hydrophis stokesii*	1	2	3	2	2	3	3	2.29	3	3	2	1	1	1.78	**2.90**
Sharks																
Collar carpetshark	*Parascyllium collare*	2	2	3	1	2	2	3	2.14	1	2	2	3	1	1.64	**2.70**

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability (additive)	Encounterability	Selectivity	Post-interaction mortality	Sustainability / Conservation	Susceptibility (multiplicative)	*PSA score*
Brownbanded bambooshark	*Chiloscyllium punctatum*	1	2	2	2	2	2	3	2.00	2	2	2	1	1	1.52	**2.51**
Colclough's shark	*Brachaelurus colcloughi*	2	2	3	1	2	3	3	2.29	3	3	2	2	3	2.55	**3.43**
Crested hornshark	*Heterodontus galeatus*	2	2	3	2	2	2	3	2.29	1	1	2	1	1	1.15	**2.56**
Eastern angelshark	*Squatina albipunctata*	2	3	3	2	2	3	3	2.57	2	2	2	3	3	2.35	**3.48**
Eastern banded catshark	*Atelomycterus marnkalha*	2	2	3	1	1	3	3	2.14	2	2	3	2	1	1.89	**2.86**
Zebra shark	*Stegostoma tigrinum*	2	3	3	2	2	2	2	2.29	2	3	1	3	1	1.78	**2.90**
Piked spurdog	*Squalus megalops*	3	3	3	1	2	3	3	2.57	2	1	3	3	1	1.78	**3.13**
Australian weasel shark	*Hemigaleus australiensis*	1	2	3	2	2	3	3	2.29	2	3	2	3	1	2.05	**3.07**
Pale Spotted Catshark	*Asymbolus pallidus*	2	2	3	1	1	2	3	2.00	1	1	3	3	1	1.55	**2.53**
Grey spotted catshark	*Asymbolus analis*	2	3	3	1	2	2	3	2.29	1	2	3	3	1	1.78	**2.90**
Orange spotted catshark	*Asymbolus rubiginosus*	2	2	3	1	1	2	3	2.00	1	1	3	3	1	1.55	**2.53**
Batoids																
Australian butterfly ray	*Gymnura australis*	2	3	3	2	2	3	3	2.57	2	3	3	2	1	2.05	**3.29**
Yellowback stingaree	*Urolophus sufflavus*	1	2	3	1	1	3	3	2.00	3	2	3	3	3	2.77	**3.41**
Patchwork stingaree	*Urolophus flavomosaicus*	1	2	3	1	1	3	3	2.00	2	2	3	3	1	2.05	**2.86**
Sandyback stingaree	*Urolophus bucculentus*	2	2	3	1	2	3	3	2.29	1	2	3	3	3	2.22	**3.19**
Kapala stingaree	*Urolophus kapalensis*	1	2	3	1	1	3	3	2.00	3	2	3	3	2	2.55	**3.24**
Greenback stingaree	*Urolophus viridis*	1	2	3	1	1	3	3	2.00	3	2	3	3	3	2.77	**3.41**

Common name	Species Name	Age at sexual maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability (additive)	Encounterability	Selectivity	Post-interaction mortality	Sustainability / Conservation	Susceptibility (multiplicative)	*PSA score*
Common stingaree	*Trygonoptera testacea*	1	2	3	1	2	3	3	2.14	1	2	3	3	2	2.05	**2.96**
Australian whipray	*Himantura australis*	2	3	3	3	2	3	3	2.71	2	2	1	2	1	1.52	**3.11**
Blackspotted whipray	*Maculabatis astra*	2	3	3	2	2	3	3	2.57	2	3	2	2	1	1.89	**3.19**
Brown whipray	*Maculabatis toshi*	2	3	3	2	2	3	3	2.57	2	3	2	2	1	1.89	**3.19**
Estuary stingray	*Hemitrygon fluviorum*	2	2	3	2	2	3	3	2.43	2	1	2	2	3	1.89	**3.08**
Coral sea maskray	*Neotrygon trigonoides*	2	2	3	1	1	3	3	2.14	2	3	3	3	1	2.22	**3.09**
Speckled maskray	*Neotrygon picta*	1	2	3	1	1	3	3	2.00	2	3	3	3	1	2.22	**2.99**
Bottlenose wedgefish	*Rhynchobatus australiae*	2	3	3	2	2	3	3	2.57	2	3	1	1	2	1.64	**3.05**
Eyebrow wedgefish	*Rhynchobatus palpebratus*	2	3	3	2	2	3	3	2.57	1	2	1	1	2	1.32	**2.89**
Eastern shovelnose ray	*Aptychotrema rostrata*	2	2	3	2	2	3	3	2.43	2	3	2	1	2	1.89	**3.08**
Giant guitarfish	*Glaucostegus typus*	2	2	3	2	2	3	3	2.43	2	2	1	2	1	1.52	**2.86**
Sydney skate	*Dentiraja australis*	2	2	3	1	2	2	3	2.14	1	2	3	3	3	2.22	**3.09**
Endeavour skate	*Dentiraja endeavouri*	2	2	3	1	1	2	3	2.00	3	2	3	3	2	2.55	**3.24**
Argus skate	*Dentiraja polyommata*	2	2	3	1	1	2	3	2.00	3	2	3	3	1	2.22	**2.99**
Narrow sawfish	*Anoxypristis cuspidata*	1	1	3	3	3	3	3	2.43	1	2	2	2	3	1.89	**3.08**
Green sawfish	*Pristis zijsron*	2	3	3	3	3	3	3	2.86	2	3	2	2	3	2.35	**3.70**

5.3.4 Sharks

The risk profiles of 12 shark species were amended as part of the RRA. In the *productivity* component, this involved risk-profile refinements using proxies, estimates from captive individuals and information compiled through expert consultation (Appendix D).

Most *susceptibility* amendments involved the *encounterability* attribute and species with broad habitat and water depth descriptions. In the RRA, further consideration was given to the habitat preferences of each species and how this might influence their *encounterability* potential. The working hypothesis being that the habitat preferences of some species provide them with a degree of natural protection *e.g.* depth profiles that extend beyond trawl depths, a preference for rocky reefs *etc*. In the RRA, it was determined that there was sufficient evidence to support a downgrading of the *encounterability* score for nine shark species (Table 6; Appendix D).

The remaining amendments involved the *availability* and *post-interaction mortality* attributes and the provision of additional data, the use of proxies and input from scientific experts. Of the species assessed, only the grey spotted catshark (*Asymbolus analis*) had an attribute score increase as part of the RRA. In this instance, the score assigned to *post-interaction mortality* was increased to account for data deficiencies and a higher degree of uncertainty (Table 6; Appendix D).

Amendments made as part of the RRA reduced the risk score for all shark species assessed. For seven species, the score reduction facilitated a downgrading of their final risk rating (Table 4 & 6). The most significant change involved the orange spotted catshark (*Asymbolus rubiginosus*) whose risk score was reduced from high to low after a review of the available distribution/encounterability data (Appendix D).

5.3.5 Batoids (non-sawfish)

All of the batoid *productivity* score amendments involved *age at sexual maturity* and *maximum age* (Table 6). *Residual Risk Analysis* considerations for the batoid subgroup closely mirrored the shark complex (section 5.3.4) with refinements centring on the use of proxies and additional information collated through targeted consultation (Table 6; Appendix D). Changes made as part of the RRA provide a better reflection of the available information on batoid age and growth and refined the risk profiles of a number of species.

Susceptibility component changes were more diverse and involved the *availability, encounterability, selectivity* and *post-interaction mortality* attributes (Table 6). However, the majority of the changes involved the *encounterability* attribute (Table 6; Appendix D). In the RRA, further consideration was given to the habitats and depth profiles preferred by each species and the regions where they are more likely to be encountered. This review determined that there was sufficient evidence to support an *encounterability* score reduction for 13 species.

Amendments for the remaining *susceptibility* attributes were less pronounced. For a number of the species, including stingarees, the PSA overestimated the *availability* risk and the scores were recalculated using a more simplified assessment of the proportionate overlap between the species distribution and the ECOTF effort footprint (Appendix D). Scores assigned to *post-interaction mortality* were also refined for seven species through the use of proxies and expert consultation. The yellowback stingaree (*Urolophus sufflavus*) and the kapala stingaree (*U. kapalensis*) had their *post-*

interaction mortality score increased from low to high to account for additional information considered within the RRA process (Table 6; Appendix D).

As body size was used as the primary determinant for scores assigned to the *selectivity* attribute, the Australian butterfly ray (*Gymnura australis*) and the Australian whipray (*Himantura australis*) were initially assessed as medium risk (Table 4). In the RRA, the *selectivity* score for *G. australis* was increased to account for their morphology (*i.e.* very low physical depth profile) and the increased probability that immature, sub-adult and mature rays will be caught in the codend of the net (*pers. comm.* I. Jacobsen; Jacobsen & Bennett, 2009; Jacobsen *et al.*, 2009). Conversely, the morphology of *H. australis* would help prevent a higher proportion of subadult and mature rays from entering the codend of the net (Table 6; Appendix D).

Amendments made as part of the RRA were sufficient to reduce the overall risk rating for four of the non-sawfish batoids: the patchwork stingaree (*U. flavomosaicus*), the common stingaree (*Trygonoptera testacea*), *H. australis* and the Sydney skate (*Dentiraja australis*), while increasing the overall rating for one species: the blackspotted whipray (*Maculabatis astra*; Table 6). While the RRA reduced the risk score for a number of other species, it did not result in a change in the overall classification.

5.3.1 Batoids (sawfish)

The RRA of the sawfish PSA produced minimal amendments to the *susceptibility* component. Body size was used as the primary determinant for *selectivity* and both species were assigned low (1) risk ratings as part of the PSA (Table 4). The rostrum of the species though increases the entanglement risk and the probability that it will be retained in a trawl net *e.g.* smaller animals passing through a TED and into the codend, the rostrum being caught in the TED or the animal becoming entangled in the anterior of the net (Brewer *et al.*, 2006; Wakefield *et al.*, 2017). This was taken into consideration as part of the RRA and scores assigned to *selectivity* were increased from low (1) to medium (2) as a precautionary measure (Table 6; Appendix D).

The remaining refinements involved *post-interaction mortality* and *encounterability*. *Post-interaction mortality* scores were reduced in anticipation of the fact that a portion of the narrow sawfish (*Anoxypristis cuspidata*) and the green sawfish (*Pristis zijsron*) will experience contact without capture events *i.e.* be able to escape the net through the TED. The *encounterability* score for *A. cuspidata* was also reduced to account for the species' general preference for shallow-water embayments, estuaries and inshore waters which attract lower levels of otter trawl effort (D'Anastasi *et al.*, 2013; Last *et al.*, 2016b; Kyne *et al.*, 2021).

Amendments made as part of the RRA were not sufficient to reduce the risk-score rating for either species (Table 6; Appendix D).

6 Risk Evaluation

When the results of the PSA and RRA were taken into consideration, the whole-of-fishery ERA classified the majority of species as being at a moderate risk from trawl fishing activities. While these results broadly align with the two previous qualitative assessments (Pears *et al.*, 2012b; Jacobsen *et* *al.*, 2015),[7] the extent of any inter-study comparisons will be limited. The primary reason for this is that ERAs developed under the *Queensland Ecological Risk Assessment Guidelines* employ different methodologies (Department of Agriculture and Fisheries, 2018b).

In the two qualitative ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015), the quantification of risk relied on an assessment of a species' *resilience* and *fishery impact profile* (Astles *et al.,* 2009). *Resilience* examined the ability of the species to resist or recover from disturbance based on intrinsic biological and/or ecological components. The *fishery impact profile* examined the pressure exerted on the species by the fishery being assessed (Astles *et al.*, 2009; Pears *et al.*, 2012b). Assessments of *resilience* and *fishery impact profile* are analogous to the *productivity* and *susceptibility* components of the PSA. However, methodological differences limit direct comparisons of species-specific risk ratings (Astles *et al.*, 2009; Hobday *et al.*, 2011; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015).

This ERA and the two qualitative assessments use similar information to quantify risk within the ECOTF (Astles *et al.*, 2009; Hobday *et al.*, 2011; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). While noting these similarities, there were notable differences in how risk was scored and quantified within this fishery (Astles *et al.*, 2009; Hobday *et al.*, 2011; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). Attributes and criteria used to assess risk in the GBR and Southern Queensland trawl ERAs were more bespoke, qualitative and often applied in a broader context. For example, attributes assessed as part of the *resilience* component included: *fecundity*, *life history strategy*, *geographic distribution*, *habitat specificity or ecological niche*, *population size/trend*, *growth rate*, *longevity*, *natural mortality* and *other (cumulative) pressures* (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). This contrasts with the more regimented approach applied in the *Ecological Risk Assessment for the Effects of Fishing* (ERAEF) approach and the broader PSA framework (Hobday *et al.*, 2007; Department of Agriculture and Fisheries, 2022a).

Given the above considerations, <u>it is not recommended that cross-study comparisons be used to draw inferences/conclusions on long-term risk trends for individual species</u>. This is because any inter-study comparison of risk needs to account for a wide range of confounding factors that cannot be easily addressed or accounted for. There is, however, merit in reviewing how the key drivers of risk have changed between assessment periods and the capacity of the ECOTF to manage risk at a whole-of-fishery, regional and species level.[8] With the risk assessment process now formalised under the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2018b), there will be greater avenues to track risk rating trends across studies and (potentially) between fisheries.

6.1 Trawl (General)

Risk management strategies employed in the ECOTF have a long history and most mitigation measures have been in place for over 20 years (Queensland Government, 2022b; c). These measures include limited licensing, spatial/temporal closures, effort controls and mandating the use of a Turtle Excluder Device (TED) and Bycatch Reduction Devices (BRDs). As the ECOTF operates within the confines of the GBRMP, operators are also subject to provisions governing the use of resources within the World Heritage Area (Great Barrier Reef Marine Park Authority, 2018;

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[7] *The ECOTF was subject to a third ERA examining the risk posed to elasmobranchs in southern Queensland (Campbell et al., 2017). This assessment used the quantitative Sustainability Assessment for Fishing Effects (SAFE) method and has fewer tangible links to risk assessment methods used in this assessment.*

[8] *Discussed in more detail in section 6.1 and section 6.2.*

Department of Agriculture and Fisheries, 2022d; Great Barrier Reef Marine Park Authority, 2022b). This includes the *Great Barrier Reef Representative Areas Program* which restricts or prohibits commercial fishing activities across a large proportion of the marine park. Similar provisions exist at a State level via the *Great Sandy Marine Park* and the *Moreton Bay Marine Park* (Department of Environment and Science, 2020a; b).

As the broader ECOTF risk-management framework has not changed significantly, the drivers of risk at a whole-of-fishery level will be similar to that observed in the two qualitative ERAs (Pears *et al.*, 2012a; Jacobsen *et al.*, 2015). However, a number of developments have reduced the level of risk across the entire ECOTF and improved the capacity of the fishery to manage longer-term risks. This is perhaps best exemplified by the reduction in annual effort levels and the introduction of regional management (Department of Agriculture and Fisheries, 2023).

In the two qualitative ERAs, effort records for the 2009 season were used as the reference year (Pears *et al.*, 2012a; Jacobsen *et al.*, 2015). During this season the annual effort level for the entire ECOTF was 38,970 days fished (Department of Agriculture and Fisheries, 2023). In the post-2009 period (2010–2021 inclusive), the ECOTF registered an annual effort average of 35,085 days fished and a range of 32,832 to 38,035 days fished. This average declines to 34,873 days fished when only the last five fishing seasons (2017–2021 inclusive) are taken into consideration (Department of Agriculture and Fisheries, 2023).

While not universal, effort reductions often equate to lower total catches (fishery wide) and a general reduction in bycatch levels. This was noted in the GBRMP Trawl ERA where lower effort levels contributed to a general decline in risk scores assigned to species across the 2005 and 2009 assessments (Pears *et al.*, 2012b). While difficult to quantify, there is an increased probability that observed declines in annual effort have contributed to a lowering of trawl-related risks in this fishery. It is further hypothesised that risk levels, at the very least, have not increased at a whole-of-fishery level since 2009 and the completion of the two qualitative assessments (Department of Agriculture and Fisheries, 2023). This hypothesis though assumes that fishing power has stayed largely the same over the post-2009 period.

Recent changes enacted as part of the harvest strategy development program have reduced the risk of an undesirable event occurring over the longer term. Regional harvest strategies came into effect on 1 July 2021 and established management guidelines for five regions: the *Northern Trawl Region*, *Central Trawl Region*, *Southern Inshore Trawl Region*, *Southern Offshore Trawl Region* and the *Moreton Bay Trawl Region* (Department of Agriculture and Fisheries, 2021d; e; f; g; h). The five strategies established effort caps for each region and decision rules for the long-term management of target and byproduct species. Each of the five harvest strategies also include mechanisms for the ongoing monitoring and management of ecological risk (Department of Agriculture and Fisheries, 2021d; e; f; g; h).

At a complex level, biological constraints were identified as a key driver of risk for a number of the subgroups and, in some instances, was the main contributor of risk (Table 6). If for example, all of the *susceptibility* attributes were assigned the lowest value possible (1), 15 per cent of the species (n = 9 out of 62) would still register a medium-risk rating. If just one of the *susceptibility* attributes were assigned a higher risk score (*e.g.* medium, 2), the number of species classified as a medium risk would almost double (27 per cent) (Fig. 1). This highlights the inherent challenge of managing fishing-related risks for species with *k*-selected life histories.

In the *susceptibility* component, the drivers of risk were more varied and at times influenced by data deficiencies. Across the study, an inability to accurately monitor catch compositions or validate data submitted through the logbook program contributed to the production of more conservative risk assessments. These deficiencies were most influential in assessments involving the *availability, encounterability, selectivity* and *post-interaction mortality* attributes (Table 4). Where possible, bycatch interaction and release fate data (including confirmed low interaction rates) were used to provide additional context on the likelihood of the species being encountered across the entire ECOTF and within each of the respective management regions (e.g. Courtney *et al.*, 2007b; Jacobsen, 2007; Kyne *et al.*, 2007b; Pitcher *et al.*, 2007a; Department of Agriculture and Fisheries, 2022e; Department of Environment and Science, 2022). These refinements were of particular relevance for species with broad habitat preferences or indicative distribution maps *e.g.* marine turtles, sharks and batoids. However, the absence of an effective mechanism to validate interaction rates and catch compositions limited the scope and extent of these refinements (Appendix D). This was arguably most evident in the risk profiles of species with restricted Queensland distributions, namely southern Queensland stingaree species (Last *et al.*, 2016b; Kyne *et al.*, 2021)

Fourteen species lacked reliable distribution maps and required assessment under the alternative criteria for *availability* (*Option 2: global distribution & stock proxy considerations*; Table 2). This may have contributed to a number of the SOCC receiving higher *availability* scores (Appendix C) and highlights the need to improve information on regional species distributions and the extent of the overlap with the trawl effort footprint (Department of Agriculture and Fisheries, 2023). Going forward, this information will be of considerable importance when determining the extent of risk variability across the five management regions (Department of Agriculture and Fisheries, 2021d; e; f; g; h). This will require improved information on regional catch compositions, the frequency of interactions and catch locations. Confirming the low interaction potential of some species may also facilitate their removal from future risk assessments *e.g.* the greenback stingaree (*Urolophus viridis*) and potentially the eastern angelshark (*Squatina albipunctata*; Appendix B).

Data deficiencies also limited the extent of *selectivity* score refinements for was largely based on TED effectiveness (Table 2; Appendix D). Research has shown that TED effectiveness is intimately linked with body size and will be highest in marine megafauna with total lengths (TL) and disc widths (DW) greater than 100 cm (Brewer *et al.*, 2006; Campbell *et al.*, 2020; National Oceanic and Atmospheric Administration Fisheries, 2021). This factor was taken into consideration as part of the species rationalisation process and helped shape the structure of the entire ECOTF SOCC ERA (Appendices A & B). With that said, uncertainty surrounding bycatch compositions and interaction rates required a number of species to be included in the assessment as a precautionary measure. With improved data, it is conceivable that some of these larger species could be removed from future ERAs *e.g.* Australian whipray, *Himantura australis, maximum DW* = 183 cm (Last *et al.*, 2016b; Kyne *et al.*, 2021).

Determining the effectiveness of TEDs beyond the complex level is more challenging. For small and large species, assessing TED effectiveness is more systematic *i.e.* low effectiveness for small species and high effectiveness for larger species. For many others, TED effectiveness will vary throughout their life-history and be dependent on their morphological development. With improved information of bycatch compositions and size classes, a more nuanced assessment of *selectivity* could be applied to a number of the risk profiles (Table 6). This would be of particular relevance to sharks, batoids and sea snakes where body size provides a more rudimentary assessment of *selectivity* (Table 2 & 6).

For species and subgroups with higher TED effectiveness (*e.g.* marine turtles, larger sharks and rays), some of the more significant risks have already been mitigated. This includes injuries incurred during the net retrieval process (*e.g.* crushing) and drownings due to extended interaction times. For species that are able to pass through the TED bar spacing (12 cm), BRD effectiveness was also a key determinant in terms of net selectivity. At a complex level, research has shown that the use of certain BRDs can improve escapement rates for sea snakes and some elasmobranchs (Courtney *et al.*, 2007b; Courtney *et al.*, 2010). While this research was accounted for in the RRA, its relevancy was restricted to a smaller number of species (Appendix D).

Outside of *selectivity*, data deficiencies were most influential in assessments involving *post-interaction mortality* (Table 6). Assessing p*ost-interaction mortality* in the marine environment is inherently difficult, especially when taking into consideration contact without capture events. In the ECOTF SOCC ERA, these deficiencies increased assessment uncertainty and contributed to the production of more conservative risk assessments. Where possible, the RRA used a weight-of-evidence approach to refine scores assigned to this attribute (Appendix D). However, the extent of these refinements were limited, conservative in nature, and focused on species more likely to experience contact without capture events.[9] With further information on interaction rates and release fates, more definitive refinements could be made to these scores. As post-release fates are more difficult to quantify, documenting landing fates (*i.e.* alive, moribund or dead) is considered a more feasible option for this fishery.

While not universal, most of the above deficiencies relate to the collection of data and improved monitoring of bycatch interactions. Of note, a number of these deficiencies are already being actively addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* and the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018a; Queensland Government, Undated-a).[10] These initiatives will take time to develop and implement; particularly in a multidimensional, multifaceted fishery like the ECOTF. In the interim, the outputs of this ERA will provide further insight into the key drivers of risk across the entire ECOTF and the species most likely to be impacted by a significant change in the current fishing environment.

As the study is based at a whole-of-fishery level, the outputs may not provide an accurate representation of risk at the management level. Examples of where this might occur include deepwater species like the pale spotted catshark (*Asymbolus pallidus*) and the orange spotted catshark (*A. rubiginosus*). While these species were assessed as a low risk across the entire ECOTF (Table 6), fishing pressures are likely to be higher in key regions. Where possible, these regional nuances were highlighted within this report and were considered as part of the broader risk assessment process (Appendices C & D). There will however be some benefit in undertaking a secondary assessment examining the fishing-related risks in each of the respective management regions. This will provide a more comprehensive overview of regional risk variability in the ECOTF.

The following recommendations have been identified as areas where risk profiles can be refined and the level of risk reduced across the ECOTF. Recommendations relating to the improvement of catch

[9] *Contact without capture events refer to those species/animals that were caught in the sweep of the net but are excluded from the catch via the TED or BRD. Contact without capture events are difficult to quantify as they are generally not observed.*

[10] *Vessel Tracking has also been mandated as part of the Queensland Sustainable Fisheries Strategy 2017–2027. However, this is less applicable to the ECOTF whose management regime which includes a long-term requirement for trawl operations to have an operational Vessel Monitoring System (VSM).*

compositions and interaction rate data should be progressed as a priority. The remaining recommendations are viewed as lower priorities and timeframes for their potential completion may be more resource dependent.

General recommendations

1. *Identify mechanisms to monitor interactions with key bycatch species (preferably in real or near-real time), validate data submitted through the logbook program, and minimise the risk of non-compliance with Threatened, Endangered and Protected Animal (TEPA) reporting requirements.*

2. *Identify mechanisms to improve the level of information on species compositions, interaction rates and landing fates (i.e. alive, moribund, dead) for species with increased conservation concerns.*

3. *When appropriate, undertake a more detailed assessment of risk at a regional level considering a) the distribution of each species in relation to the five harvest strategies and b) the likelihood of the risk coming to fruition within each management region over the short to medium term.*

4. *Explore the benefits of assessing the risk posed to key subgroups, namely sharks and batoids, using a quantitative ERA method such as a base Sustainability Assessment for Fishing Effects (where applicable).*

5. *Identify avenues to improve the efficacy of the current logbook reporting systems (e.g. electronic logbooks) and review nomenclature used in fisheries legislation / logbook reporting systems to ensure that it reflects the best available data.*

6. *Undertake a review of the resources made available to licence holders to assist in the identification of TEP species and avenues to better integrate data collected through the TEPA logbook program with ancillary programs like the Marine Wildlife Stranding and Mortality Database (StrandNET).*

7. *Explore avenues to improve research on the distribution and biology of key subgroups through engagement with industry and third-party representatives (e.g. the Queensland Museum and regional universities).*

6.2 Species-Specific Assessments

The scope of the ECOTF SOCC ERA was established through a detailed species rationalisation process which considered a) the probability of the species being encountered and b) the likelihood that it will be retained in the codend of the net (Appendix A). For some species, it was more difficult to assess their interaction potential and the effectiveness of measures designed to exclude them from the catch. This uncertainty resulted in a number of species being included in the assessment as a precautionary measure (Appendix B). The inclusion of these species provided the whole-of-fishery ERA with additional scope and will assist in the long-term management of trawl-related risks. This approach also minimises the potential of an at-risk species being omitted from the analysis due to misidentifications or low interactions. The inherent trade off being that risk ratings assigned to some species may be more precautionary.

The PSA provides a detailed overview of the biological risks, fishing-related risks and the potential consequences of a trawl interaction. This provides a more holistic account of factors that can contribute to a species experiencing an undesirable event, such as a long-term decline in their conservation status or increased susceptibility to cumulative fishing pressures/risks. The key drivers of risk will vary between species and, in some instances, may be more difficult to mitigate through a fisheries management framework. For example, biological constraints may result in a species receiving a higher risk rating despite fishing-related risks being well managed within the current fishing environment. Alternatively, an assigned rating may be more reflective of the potential risk, meaning there is a lower probability of it coming to fruition over the short to medium term unless there is a notable divergence from the current fishing environment *e.g.* an increase in the effort footprint or a downgrading of a species' conservation status.

The above nuances place added importance on understanding the key drivers of risk for each species and differentiating between risk management and risk mitigation. Similarly, it is important to understand if and when data deficiencies or uncertainty contributed to the production of more conservative risk assessments. In the ECOTF SOCC ERA, potential risk overestimates and false-positive results are addressed through the RRA and the assignment of precautionary risk ratings. Precautionary risk ratings are assigned to species whose risk profiles may have been influenced by data deficiencies and the conservative nature of the methodology. In the ECOTF SOCC ERA, the decision to classify an assessment as precautionary was supported by an *ad-hoc Likelihood & Consequence Analysis* (LCA). The primary purpose of the LCA was to provide further insight into the probability of the risk coming to fruition over the short to medium term (Appendix E).[11]

Management of the risk posed to species with precautionary ratings, beyond what is already being undertaken as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017a), is not considered an immediate priority. In most instances, these risks are best addressed through the *Data Validation Plan* and the *Monitoring & Research Plan* (Department of Agriculture and Fisheries, 2018a; c; Queensland Government, Undated-a). With a better understanding of SOCC catch compositions and interaction rates, some of these species could be excluded from future risk assessments.

The following provides an overview of the key drivers of risk for all subgroups included in the ECOTF SOCC ERA. Where possible, these evaluations incorporate recommendations on where risk may be reduced within a particular subgroup and avenues that could be used to improve the accuracy of species-specific risk assessments. When and where appropriate, the region/s where the risk assessment is most applicable has been identified *e.g. All*, *Northern*, *Central*, *Southern Inshore*, *Southern Offshore* and *Moreton Bay Trawl Region*.

6.2.1 Marine turtles

Species	**Key Risk Regions**	**Risk Rating**
Loggerhead turtle *(C. caretta)*	ALL	Precautionary Medium
Green turtle *(C. mydas)*	ALL	Medium
Leatherback turtle *(D. coriacea)*	ALL	Precautionary Medium
Hawksbill turtle *(E. imbricata)*	ALL	Medium

[11] The Likelihood & Consequence Analysis (LCA) is a fully qualitative assessment and was used to provide an indicative assessment of how conservative the PSA might be (Appendix E). The LCA is qualitative and lacks the detail of the PSA; therefore it should not be viewed as an alternate or competing risk assessment. The results of the PSA/RRA will take precedence over the LCA.

Species	Key Risk Regions	Risk Rating
Olive ridley turtle *(L. olivacea)*	Northern & Central	Precautionary medium
Flatback turtle *(N. depressus)*	ALL	Medium

As the ECOTF SOCC ERA applied a different methodology, any inter-study comparison of marine turtle risk ratings will be qualified (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). With that said, risk ratings assigned in this report were similar to that obtained in the GBRMP trawl ERA (intermediate-low; Pears *et al.*, 2012b) and the Southern Queensland trawl ERA (intermediate-low; Jacobsen *et al.*, 2015). While the current study assigned marginally higher ratings, this differential is attributed to application of different methodology including for the treatment/assessment of biological risk (refer section 6). Accordingly, inter-study variance in marine turtle ratings should not be directly interpreted as an increase in the level of risk posed to this subgroup. This inference was supported by the LCA which provides further insight into the probability of the risk coming to fruition over the short to medium term (Appendix E).

Some of the key risks for this subgroup relate to their biological constraints and *k-selected* life-history *i.e.* longer-lived, delayed maturity, comparatively low levels of fecundity (Limpus, 2007b; a; 2008b; c; a; 2009). These constraints have direct implications in terms of the long-term conservation of regional marine turtle populations, their ability to absorb fishing mortalities and their capacity to rebound from decline (Department of Environment and Science, 2021). As these are biological risks, they are difficult to address or directly mitigate through a fisheries management framework. They are, however, taken into consideration as part of the broader management regime *e.g.* establishing spatial and temporal closures to minimise fishing-related risks at known nesting sites (unpub. data, Department of Agriculture and Fisheries; Department of Environment and Science, 2020a; b; Great Barrier Reef Marine Park Authority, 2022a).

The distribution of all six species overlaps with the trawl effort footprint and there is an increased probability of the complex interacting with the ECOTF (Limpus, 2007b; a; 2008b; c; a; 2009; Department of Environment and Science, 2021). While noting this potential, mechanisms are in place to minimise the risks and consequences of a marine turtle – trawl net interaction. The use of a TED remains a pivotal component of the broader ECOTF management regime and is arguably the most effective risk-mitigation strategy employed for this subgroup. Research has shown that the combined use of a TED with a BRD can reduce landing rates for marine turtles by 97–99 per cent (Brewer *et al.*, 2006; Department of Agriculture and Fisheries, 2012; Campbell *et al.*, 2020; National Oceanic and Atmospheric Administration Fisheries, 2021).

A TED prevents marine megafauna from entering the codend and facilitates their removal *via* an escape opening in the top or bottom of the net (Department of Agriculture and Fisheries, 2012; Business Queensland, 2022). While marine turtles may still be caught in the anterior of the net, the use of a TED helps mitigate some of the more significant risks posed to this subgroup, namely drownings due to extended interactions and mortalities resulting from injuries (internal and external). If and when a marine turtle is caught within the sweep of the net, a high percentage of the individuals will experience a contact without capture event (Brewer *et al.*, 2006; Campbell *et al.*, 2020). These types of events are less likely to result in significant injuries and pose a lower long-term risk to the affected individual. These factors were taken into consideration in assessments involving the *selectivity* and *post-interaction mortality* attributes (Table 6).

When a turtle is observed within a trawl net, operators must report the interaction though the TEPA logbook (Queensland Government, 2022a). Data compiled through this logbook suggests that marine turtles interact infrequently with this fishery (*n* = 41 since 2012; Department of Agriculture and Fisheries, 2023). There are however a number of operational limitations that reduce the level of confidence in this data and heighten the risk of under-reporting. For example, the ECOTF does not have a mechanism in place to monitor catch in real or near-real time and there is limited capacity within the current management framework to validate data submitted through the logbook program (Queensland Government, Undated-a).

Without direct validation of catch/interaction rates, it is difficult to draw inferences on the accuracy of marine turtle landing reports and/or the potential for under-reporting (Department of Agriculture and Fisheries, 2023). The extent of this challenge is highlighted by comparisons with TEP data collected from the *Northern Prawn Fishery* (NPF).The NPF has *Marine Stewardship Council* (MSC) certification and operates a multi-faceted catch validation program that includes crew member observers and scientific observers (Australian Fisheries Management Authority, 2023b; Marine Stewardship Council, 2023). From 2018 to 2022 (inclusive), the NPF observer program recorded 525 marine turtle interactions (Australian Fisheries Management Authority, 2023c) [12]. Over this same period, the ECOTF reported 35 marine turtle interactions through the TEPA logbook (Department of Agriculture and Fisheries, 2023). This differential occurred despite the NPF having a smaller operating potential: *NPF*: 52 licences, ~8,000 annual effort days; *ECOTF*: ~300 active licences, >30,000 effort days (Patterson *et al.*, 2022; Department of Agriculture and Fisheries, 2023).

In an ERA context, an inability to validate interaction rate data for marine turtles required the adoption of a more precautionary approach (section 4). It is also considered a longer-term risk area for this fishery (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). With improved data, risk profiles for all six marine turtles could be improved and further refined. Within the current ERA framework, these refinements would likely involve the *encounterability* and *availability* attributes (Table 6). Promisingly, these deficiencies are now being actively addressed as part of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018a). A key focus of this plan being field trials of onboard cameras, control systems and software to detect interactions with threatened, endangered and protected species during commercial trawl fishing activities (Queensland Government, Undated-a).

Risk assessments for the marine turtle complex highlight the importance of differentiating between ‘risk mitigation’ and ‘risk management’. For this subgroup, the largest gains in terms of risk mitigation have arguably been achieved with the introduction of TEDs and the establishment of a comprehensive system of spatial and temporal closures. While not complex-specific, the introduction of the harvest strategies will further assist in terms of managing effort at a regional level. With that said, the effectiveness of any long-term risk management program will ultimately depend on the quality of the available data. To this extent, the acquisition of accurate information on marine turtle interactions and catch compositions will remain an ongoing management priority for this fishery. This information will be of particular importance when determining how the ECOTF contributes to cumulative fishing pressures along the Queensland east coast. This is of particular importance as small levels of fishing mortality may have longer-term consequences for some species.

[12] *The NPF is a Commonwealth managed fishery that operates in waters of the Gulf of Carpentaria, Northern Territory and Joseph Bonaparte Gulf. There are notable operational differences between the NPF and ECOTF, however, the general construct of the trawl apparatus and bycatch mitigation strategies are similar for both (e.g. prawn trawls, the use of a TED and BRDs). 2022 data is based on incomplete datasets.*

The *Queensland Marine Turtle Conservation Strategy 2021–2031* classifies domestic fisheries bycatch as a more moderate threat for regional green turtle populations (*Chelonia mydas*; Department of Environment and Science, 2021).[13] *Chelonia mydas* has the largest population on the Queensland east coast (Department of the Environment, 2019a) and the species is well represented in data compiled through the TEPA logbook and StrandNET (Greenland & Limpus, 2004; Biddle *et al.*, 2011; Meager & Limpus, 2012; Department of Agriculture and Fisheries, 2023). The size of the green turtle population indicates that this species may be better positioned to absorb trawl fishing mortalities when compared to the other species. The risk of a *C. mydas* interaction ending in mortality will also be higher in other fisheries; namely the *East Coast Inshore Fishery* (Department of Agriculture and Fisheries, 2019b; Jacobsen *et al.*, 2021a). The key caveats being that marine turtle populations have declined through time and concerns still remain about the long-term sustainability of this species (*pers. comm.* C. Limpus).

The situation surrounding the rest of the complex is more complicated and (potentially) regionally specific. Domestic fisheries bycatch is classified as a low threat for loggerhead turtles (*Caretta caretta*; Department of Environment and Science, 2021) and there is a lower risk of the ECOTF contributing (*e.g.*) to an ongoing decline in their conservation status. Similarly, adult leatherback turtles (*Dermochelys coriacea*) have a general preference for deeper, pelagic waters and the species is less likely to be encountered in the ECOTF (Limpus, 2009; Eckert *et al.*, 2012; Department of Environment and Science, 2021). When compared, *D. coriacea* is more likely to be captured as bycatch in long-line fisheries with research suggesting that most major threats occur outside of Australian waters (Department of Environment and Science, 2021). These regional nuances contributed to *D. coriacea* being assigned a *precautionary* risk rating in the current assessment (Appendix E).

While the *Queensland Marine Turtle Conservation Strategy 2021–2031* classified domestic fisheries bycatch as a moderate threat for the hawksbill turtle (*Eretmochelys imbricata*), trawl interactions with this species are more likely to occur in central/northern Queensland (Limpus, 2007a; Department of Agriculture and Fisheries, 2021d; f; Department of Environment and Science, 2021). Similarly, the olive ridley turtle (*Lepidochelys olivacea*) primarily inhabits waters of northern Australia (Limpus, 2007a; 2008c) and interactions are more likely to occur in the NPF.

Species-specific recommendations

1. ***Identify avenues/mechanisms that can be used to monitor marine turtle interaction rates, validate data submitted through the Threatened, Endangered and Protected Animals (TEPA) logbook program, and minimise the risk of non-compliance with mandatory reporting requirements.***

   The ECOTF does not have a mechanism in place to effectively (and efficiently) monitor the catch of non-target species or verify the accuracy of information submitted through the logbook program. This deficiency makes it difficult to interpret trends in the TEPA data and increases the level of assessment uncertainty. It is a risk element that applies to a wide range of species and, therefore, needs to be addressed at a whole-of-fishery level (section 6.1).

   Increasing the capacity of the ECOTF to monitor marine turtle catch trends will be of central importance when assessing the ongoing effectiveness of bycatch mitigation strategies already in

[13] *Represents the collective threat, not just that posed by the ECOTF. The threat posed to the Gulf of Carpentaria C. mydas population was considered to be high (Department of Environment and Science, 2021).*

place in this fishery. Any initiative that helps validate data submitted through the logbook program will build confidence in the accuracy of the data and facilitate further refinement of the current risk profiles. At a regional level, this information could be used to provide further insight into the effectiveness of finer-scale management strategies and the extent of any cumulative fishing pressures.

2. ***Provide a synthesis of regional marine turtle distributional data to a) evaluate the level of overlap with ECOTF effort, b) identify key areas that have no or low levels of effort but can be still accessed by the fishery, and c) evaluate the level of protection already afforded to the species through marine park reserves, fisheries closures etc.***

   When compared to data validation, this recommendation presents as a lower priority for the ECOTF. There will however be some benefits in establishing a more complete picture of where marine turtles are found in higher densities, the distribution of habitats critical to their survival and areas where trawl-related risks are being effectively managed. Ideally, this information would be provided in a shapefile that could be overlayed with a map depicting the distribution of trawl effort along the Queensland east coast. This would facilitate easier and more accurate comparisons of how this fishery interacts with this subgroup across and within fishing years.

   Of notable importance, *Vessel Tracking* in the ECOTF is already well established and has a longevity that pre-dates the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017a). This requirement, combined with the development of *TrackMapper* (Courtney *et al.*, 2016), facilitates the development of fine-scale effort distribution maps. The ability to access finer-scale effort maps will be of considerable benefit when discussing the impact of the fishery on regional marine turtle populations.

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

   Unless an interaction is reported through both programs, data compiled through the TEPA logbook is not made available for direct entry into StrandNET. Instead StrandNET collects information on fishing-related strandings and mortalities through direct observations or reports from fishers, necropsies, and a weight-of-evidence approach. This data is supplemented with information from annual reports that are made available to the public *e.g.* the species, apparatus and release fate (Department of Agriculture and Fisheries, 2022e).

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

   This recommendation, as with the previous one, is viewed as a lower priority for the ECOTF. When compared, improving the linkages between the two reporting programs will provide greater value to risk assessments involving other fisheries *e.g.* the *East Coast Inshore Fishery*.

6.2.2 Sea snakes

Species	Key Risk Regions	Risk Rating
Reef shallows sea snake (*A. duboisii*)	Central, Southern Inshore	Medium
Mosaic sea snake (*A. mosaicus*)	Northern, Central, Southern Inshore	Low
Olive sea snake (*A. laevis*)	Central, Southern Inshore	Medium
Spine-bellied sea snake (*H. curtus*)	Northern, Central, Southern Inshore	Medium
Elegant sea snake (*H. elegans*)	ALL	Medium
Spectacled sea snake (*H. kingii*)	Northern, Central	Medium
Turtle-headed sea snake (*E. annulatus*)	N/A	Precautionary Medium
Olive-headed sea snake (*H. major*)	Central	Medium
Small-headed sea snake (*H. macdowelli*)	Central	Medium
Spotted sea snake (*H. ocellatus*)	Central	Medium
Horned sea snake (*H. peronii*)	Northern, Central	Medium
Beaked sea snake (*H. zweifeli*)	Northern, Central, Southern Inshore	Medium
Stoke's sea snake (*H. stokesii*)	Central	Medium

All but one of the sea snakes assessed were assigned medium risk ratings through the PSA/RRA process.[14] This contrasts with the two previous ERAs where the subgroup registered ratings from low/intermediate to high (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). The most notable divergence between the three studies involved the elegant sea snake (*Hydrophis elegans*) and the spotted sea snake (*H. ocellatus*) which were previously assessed as a high-risk (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). This score differential is largely attributed to the use of different methodologies and assessment criteria (section 6; Table 1 & 2). However, other factors including a general reduction in annual effort levels may have contributed to the observed variance (section 6.1).

The mosaic sea snake (*Aipysurus mosaicus*) was the only species in the complex assigned a risk rating below medium (Table 6). This differential was primarily due to *A. mosaicus* having the lowest *productivity* score of the complex. While cross-study comparisons of individual risk ratings is problematic (section 6.1), the two previous qualitative assessments also positioned *A. mosaicus* at the lower end of the risk spectrum (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015).

Across the subgroup, data deficiencies and assessment uncertainty were notable factors of influence. This is perhaps best exemplified by catch data compiled through mandatory reporting requirements and the TEPA logbook. Sea snakes have the largest representation within the TEPA logbook data with records indicating that most are released alive.[15] However, this data has poor species resolution and

[14] One species, the turtle-headed sea snake (Emydocephalus annulatus), was allocated a precautionary rating; a decision that was informed by an ad-hoc Likelihood & Consequence Analysis (Appendix E). The main justification for the precautionary rating was that the species was likely to have low to negligible interactions with trawling operations in the ECOTF.

[15] Considers information collated through the historic Species of Conservation Interest (SOCI) logbook which was superseded by the TEPA logbook.

shows considerable inter-year variability (*2003–2021 average* = 1,655 interactions, *range* = 336–4,753 interactions; Department of Agriculture and Fisheries, 2023). This issue is complicated by the fact that the ECOTF does not have a mechanism in place to monitor catch rates for non-target species or the ability to validate data submitted through the logbook program including release fates.

From an ERA perspective, the absence of an effective mechanism to validate logbook data increases the risk of non-compliance *e.g.* the non-reporting of sea snake interactions and the submission of erroneous release-fate data. This combined with catch data uncertainty makes it more difficult to assess the interaction/encounterability potential and reduces the accuracy of mortality rate estimates. Promisingly, these deficiencies are now being actively addressed as part of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018a). A key focus of this plan being field trials of onboard cameras, control systems and software to detect interactions with threatened, endangered and protected species during commercial trawl fishing activities (Queensland Government, Undated-a). These measures are being complemented by ancillary research on sea snake population dynamics, their conservation status and the overall effectiveness of current and new BRD designs (Department of Agriculture and Fisheries, 2020c; 2022f).

Data deficiencies were less of an issue in the *productivity* component where most attribute scores were supported by data or could be refined with further analysis (Table 6; Appendix D). Of note, all 13 species were assigned the maximum score for at least three attributes: *fecundity*, *reproductive strategy* and *trophic level* (Table 6). Sea snakes employ an ovoviviparous reproductive strategy and, for the most part, have reproductive cycles that produce average clutch sizes of <10 eggs (Fry *et al.*, 2001; Zhou *et al.*, 2012). These constraints may limit the rebound potential of regional sea snake populations and increases their long-term susceptibility to over-fishing. In the ECOTF SOCC ERA, these constraints contributed to the sea snake complex receiving higher risk ratings (Table 6).

In the *susceptibility* component, data deficiencies and assessment uncertainty played a more prominent role. This uncertainty extended beyond catch composition and interaction rate data to some of the more fundamental risk assessment elements. A 2014 taxonomic review made a number of key changes to sea snake nomenclature and distributions (Rasmussen *et al.*, 2014). However, the outcomes of this review have yet to be fully incorporated into the literature and several of the source materials reference out-of-date taxonomic classifications and/or species distributions. These discrepancies created uncertainty surrounding the distribution of some species and the extent of the overlap with the trawl effort footprint (*i.e. availability*; Table 2 & 4). For example, the prescribed distribution maps for the beaked sea snake (*H. zweifeli*)[16] do not reflect the current understanding of sea snake range descriptions (pers. comm. V. Udyawer; Ukuwela *et al.*, 2013; Rasmussen *et al.*, 2014). Where possible, these uncertainties were addressed as part of the RRA with input from scientific experts (Appendix D). However, further work may be required within the ECOTF to ensure that reference materials provided to industry reflect the best available information.

Two of the more complicated aspects of the sea snake assessment involved the *selectivity* and *post-interaction mortality* attributes. Research has shown that bycatch strategies employed in the ECOTF reduce sea snake interaction rates (Milton *et al.*, 2009; Courtney *et al.*, 2010; Queensland Government, 2022b).[17] This information was taken into consideration as part of the *selectivity* attribute

[16] *Assessment also considered data for H. schistosus which is a synonym of H. zwifeli.*

[17] *The current management regime includes limitations on the types of BRDs that can be used in regions where sea snake interactions are more likely to occur, specifically in areas where red-spot king prawns (Metapenaeus*

assessment. However, the outputs of this research had poor species resolution and all sea snakes were assigned an initial score of high risk for *selectivity* (Table 4). While all of these scores were reduced as part of the RRA (Table 6; Appendix D), the extent of these refinements were limited by an absence of information on catch compositions. With additional information on regional sea snake catch compositions, a more informed, albeit inferred assessment of TED/BRD effectiveness could be undertaken. This could theoretically be achieved through a direct comparison of regional catch compositions and sea snake distributions *i.e.* species that are caught within a management region *versus* species that are known to occur within a management region.

For attributes like *post-interaction mortality*, assessment score uncertainty was addressed through the RRA and the adoption of a weight-of-evidence approach (Appendix D). Unlike *selectivity*, previous research includes information on species-specific trawl-related mortalities. This research revealed that sea snake mortality rates are influenced by a range of factors including the size of the species, the depth and duration of the trawl shot, the catch composition (*e.g.* bycatch comprising of venomous or barbed species is more likely to result in envenomation or injuries), and the time at which a sea snake enters the codend in relation to the duration of a trawl shot (Wassenberg *et al.*, 2001; Milton *et al.*, 2009; Courtney *et al.*, 2010).

In the ECOTF, the length of the interaction will have a considerable impact on the chance of a sea snake surviving the event. For individuals that are able to escape through a BRD, the long-term consequences of the interaction will be minimal. Risk levels will be notably higher for individuals that cannot escape through a BRD and are retained within the codend of the net. In the ECOTF, logbook data indicates that between three and 30 per cent of landed sea snakes die due to drowning or injuries sustained during the fishing event (Department of Agriculture and Fisheries, 2023).[18] Without a mechanism to validate TEPA data, it is difficult to assess the accuracy of these reports. However, research documenting sea snake interactions in the ECOTF and *Northern Prawn Fishery* (NPF) provide species-specific mortality rates from 1.2 to 44 per cent (Appendix D; Wassenberg *et al.*, 2001; Milton *et al.*, 2009; Courtney *et al.*, 2010). For context, the NPF observer program reports quarterly sea snake mortality rates of between 16.1 and 25.3 per cent (Australian Fisheries Management Authority, 2023c).

In addition to within-net mortalities, there is a heightened risk that the sorting and handling process will compound injuries sustained during the trawl fishing event. Anecdotal evidence suggests that poor handling techniques may result in sea snakes sustaining significant injuries during the release stage of an interaction. This increases the *post-interaction mortality* risk and the likelihood that total rates of fishing mortality are higher than what is reported.[19] One working hypothesis being considered for the fishery is that the expanded use of release aids could minimise this post-capture risk. Release aids are utilised in some operations as a workplace health and safety measure and help crew members control landed sea snakes. However, their use also supports the weight of the animal when removed from the catch and facilitates a more controlled release from the boat (Broadhurst *et al.*, 2006;

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endeavouri) and saucer scallops are targeted (Queensland Government, 2022a). Red-spot king prawns are a primary target in the Central Region and saucer scallops are targeted in the Southern Inshore Region (Department of Agriculture and Fisheries, 2021d; g; Queensland Government, 2022b).

[18] *2012 registered an annual sea snake mortality rate of 30.4 per cent but had the lowest number of reported interactions across the 2003 to 2021 period inclusive (Department of Agriculture and Fisheries, 2023).*

[19] *For example, within net mortalities plus unobserved mortalities resulting from the death of a sea snake that was released alive.*

Australian Fisheries Management Authority, Undated). The use of a release aid is not mandatory in the ECOTF and their ability to minimise injuries / improve post-interaction survival rates requires further research. There may however be some merit in further exploring their use in the ECOTF.

With the exception of the turtle-headed sea snake (*Emydocephalus annulatus*), the outputs of the whole-of-fishery ERA are considered more representative of an actual or real risk (Table 6). While some sea snakes have been well researched, data sets vary between species. From a management perspective, a limited understanding of interaction rates and catch compositions makes it difficult to assess the effectiveness of bycatch reduction strategies already employed in this fishery and the extent of any inter-specific risk variability. With improved information, further refinements of the sea snake risk profiles could be achieved at a whole-of-fishery and regional level.

Species-specific recommendations

1. ***Identify avenues/mechanisms that can be used to monitor sea snake interaction rates, validate data submitted through the Threatened, Endangered and Protected Animals (TEPA) logbook, and minimise the risk of non-compliance with mandatory reporting requirements.***

   The ECOTF does not have a mechanism in place to effectively (and efficiently) monitor the catch of non-target species or verify the accuracy of information submitted through the logbook program. This deficiency makes it difficult to interpret trends in the TEPA data and increases the level of assessment uncertainty. It is a risk element that applies to a wide range of species and, therefore, needs to be addressed at a whole-of-fishery level (section 6.1).

   Increasing the capacity of the ECOTF to monitor sea snake catch trends will be of central importance when assessing the ongoing effectiveness of bycatch mitigation strategies and the extent of any regional risk variability. This is of particular relevance to this complex as sea snake interactions are more likely to occur in key sectors or fisheries, namely in operations targeting red spot king prawns and scallops (Courtney *et al.*, 2010; Department of Agriculture and Fisheries, 2021d). Any initiative that helps validate data submitted through the logbook program will build confidence in the accuracy of the TEPA data and facilitate further refinement of the current risk profiles.

   At a regional level, this information could be used to provide further insight into the effectiveness of finer-scale management strategies implemented as part of the ECOTF harvest strategy program (Department of Agriculture and Fisheries, 2021d; h; f; g; e).

2. ***Continue to work with industry to improve sea snake handling and release protocols in the ECOTF. As part of this process, some consideration should be given to the use of release aids and their value as a bycatch mitigation strategy.***

   While research has shown that the use of a TED and BRD can reduce sea snake capture rates (Courtney *et al.*, 2010), their complete removal from the prawn trawl catch will be difficult. If retained in the net, there is an increased probability that a sea snake will be injured during the fishing event and/or during the sorting process.

   Once landed, the risk of a sea snake being injured or sustaining additional injuries will be highly dependent on the handling processes employed. It is recommended that management review the sea snake handling resources provided to industry and, when and where appropriate, update to align with industry best practice. As part of this process, further consideration should be given to the use of release aids as a bycatch mitigation strategy.

Anecdotal evidence suggests that the use of release aids is becoming more commonly used on trawling operations. The use of this apparatus in the ECOTF and the techniques employed by industry will likely vary. To this extent, there may be some benefit in providing industry with additional information on how to use release aids and avenues to minimise the risk of injury. These techniques may be distributed in the form of visual aids which can be easily interpreted by a range of individuals (*e.g.* printable posters) and potentially supported through audiovisual material *e.g.* YouTube tutorials.

3. ***Review available regional distribution data for sea snake species to accurately evaluate a) the level of overlap with ECOTF effort, b) the level of protection already afforded to the species in the region and c) to formulate updated data since major taxonomy changes have occurred to inform future assessments.***

When compared to data validation, this recommendation presents as a lower priority for the ECOTF. There will however be some benefits in establishing a more complete picture of sea snake compositions, habitats critical to their survival and areas where trawl-related risk is being effectively managed. Ideally, this information would be provided in a shapefile that could be overlayed with a map depicting the distribution of trawl effort along the Queensland east coast. This would facilitate easier and more accurate comparisons of how this fishery interacts with this subgroup across and within fishing years.

Given the taxonomic changes and (general) uncertainty surrounding sea snake distributions, it may be more difficult to fulfill this recommendation. Data collected from the ECOTF may assist in this process and improve the level of information on sea snakes most likely to be encountered in each of the five management regions.

4. ***Explore avenues to improve the level of information on sea snakes through engagement with industry and third-party representatives (e.g. the Queensland Museum, Australian Institute of Marine Science).***

This recommendation is intimately linked with the above recommendation. A degree of uncertainty remains surrounding the distribution of these sea snake species on the Queensland east coast since taxonomic changes. Where possible, it is recommended that management and industry explore avenues to increase research opportunities for this subgroup. One such option would be the provision of samples or analogous information (*e.g.* sample photos) to third-party representatives like the Queensland Museum.

6.2.3 Syngnathids

Species	Key Risk Regions	Risk Rating
Tiger pipefish (*F. tigris*)	ALL	Medium
Spiny seahorse (*H. spinosissimus*)	ALL	Medium
Great seahorse (*H. kelloggi*)	ALL	Medium

Species	Key Risk Regions	Risk Rating
White's seahorse (*H. whitei*)	Southern Inshore, Southern Offshore, Moreton Bay	Medium
Duncker's pipehorse (*S. dunckeri*)	Southern Inshore, Southern Offshore, Moreton Bay	High
Pallid pipehorse (*S. hardwickii*)	ALL	Medium
Bentstick pipefish (*T. bicoarctatus*)	ALL	Medium
Straightstick pipefish (*T. longirostris*)	Northern	Low
Ribboned pipefish (*H. taeniophorus*)	Northern	Low

When compared to the two previous qualitative assessments, ratings compiled using the PSA showed more variability (Table 6). For reference, both the GBRMP and southern Queensland trawl ERA classified all species within the *Syngnathidae* subgroup as an intermediate risk (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). The source of this variability, again, relates to the use of an alternate ERA methodology and the use of different attributes to quantify risk (refer section 6.1). This differential was most notable in the Duncker's pipehorse (*Solegnathus dunckeri*) risk profile. A review of the key drivers of risk determined that the use of alternate fishery-impact attributes (*susceptibility*) contributed to this species receiving a higher risk rating. Given these factors and declining effort levels (section 6.1), the assessment considered assigning *S. dunckeri* a precautionary-high risk rating. The decision to maintain the status-quo was due, in part, to the retention of this species as byproduct and uncertainty surrounding total interaction rates (retained plus discards). With improved information, it is conceivable that the risk score for *S. dunckeri* could be aligned more closely with the Pallid pipehorse (*S. hardwickii*); the only other syngnathid permitted for retention in the ECOTF.

Risk assessments involving syngnathids had to contend with a higher degree of uncertainty. This uncertainty stems from a broader deficiency in the amount of available information on *Syngnathidae* distributions, ecology and biology (*pers. comm.* D. Harasti). These deficiencies were partially addressed through the RRA and the risk profiles of all nine species were refined through additional consultation and scientific input (Appendix D). These refinements were more pronounced in the *productivity* component and primarily related to the *maximum age*, *age at sexual maturity* and *fecundity* attributes (Table 6). Fewer refinements could be made to the *susceptibility* attribute scores and RRA amendments for this component were more precautionary (Table 6).

The *Syngnathidae* registered the highest average score for the *susceptibility* component of the PSA (Table 4). Several factors contributed to this outcome including difficulties assessing the interaction potential (*encounterability*) for species with more restrictive data sets. Range descriptions for many species are largely inferred and require further investigation to determine if they are localised, patchy or continuous along the Queensland east coast (*availability*). Similarly, a number of species had relatively broad or ill-defined habitat descriptors which increased uncertainty surrounding the *encounterability* attribute. For example, IUCN Red List range descriptions for the spiny seahorse (*Hippocampus spinosissimus*) only incorporates northern Australia (Pollom, 2017b). However, Lourie (2016) indicates that this species does occurs on the Queensland east coast; an inference supported by *Queensland Museum* records (pers. comm. J. Johnson; Department of the Environment, 2022d;

Queensland Government, 2022d; Atlas of Living Australia, Undated).[20] This is just one example of where uncertainty surrounding the distribution of a species contributed to the production of more conservative risk assessments.

Of the remaining *susceptibility* attributes, syngnathids scored highly for both the *selectivity* and *post-interaction mortality* attributes (Table 6). Due to their size, syngnathids will pass easily through the TED bar spacings (12 cm) and the subgroup has a higher probability of being retained in the net. There is limited information on how effective BRDs are at removing syngnathids from the trawl catch and/or the risk of mortality. However, the use of BRDs like the square-mesh codend may yield greater benefits for this subgroup. If and when a sea horse or pipefish is retained in the net, their morphology and size increases the risk of injury and *in-situ* (within-net) mortalities *e.g.* internal and external injuries incurred during the trawl fishing event and the accumulation of the trawl shot weight.

If landed, the fate of a syngnathid caught in the ECOTF will depend on its status within the fishery. Under the current arrangements, a limited number of *S. dunckeri* and *S. hardwickii* can be retained for sale. *Solegnathus dunckeri* and *S. hardwickii* make up a high percentage of the ECOTF syngnathid catch (Connolly *et al.*, 2001; Dodt, 2005) and around 0.5 t are retained in the fishery each year (*2011–2021 average* = 0.48 t, *range* = 0.14–1.68 t; Department of Agriculture and Fisheries, 2023). The take of *S. dunckeri* and *S. hardwickii* is restricted by a combined trip limit of 50 individuals and both species must be discarded once this limit is reached. Operators are not required to record discard numbers (or fates) for *S. dunckeri* and *S. hardwickii* meaning interaction rates will be higher than what is reported through the logbook system. As a portion of this catch will be discarded in a dead or moribund state, fishing-mortality rates for both species will also be higher.

The remaining members of the *Family Syngnathidae* are all classified as no-take and are subject to mandatory reporting requirements through the TEPA logbook (Queensland Government, 2022a). Historical catch data for non-retainable syngnathids is limited, with less than 10 interactions reported through the logbook program over the last 10 years (Department of Agriculture and Fisheries, 2023). This data has poor species resolution and likely underestimates the number of syngnathids that are caught in the ECOTF annually. Under-reporting in this subgroup is likely attributed to the fact that these species are comparatively small and have more cryptic behaviours (Browne *et al.*, 2008). These factors increase the probability of a) a syngnathid going undetected within the broader trawl catch and b) being discarded without observation.

While acknowledging the potential for underreporting, expectations are that syngnathid interaction rates will be low when compared to other subgroups. Available information indicates that syngnathids are found in a range of habitats including in areas less-exposed to trawl fishing activities *e.g.* harder substrates, algal beds, seagrass and habitats with more complex three-dimensional structures (Lourie, 2016). Similarly, the complex will benefit from the range of spatial and temporal closures implemented on the Queensland east coast through marine parks and fisheries legislation. These habitat preferences and management arrangements provide the complex with a degree of natural protection from trawl fishing activities.

At a species level, the outputs of the PSA identified *S. dunckeri* and *S. hardwickii* as two of the more vulnerable syngnathid species. Information sets for *S. dunckeri* and *S. hardwickii* are limited and both are classified as *Data Deficient* through the *IUCN Red List of Threatened Species* (Pollom, 2017d; c).

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[20] *Hippocampus spinosissimus records have been previously registered under the synonym of H. queenslandicus.*

In the current study, biological data deficiencies were partly addressed through the RRA and further consultation (Table 6; Appendix D). These refinements though were not sufficient to reduce the *S. dunckeri* risk score below the high-risk rating threshold and/or offset deficiencies within the catch data (Table 6; Fig.1). From a risk management perspective, increasing the level of information on the life-history of *S. dunckeri* and *S. hardwickii* would provide further assurance that harvest numbers are sustainable. Any improvement in the biological data should coincide with an improvement in the overall level of information on catch compositions and interaction rates (retained plus discards).

Classifications for the remaining species are varied with most classified as *Least Concern* under the *IUCN Red List* criteria (Austin & Pollom, 2016; Pollom, 2016a; Pollom, 2016b; Pollom, 2016c). The notable exceptions being White's seahorse (*H. whitei*, *Endangered*), the great seahorse (*H. kelloggi*, *Vulnerable*) and *H. spinosissimus* (Vulnerable; Harasti, 2017; Pollom, 2017b; a). In an ERA context, the extinction risk classification of all three species increases the risk that trawl fishing activities will contribute to an undesirable event *e.g.* a decline in the viability of regional populations, reduced genetic diversity and further fragmentation of regional populations (Table 6). The key caveat being that IUCN ratings for all three species are based at the global level and may be less applicable in Australian waters (Harasti, 2017; Pollom, 2017b; a).

At a whole-of-fishery level, it is hypothesised that syngnathid interaction rates will be lower in the ECOTF when compared to other subgroups. The challenge being how best to quantify interaction rates (retained plus discards) and address assessment uncertainty. The capture of syngnathids in the ECOTF increases the risk to regional populations and may have a bearing on their long-term conservation status. The key determinants in this equation being a) the distribution of regional populations, b) the location of habitat critical to the survival of the species and c) the frequency and intensity of fishing events/effort within these areas. Without this information it will be difficult to determine if the outputs of this ERA are conservative or are consistent with what is occurring in the current fishing environment. From a management perspective, a lack of understanding of where these species occur and their relationship with the fishery will impede efforts to manage risks effectively.

Improving the level of information on syngnathid biology, distribution and habitat preferences would improve the accuracy of future risk assessments. It may also facilitate the removal of species that are less likely to interact with this fishery. This is considered of particular relevance to this group as risk levels will be dependent on the how extensively these habitats overlap with the entire ECOTF and each of the respective management regions.

Species-specific recommendations

1. ***Review material provided to industry to assist with syngnathid identification in an active fishing environment.***

   All syngnathids included in this assessment are subject to mandatory reporting requirements, whether that be through the TEPA logbook (no-take species) or logbooks that are used to track retained catch (*S. hardwickii* and *S. dunckeri*). While there are clear benefits to species-specific reporting, this can be more challenging for this subgroup. Some of the more notable challenges include detecting a syngnathid interaction within a multi-species catch, providing accurate identifications within an active fishing environment and/or for individuals that have sustained injuries during the trawl event (*e.g.* crushing and disfigurement of appendages).

For some non-target species, catch validation is being actively addressed through trials of alternate and innovative catch monitoring systems *e.g.* cameras (Department of Agriculture and Fisheries, 2018a; Queensland Government, Undated-a). These measures will be less effective for syngnathids as they will be harder to detect by the cameras. This means that the quality of the *Syngnathidae* data will continue to be dependent on the capacity of industry to a) detect a syngnathid interaction and b) differentiate between species. Given this, it is recommended that management review the resources provided to industry to determine their suitability and relevance. This review should take into consideration information contained in this report, taxonomic reviews and (when applicable) feedback from scientific experts on the species most likely to be encountered in this fishery.

2. ***Explore avenues to improve the quality of data on non-retainable syngnathids caught in the ECOTF including on interaction rates, species compositions and release fates.***

While operators are required to report the catch of all non-target/non-retainable syngnathids through the TEPA logbook, this portion of the catch is only recorded to the family level (*Family Syngnathidae*). As noted, recording syngnathids to species level is challenging and data validation mechanisms being considered for this fishery will be less effective for this subgroup. These limitations re-enforce the importance of industry in collecting information of syngnathid interaction rates, catch compositions and release fates.

A potentially viable option going forward would be to transition *Syngnathidae* reporting requirements to the sub-family level *i.e.* pipefish/pipehorse (*e.g. Filicampus spp*., *Trachyrhamphus spp*., *Solegnathus spp*., *etc*), sea horses (*Hippocampus spp.*) and sea dragons (*Phyllopteryx spp.,* and *Phycodurus sp.*). Data collected at the sub-family level will still provide a coarse overview of the syngnathid catch. It will however provide further insight into the complexes most likely to interact with this fishery and areas where research could be directed more effectively *e.g.* third-party catch composition analyses (recommendation 4).

3. ***Review reporting requirements for the two retainable species: S. hardwickii and S. dunckeri.***

As noted, *S. hardwickii* and *S. dunckeri* are the only syngnathid species that can be retained for sale in the ECOTF. While retention rates for these species are well documented within the logbook reporting system, there is limited information on discards. Operators are not required to report *S. hardwickii* and *S. dunckeri* discards and, as they are classified as byproduct, their capture is not reported through the TEPA logbook. It is recommended that a review of the current reporting requirements for *S. hardwickii* and *S. dunckeri* be undertaken to identify alternate options to monitor total interaction rates (retained plus discards) across the ECOTF.

4. ***Explore avenues to improve the level of information on syngnathid identifications and distributions along the Queensland east coast including with industry and third-party representatives (e.g. the Queensland Museum).***

This recommendation is intimately linked with the review of materials provided to industry to assist with syngnathid identification. As noted, datasets for the syngnathid complex are less developed and there remains a degree of uncertainty surrounding the distribution of these species on the Queensland east coast. Where possible, it is recommended that management and industry explore avenues to increase research opportunities for this subgroup. One such option would be the provision of samples or analogous information (*e.g.* sample photos) to third-party representatives like the *Queensland Museum* or regional universities.

Outside of catch compositions, future risk assessments would benefit from a greater synthesis of the available information on *Syngnathidae* distributions and preferred habitats. Range, habitat and abundance data for the majority of syngnathids is fragmented and further investigations are required to resolve discrepancies among distribution sources. In an ERA framework, this uncertainty contributed to the production of more conservative risk assessments.

From a fisheries management perspective, this type of uncertainty makes it difficult to assess fishing-related risks and the long-term consequences. Obtaining a more comprehensive overview of the available information on their distribution and habitat preferences would assist in this process. Given the fragmented nature of this information, this may require a greater reliance on inferred distribution descriptions based on habitats where these species are most likely to be encountered.

6.2.4 Sharks

Species	Key Risk Regions	Risk Rating
Collar carpetshark (*P. collare*)	Southern Offshore, Moreton Bay	Precautionary Medium
Brownbanded bambooshark (*C. punctatum*)	ALL	Low
Colclough's shark (*B. colcloughi*)	Central, Southern Inshore, Southern Offshore, Moreton Bay	High
Crested hornshark (*H. galeatus*)	Southern Offshore, Moreton Bay	Low
Eastern angelshark (*S. albipunctata*)	Northern, Central, Southern Inshore, Southern Offshore	Precautionary high
Eastern banded catshark (*A. marnkalha*)	Northern, Central, Southern Inshore	Precautionary Medium
Zebra shark (*S. tigrinum*)	ALL	Precautionary Medium
Piked spurdog (*S. megalops*)	Central, Southern Inshore, Southern Offshore	Medium
Australian weasel shark (*H. australiensis*)	ALL	Precautionary Medium
Pale spotted Catshark (*A. pallidus*)	Central, Southern Offshore	Low
Grey spotted catshark (*A. analis*)	Southern Offshore	Precautionary Medium
Orange spotted catshark (*A. rubiginosus*)	Southern Offshore	Low

None of the listed shark species are afforded species-specific protections under the *Fisheries Act 1994* or listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2019d; 2023). As a consequence, operators are not required to report interactions with these species through the *Threatened, Endangered and Protected Animals*

(TEPA) logbook (Queensland Government, 2022a).[21] However, all elasmobranchs are classified as no-take in the ECOTF meaning they cannot be retained for sale. To this extent, the presence or absence of additional legislative protections has fewer implications for this fishery. The fishery though will be a contributor of risk for this subgroup and, at present, their capture in the ECOTF is not subject to any long-term monitoring.

Risk profiles for a number of the sharks were influenced by data deficiencies and uncertainties surrounding the *productivity* analysis. *Age at maturity* was the most heavily deficient attribute, with 83 per cent of species being assigned a precautionary high-risk rating (Table 4 & 5). Additional deficiencies were evident within the *maximum age* and *fecundity* attributes (Table 4). As most sharks have *k-selected* life-histories (*e.g.* slow growth, long-lived and low fecundity; Adams, 1980; Camhi, 1998), a precautionary high score for these attributes may align with the biological constraints of some species (Last & Stevens, 2009; Ebert *et al.*, 2021; Kyne *et al.*, 2021). In others, this approach will overestimate the attribute risk and contribute to the production of more conservative risk assessments. Where possible, these deficiencies were addressed in the RRA through further consultation and the use of proxies (Appendix D; Table 6).

Within the *susceptibility* analysis, data deficiencies and uncertainty factored into a number of the attribute assessments (Table 4 & 6). This was most evident in assessments involving *post-interaction mortality* which is inherently difficult to quantify in a marine environment. While data on trawl-related mortalities were available for some species (e.g. the Australian weasel shark, Hemigaleus australiensis; Stobutzki *et al.*, 2002; Kyne, 2008), these were in the minority. This was reflected in the current assessment where, in the absence of data, *post-interaction mortalities* were identified as a key driver of risk for this subgroup (Appendix D; Table 6).

Criteria used to assess *selectivity* were primarily based on TED/BRD effectiveness (Table 2). Trawl nets used in the ECOTF must be fitted with an approved TED and BRD to help mitigate against the capture of non-target species (State of Queensland, 2010). While not universal, research indicates that TEDs are effective at excluding larger sharks (>100 cm) from the prawn trawl catch (Brewer *et al.*, 2006; Campbell *et al.*, 2020). However, smaller species will still be retained in the codend of the net where they will be exposed to an increased risk of injuries (external and internal) and mortalities across the fishing, landing and sorting processes (Stobutzki *et al.*, 2002; Kyne, 2008; Ellis *et al.*, 2017; Campbell, 2022; Scacco *et al.*, 2023).

In the ECOTF SOCC ERA, larger sharks were excluded from the analysis as part of the species rationalisation process (Appendices A & B). This was reflected in the construct of the current report where more than half of the assessed species had a maximum total length of less than 100 cm (Table 6). Further, only two shark species had a size-at-sexual maturity that exceeded 100 cm total length (Last & Stevens, 2009; Ebert *et al.*, 2021; Kyne *et al.*, 2021). For the listed species, these factors increase their vulnerability to capture across a wider expanse of their life history *i.e.* immature, sub-adult and mature (Table 6). This in turn increases their vulnerability/susceptibility to trawl fishing activities.

While noting the influence of body size on TED effectiveness, a number of other factors including the morphology of the cranium, body depth, width and rigidity may assist in the exclusion of some species.

[21] *The eastern angelshark (Squatina albipunctata) has been prioritised for a threatened species assessment through the EPBC Act (Threatened Species Scientific Committee, 2022). The outcome of this assessment is due in October 2024 and may result in an elevation of reporting requirements for this species.*

Where possible, these factors were taken into consideration as part of the RRA and helped refine *selectivity* attribute assessments (Appendix D; Table 6). These refinements were limited by an absence of information on shark catch compositions and interaction rates. This by default left body size as the key determinate of net selectivity. With improved information on species compositions and catch locations, a more inferred but informed assessment of net selectivity could be applied. For example, this data could be used in a weight-of-evidence approach to a) give further consideration to the morphology of each species and how it effects trawl-net selectivity and b) provide further insight into the probability (low, medium, high) of a species experiencing a contact without capture event in areas where they are most likely to be found.

Outside of *post-interaction mortality* and *selectivity*, *encounterability* was a notable factor of influence in the risk ratings of shark species. In the PSA, broad habitat and bathymetric descriptors resulted in several sharks being assigned higher risk ratings (Table 4). These assessment deficiencies were addressed in the RRA and helped refine the risk profiles of a number of species including the pale spotted catshark (*Asymbolus pallidus*) and the orange spotted catshark (*A. rubiginosus*; Appendix D; Table 6). However, the extent of these refinements were (again) limited by catch data deficiencies and the risk profiles of a number of other species (*e.g.* the eastern angelshark, *Squatina albipunctata*) could be refined with additional information on shark interaction rates and locations.

At a species level, the PSA indicated that trawl fishing posed a medium to high risk to most of the shark species assessed. The key caveat being that a number of these species were assigned more conservative ratings due to the aforementioned data deficiencies and the nature of the ERA methodology (Hobday *et al.*, 2007; Hobday *et al.*, 2011; Zhou *et al.*, 2016; Department of Agriculture and Fisheries, 2022a). In the ECOTF SOCC ERA, potential risk overestimates or false-positive results were classified as *precautionary*. The decision to classify these assessments as precautionary was supported by an *ad-hoc Likelihood & Consequence Analysis* (LCA). The primary purpose of the LCA was to provide further insight into the probability of the risk coming to fruition over the short to medium term (Appendix E).[22]

Of the species assessed, one of more immediate risk areas relate to the Colclough's shark, *Brachaelurus colcloughi*. *Brachaelurus colcloughi* is a rare Australian endemic with a small population (<10,000 individuals) and a poorly defined distribution (Last & Stevens, 2009; Ebert *et al.*, 2021). Third-party assessments suggest regional *B. colcloughi* populations are in decline and the extinction risk for this species was classified as *Vulnerable* under the *Action Plan for Australian Sharks and Rays* (Kyne *et al.*, 2021). While fishing activities have been identified as a threatening process (Kyne *et al.*, 2019a), the latest assessment classifies commercial fisheries bycatch as a low-threat element (Kyne *et al.*, 2021). With that said, the ECOTF will be a contributor of risk for this species and trawl-related mortalities have the potential to impact regional *B. colcloughi* populations.

Improving the level of information for *B. colcloughi* will be difficult as data sets for this species are based on less than 80 individuals (Kyne *et al.*, 2019a; Kyne *et al.*, 2021). While *B. colcloughi* has a restricted distribution on the Australian east coast, it does occur in waters accessed by trawl fishers (Kyne *et al.*, 2021). Catch of this species is not monitored through the TEPA logbook and ECOTF

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

interactions are largely undocumented. There has however been limited reports of the species being caught as bycatch in research projects quantifying otter trawl catch compositions (Courtney *et al.*, 2007b; Kyne, 2008; Kyne *et al.*, 2011a; Kyne *et al.*, 2019a). Going forward, the level of information on *B. colcloughi* interactions is unlikely to improve unless there is a change in the EPBC Act conservation status or legislative protections. This highlights the need to prioritise this species for long-term monitoring under the *Data Validation Program* (Department of Agriculture and Fisheries, 2018a; Queensland Government, Undated-a).

Outside of *B. colcloughi*, priority risk areas will vary and may be regionally dependent. For most sharks, improving the level of information on species compositions and interaction rates remains one of the more pressing risk areas. This information is of considerable importance when determining the need/necessity of management intervention at a whole-of-fishery or regional level. This is perhaps best exemplified by the deepwater shark species. These species often exhibit slower growth rates, later ages at maturity and higher longevities (Rigby *et al.*, 2015; Rigby *et al.*, 2016b; Kyne *et al.*, 2021) which make them more vulnerable to trawl fishing activities. However, species like *S. albipunctata* will interact with a smaller portion of the ECOTF and the rating may hold more relevance at a regional level (Table 6). Conversely, regional risk levels for the grey spotted catshark (*A. analis*), *A. pallidus* and *A. rubiginosus* may be higher than what is reported across the entire ECOTF (Table 6).

Issues relating to data validation and catch monitoring are now being addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* and the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a). A key focus of this plan being field trials of onboard cameras, control systems and software to detect interactions with threatened, endangered and protected species and other non-target catch during commercial trawl fishing activities (Queensland Government, Undated-a). The ability of this trial to identify shark bycatch to species level is still to be determined, as is the long-term viability of the program in the ECOTF. It does however represent the best opportunity to collect information on shark interaction rates and species compositions since the conclusion of the *Fisheries Observer Program* in 2012 (Queensland Government, Undated-b).

Going forward, the complex would benefit from further assessment using SAFE (Zhou & Griffiths, 2008; Zhou *et al.*, 2008). While SAFE was considered for the current ERA (section 4), the methodology is less suited to assessments involving a number of the key subgroups, namely marine turtles, sea snakes and syngnathids. Research has shown that SAFE produces fewer false-positives when compared to semi-quantitative methods like the PSA (Zhou *et al.*, 2016). These results align with a more generalised hypothesis that risk assessments derived from qualitative methods are more conservative (Hobday *et al.*, 2011; Zhou *et al.*, 2016; Campbell, 2022). Subjecting the shark complex to a SAFE assessment could negate broader issues surrounding false-positive results and precautionary risk ratings. However, the scope of any future assessment would benefit immensely from additional information on shark interaction rates and catch locations.

As noted with the deepwater sharks, some species were assigned *precautionary* ratings as the risk may be more applicable at a regional level. For species with restricted ranges or bathymetric preferences, risk levels outlined in Table 6 will not apply to all management regions. Where possible, the ‘key risk region’ has been identified within the summary table (see above). The subgroup though would benefit from a more detailed assessment of the risk posed to each species across the five management regions (Department of Agriculture and Fisheries, 2021d; h; f; g; e).

Species-specific recommendations

1. ***Increase the level of available information on high-risk species through long-term monitoring of interaction rates and release fates.***

   It is recommended that shark species assigned medium and high-risk ratings be considered for inclusion in long-term monitoring programs being implemented as part of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018a). While this plan is primarily focused on TEP species, gaining information on interaction rates and release fates would also benefit this complex. In the event that the proposed species list is too extensive, *B. colcloughi, S. albipunctata* and species at higher risk (including precautionary ratings) should be prioritised due to ongoing sustainability concerns, an elevated vulnerability, expected poor post-release survival rates and, an increased interaction potential in key sectors of the ECOTF.

   Any information obtained from this program would provide further insight into species distributions and their interaction potential in the ECOTF. It would benefit species with unconfirmed reports beyond its recognised range (*e.g. B. colcloughi*) and help account for regional risk variability. Notably, this recommendation is not necessarily restricted to the aforementioned species or shark subgroup and could be applied to a wider array of species.

2. ***Examine the need and potential benefits of undertaking an additional assessment of trawl-related risks using a quantitative Sustainability Assessment for Fishing Effects (SAFE).***

   Sharks are one of the subgroups included in the ECOTF SOCC ERA where a SAFE assessment can be applied effectively. Given the potential for the PSA to over-estimate the risk for some species, further assessment of the risk posed to sharks using SAFE should be considered. SAFE has been used to assess trawl-related risks for elasmobranchs in southern Queensland (Campbell *et al.*, 2017; Campbell, 2022) and the assessment could be extended to the rest of the ECOTF.

   Any SAFE involving the shark complex would likely be done in conjunction with the batoids (section 6.2.5). In the event that data deficiencies limit the applicability of SAFE for some species, the content of this report provides a comprehensive overview of the trawl-related risks.

3. ***Identify avenues to further explore the extent of any regional risk variability, specifically between the five management regions.***

   As noted, some species were assigned *precautionary* ratings as the outputs were considered to be more reflective of what is occurring at a regional level. For species with restricted ranges or bathymetric preferences, risk levels across the five management regions will not be uniform. Where possible, the ‘key risk region’ has been identified within the summary table of this report (see above). However, the subgroup would benefit from a more detailed assessment of the risk posed to each species across the five management regions (Department of Agriculture and Fisheries, 2021d; h; f; g; e).

   When and where appropriate, it is recommended that further consideration be given to undertaking an assessment of the risk posed by trawl fishing at a regional level. With the ECOTF now operating under regional management, the framework of this assessment could be aligned with the boundaries of the five harvest strategies (Department of Agriculture and Fisheries, 2021d; h; f; g; e). The key challenges being how best to quantify risk within artificial boundaries and for species whose distributions extend across multiple management regions. Evidently, the need to meet these two objectives might require the adoption of a more qualitative assessment methodology.

4. ***Identify avenues to improve the level of information for the Colclough's shark (B. colcloughi) and deepwater species e.g. the provision of additional reference material and sample collection for biological review and assessment.***

These species have key conservation and sustainability concerns which is compounded by the high susceptibility they demonstrate with the ECOTF. Both *B. colcloughi* and *S. albipunctata* have increased conservation concerns, inferred levels of population decline, unknown trawl-related mortality rates (at a species level) and ranges restricted to the east coast of Australia. While the extinction risk outlook for the remaining deepwater species (*e.g. Asymbolus spp*.) is better, there remain notable information gaps in their biology and distribution. These gaps reflect a broader deficiency in the level of information on deepwater sharks, skates and rays.

One of the more simple, cost-effective measures would be to provide industry with additional information on how to identify and photograph *B. colcloughi*. As a small shark with predominantly grey colouration, there is some potential for this species to be misidentified for (*e.g.*) the relatively common adult brownbanded bambooshark (*Chiloscyllium punctatum*) or the blind shark (*B. waddi*). With the provision of additional material and support, industry could become an invaluable asset in terms of increasing the level of information of this poorly known species.

6.2.5 Batoids

The batoid subgroup is one of the more diverse complexes assessed as part of the ECOTF SOCC ERA. It includes a variety of species with varying morphological traits, habitat preferences and conservation threats. The most notable morphological distinction being between sawfish (*Family Pristidae*) and non-sawfish batoids. These morphological differences (*e.g.* the presence/absence of a toothed rostrum) will have a bearing on the effectiveness of bycatch mitigation strategies employed in this fishery. Further, the sawfish complex have significant conservation concerns and are fully protected under the *Fisheries Act 1994*; a level of protection afforded to few other batoids. Due to these considerations, the outputs of the ECOTF SOCC ERA were considered separately for sawfish and non-sawfish batoids.

6.2.5.1 Batoids (Non-sawfish)

Species	Key Risk Regions	Risk Rating[23]
Australian butterfly ray (*G. australis*)	ALL	Precautionary High
Yellowback stingaree (*U. sufflavus*)	Southern Offshore	Precautionary High*
Patchwork stingaree (*U. flavomosaicus*)	Central, Southern Inshore, Southern Offshore	Precautionary Medium

[23] *Species with '*' were assigned precautionary ratings, in part, because they have more restrictive distributions in Queensland, primarily stingarees (Family Urolophidae) and skates (Family Rajidae). While some of these species have ongoing extinction risk/conservation concerns (Kyne et al., 2021), ratings assigned to these species may reflect regional risk versus risk at a whole-of-fishery level.*

Species	Key Risk Regions	Risk Rating[23]
Sandyback stingaree (*U. bucculentus*)	Southern Offshore	Precautionary High*
Kapala stingaree (*U. kapalensis*)	Southern Offshore	Precautionary High*
Greenback stingaree (*U. viridis*)	Southern Offshore	Precautionary High*
Common stingaree (*T. testacea*)	Southern Offshore	Medium
Sydney skate (*D. australis*)	Southern Offshore	Medium
Endeavour skate (*D. endeavouri*)	Southern Offshore	Precautionary High*
Argus skate (*D. polyommata*)	Central, Southern Offshore	Medium
Australian whipray (*H. australis*)	ALL	Medium
Blackspotted whipray (*M. astra*)	ALL	Precautionary High
Brown whipray (*M. toshi*)	ALL	Precautionary High
Estuary stingray (*H. fluviorum*)	Central, Southern Inshore, Southern Offshore, Moreton Bay	Medium
Coral sea maskray (*N. trigonoides*)	ALL	Medium
Speckled maskray (*N. picta*)	Northern, Central, Southern Inshore, Southern Offshore	Precautionary Medium
Bottlenose wedgefish (*R. australiae*)	ALL	Precautionary Medium
Eyebrow wedgefish (*R. palpebratus*)	Northern, Central	Precautionary Medium
Eastern shovelnose ray (*A. rostrata*)	Central, Southern Inshore, Southern Offshore, Moreton Bay	Precautionary Medium
Giant guitarfish (*G. typus*)	ALL	Precautionary Medium

Legislative protections for the batoid subgroup vary and few are classified as *Threatened, Endangered or Protected* under the *Environment Protection and Biodiversity Conservation Act 1999* or afforded additional protections under the *Fisheries Act 1994*. Some of the key exceptions being sawfish (*Family Pristidae*) and manta rays (*Mobula birostris* & *M. alfredi*)[24] which are fully protected in Queensland waters and the estuary stingray (*Hemitrygon fluviorum*) which is classified as *Near Threatened* under the *Nature Conservation Act 1992.* Of notable importance, all batoids are classified as no-take in the ECOTF and they cannot be retained for sale. To this extent, the presence or absence of additional legislative protections has fewer implications for this fishery. Trawl-related mortalities though will be a contributing factor in terms of the cumulative risk posed to these species (Department of Agriculture and Fisheries, 2019b).

There have been a number of notable projects examining the impact of trawl fishing on regional batoid communities. On the Queensland east coast this includes research on the composition and weight of the non-targeted trawl catch and detailed exploration of TED/BRD effectiveness (Courtney *et al.*,

[24] *Manta rays are defined under the Fisheries (General) Regulation 2019 as Manta spp. A taxonomic review of the Mobulidae reclassified manta rays as being part of the Mobula genus (White et al., 2017). As the intent of the legislation remains the same, M. birostris (formally Manta birostris) and M. alfredi (formally Manta alfredi) remain protected in Queensland waters.*

2007a; Courtney *et al.*, 2007b; Kyne, 2008; Courtney *et al.*, 2010; Courtney *et al.*, 2014; Rigby *et al.*, 2016b; Campbell *et al.*, 2017; Wang *et al.*, 2019). These studies are complemented by analogous assessments examining the broader impacts of the ECOTF and the species/communities that interact with the fishery (e.g. Pitcher *et al.*, 2007a; Pitcher *et al.*, 2009; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017; Pitcher *et al.*, 2017; Pitcher *et al.*, 2022). While this research provides the ECOTF with a strong baseline of historic information, data on recent catch trends and batoid compositions is more limited. This deficiency stems from the fact that the ECOTF does not have a mechanism in place to monitor and track catch compositions within an active fishing environment.

In the ECOTF ERA, these deficiencies limited the extent of refinements made as part of the *Residual Risk Analysis* (RRA) and potentially contributed to the production of more conservative risk assessments. For example, distribution data inconsistencies required the yellowback stingaree (*Urolophus sufflavus*), kapala stingaree (*U. kapalensis*) and the greenback stingaree (*U. viridis*) to be assessed under the alternate criteria for *availability* (Table 2). With improved information on interaction rates, catch locations and range extremities, the risk profiles of all three species could be refined. For *U. kapalensis*, which was assigned a precautionary high-risk rating, any score refinement would likely result in risk score reclassification to medium. Similarly, improving the level of information on catch compositions could facilitate the removal of some species from future updates due to a low interaction potential *e.g. U. viridis* (Appendices A & B).

Improving the level of information on species compositions and interaction rates is a more pressing risk area for batoids. In the ECOTF SOCC ERA, an absence of accurate catch composition data had a direct impact on the scope of the assessment. For example, limited information on interaction rates and locations resulted in a number of the species being included in the assessment as a precautionary measure (Appendix B). The inherent trade off with this approach is that the study may include species that interact with the ECOTF with less frequency and/or batoids whose interaction potential has declined through time *e.g.* due to a retraction in the ECOTF effort footprint (Department of Agriculture and Fisheries, 2023).

At an assessment level, batoids were one of the more morphologically diverse complexes included in the ECOTF SOCC ERA. This subgroup comprised around a third of the assessed species and included representatives from seven different families: *Gymnuridae* (butterfly rays), *Dasyatidae* (stingrays), *Urolophidae* (stingarees), *Rajidae* (hardnose skates), *Rhinidae* (wedgefishes), *Glaucostegidae* (giant guitarfish) and *Trygonorrhinidae* (banjo rays; Last *et al.*, 2016b; Kyne *et al.*, 2021). While noting this diversity, the key drivers of risk will be similar: biological constraints, TED/BRD effectiveness, a higher potential for post-interaction mortalities and ongoing uncertainty surrounding interaction rates and release fates (Table 6).

All of the listed species have biological traits and characteristics that are more consistent with a *k*-selected life-history *e.g.* longer lived, delayed maturity and lower levels of fecundity (Adams, 1980). These parameters will have a bearing on a species ability to absorb fishing mortalities and rebound from potential decline (Last *et al.*, 2016b; Kyne *et al.*, 2021). This was reflected in the *productivity* scores assigned to each species and was influential in the final risk ratings (Table 6). Evidently, biological constraints were identified as a key driver of risk in a number of the risk profiles. In this respect and, given the assessment methodology, it was always likely that a portion of the batoids would be assigned a higher risk rating.

Within the *susceptibility* component, the batoid risk profiles shared a number of commonalities which contributed to the subgroup receiving higher risk ratings. Most species included in this assessment are small (DW < 100cm) and are more likely to pass through the TED bar spacings (Brewer *et al.*, 2006; Griffiths *et al.*, 2006). Similarly, the use of BRDs, while effective for some species (*e.g.* the eastern shovelnose ray, *Aptychotrema rostrata*), will yield limited benefits for smaller rays (Courtney *et al.*, 2007a; Courtney *et al.*, 2007b; Kyne *et al.*, 2007b). Once retained in the codend of a trawl net, the ray will be exposed to a higher risk of mortality and injury; both internal and external. These factors were accounted for in assessments involving the *selectivity* and *post-interaction mortality* attributes (Table 6; Appendix D).

At a species level, data deficiencies were influential in a number of the *susceptibility* attribute assessments. For example, broad habitat and bathymetric descriptors resulted in several batoids being assigned a higher risk rating for *encounterability*. While some *encounterability* scores were refined as part of the RRA (Appendix D; Table 6), the extent of these refinements were limited by an absence of information on catch compositions and locations. With improved information on batoid interactions (including locations), future ERAs could utilise a more inferred but informed assessment of batoid *encounterability*. While difficult to quantify, this information could also be used in a weight-of-evidence approach to refine assessments of batoid *availability*. This in turn may facilitate a score reduction and reclassification for species like the blackspotted whipray (*Maculabatis astra*), the brown whipray (*M. toshi*) and the endeavour skate (*Dentiraja endeavouri*) whose scores sit just above the threshold of a high-risk rating (Fig. 1; Table 6).

Issues relating to data validation and catch monitoring are now being addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* and the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a). A key focus of this plan being field trials of onboard cameras, control systems and software to detect interactions with threatened, endangered and protected species and other non-target catch during commercial trawl fishing activities (Queensland Government, Undated-a). The ability of this trial to identify batoid bycatch to species level is still to be determined, as is the long-term viability of the program in the ECOTF. It does however represent the best opportunity to collect information on batoid interaction rates and species compositions since the conclusion of the *Fisheries Observer Program* in 2012 (Queensland Government, Undated-b).

While all species within this subgroup were classified as a medium or high risk, the relationship between these ratings and our broader understanding of their conservation status is more complicated (Kyne *et al.*, 2021; International Union for Conservation of Nature's Red List of Threatened Species, 2022). This situation is perhaps best exemplified by the Australian butterfly ray, *Gymnura australis*. *Gymnura australis* registered one of the highest *productivity* scores of the assessment, occurs across a wider expanse of the trawl effort footprint and is found in habitats that are more conducive to trawl fishing activities (Table 6). Further, *G. australis* has feeding behaviours and predator avoidance strategies that increase the probability of it being caught if located within the sweep of the net (*pers. comm.* I. Jacobsen; Jacobsen & Bennett, 2009; Jacobsen *et al.*, 2009). Each of these factors, combined with an absence of data on interaction rates, contributed to *G. australis* being assigned a high-risk rating in the ECOTF SOCC ERA (Table 6).

While noting the above, third-party assessments and research indicates that there are fewer concerns surrounding the long-term sustainability of *G. australis* populations. The species was assigned an extinction risk classification of *Least Concern* as part of the *Action Plan for Australian Sharks and Rays* and research from the *Northern Prawn Fishery* indicates that regional rates of fishing mortality are unlikely to lead to population declines (Kyne *et al.*, 2021). While more limited in scope, a SAFE assessment of trawl-related risks in southern Queensland also categorised the regional *G. australis* risk as low (Campbell, 2022).[25] It is further hypothesised that the species would be classified as *sustainable* if assessed using protocols outlined in the *Shark Report Card* (pers. comm. I. Jacobsen; Simpfendorfer *et al.*, 2019a; Fisheries Research and Development Corporation, 2021a).

The above considerations highlight the importance of providing context when interpreting the outputs of the ECOTF SOCC ERA and the need for management intervention. The PSA identifies aspects of a species biology and fishery impact profile that make it more vulnerable to fishing pressures. However, the risk posed to some species is unlikely to come to fruition unless there is a notable divergence from the current fishing environment. In the ECOTF SOCC ERA, batoid ratings representing a false-positive result or a potential risk overestimate were classified as *precautionary*. The decision to classify these assessments as precautionary was supported by an *ad-hoc Likelihood & Consequence Analysis* (LCA). The primary purpose of the LCA was to provide further insight into the probability of the risk coming to fruition over the short to medium term (Appendix E).[26]

In addition to potential over-estimates, *precautionary* ratings may be applied to species where the rating is more reflective of what is occurring at a regional level. This is of particular relevance to stingarees (*Family Urolophidae*) and skates (*Family Rajidae*) where known distributions are frequently confined to southern Queensland or deeper water environments (Last *et al.*, 2016b; Kyne *et al.*, 2021). Going forward, the batoid subgroup would benefit from a more detailed assessment of the risk posed to each species across the five management regions (Department of Agriculture and Fisheries, 2021d; h; f; g; e). This type of assessment would arguably be of most benefit to species like (*e.g.*) the Sydney skate (*Dentiraja australis*), *U. sufflavus* and *U. viridis* which have ongoing conservation concerns but only interact with a small portion of the ECOTF (Last *et al.*, 2016b; Kyne *et al.*, 2021).

As with sharks (section 6.2.4), batoids would also benefit from further assessment using SAFE (Zhou & Griffiths, 2008; Zhou *et al.*, 2008). While SAFE was considered for the current ERA (section 4), the methodology is less suited to assessments involving a number of the key subgroups, namely marine turtles, sea snakes and syngnathids. Research has shown that SAFE produces fewer false-positives when compared to semi-quantitative methods like the PSA (Zhou *et al.*, 2016). These results align with a more generalised hypothesis that risk assessments derived from qualitative methods are more conservative (Hobday *et al.*, 2011; Zhou *et al.*, 2016; Campbell, 2022).Subjecting the batoid complex to a SAFE assessment could negate broader issues surrounding false-positive results and precautionary risk ratings. However, the scope of any future assessment would benefit immensely from additional information on shark interaction rates and catch locations.

Species-specific recommendations

1. ***Identify avenues/mechanisms that can be used to monitor batoid interaction rates at a whole-of-fishery and regional level.***

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[25] *Additional information as to why the Productivity & Susceptibility Analysis (PSA) was adopted over the Sustainability Analysis for Fishing Effects (SAFE) is provided in the Methods section (see section 4).*

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

The ECOTF does not have a mechanism in place to effectively (and efficiently) monitor the catch of non-target species. While some information on batoid interaction rates is collected through the *Threatened, Endangered and Protected Animals* (TEPA) logbook, this data is limited to sawfish (*Family Pristidae*) and the estuary stingray (*Hemitrygon fluviorum*). No fishery-dependent data is collected on batoid species that are not included in the TEPA logbook (Queensland Government, 2022a). This deficiency in information makes it difficult to assess the effectiveness of bycatch mitigation strategies used in this fishery and the long-term implications for regional batoid communities.

Improving the level of information on batoid compositions and interaction rates will be of considerable importance to future ERAs. This information will help differentiate between real and potential risks and provide further insight on areas where further management might be required. As most batoids are not included in the TEPA logbook, it is recommended that this information be collected through data validation programs being considered for this fishery.

2. ***Examine the need and potential benefits of undertaking additional assessment of trawl-related risks using a quantitative Sustainability Assessment for Fishing Effects (SAFE).***

   Batoids are one of the subgroups included in the ECOTF SOCC ERA where a SAFE assessment can be applied effectively. Given the potential for the PSA to over-estimate the risk for some species, further assessment of the risk posed to batoids using SAFE should be considered. SAFE has been used to assess trawl-related risks for elasmobranchs in southern Queensland (Campbell *et al.*, 2017; Campbell, 2022) and the assessment could be extended to the rest of the ECOTF. In the event that data deficiencies limit the applicability of SAFE for some species, the content of this report provides a comprehensive overview of the trawl-related risks.

3. ***Identify avenues to further explore the extent of any regional risk variability, specifically between the five management regions.***

   As the ECOTF SOCC ERA is based at a whole-of-fishery level, the outputs may not reflect what is occurring at a regional level. This is of particular relevance to species with restricted geographical ranges or bathymetric preferences that limit their interaction potential in the ECOTF (*e.g.* deep-water species).

   When and where appropriate, it is recommended that further consideration be given to undertaking an assessment of the risk posed by trawl fishing at a regional level. With the ECOTF now operating under regional management, the framework of this assessment could be aligned with the boundaries of the five harvest strategies (Department of Agriculture and Fisheries, 2021d; h; f; g; e). The key challenges being how best to quantify risk within artificial boundaries and for species whose distributions extend across multiple management regions. Evidently, the need to meet these two objectives might require the adoption of a more qualitative ERA methodology.

4. ***Undertake a review of the resources made available to licence holders to assist in the identification of batoids including for the estuary stingray (Hemitrygon fluviorum).***

   A review of the current resources would help identify some of the current shortfalls and areas where licence holders would benefit from additional information. This could (theoretically) include a range of options such as more relevant and fishery-specific batoid identification guides, dedicated workshops and/or the development of electronic, user-friendly guides that can be readily accessed during a fishing event.

This recommendation is viewed as a lower priority for the ECOTF but may become more pressing if, for example, crew member observers become part of the broader ECOTF data validation program. Similarly, the fishery would benefit from the provision of additional information on the identification features of the *H. fluviorum*; the only species from this subgroup that is included in the TEPA logbook. While *H. fluviorum* interactions are more likely to occur in the *River and Inshore Beam Trawl Fishery*, the species may interact with otter trawlers operating in near-shore environments.

6.2.5.2 Batoids (Sawfish)

Species	Sub-fishery / Apparatus	Risk Rating
Narrow sawfish *(A. cuspidata)*	Northern, Central	Medium
Green sawfish *(P. zijsron)*	ALL	High

Ratings assigned to the two sawfish were higher than that reported in the two previous qualitative risk assessments (low-intermediate to intermediate; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). Factors contributing to this differential are similar to that reported at the whole-of-fishery level (section 6 & 6.1) and include the use of different ERA methodologies. The ECOTF SOCC ERA also considered risk at a whole-of-fishery level where the two previous assessments were confined to the GBRMP (Pears *et al.*, 2012b) and southern Queensland (Jacobsen *et al.*, 2015). For species that have experienced significant range contractions (*e.g.* sawfish), extending the assessment area may exert greater influence on the final risk ratings and conflate the extent of the risk posed at a whole-of-fishery and regional level.

The above considerations increase the probability that the observed change in sawfish ratings were the construct of changing methodology *versus* risk levels increasing across assessment periods. These factors limit inter-study comparisons and the extent of inferences drawn on how sawfish risk levels have changed between ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). With the current assessment examining risk across the entire ECOTF, it is considered the most up-to-date account of trawl-related risks and their potential to impact sawfish populations on the Queensland east coast.

The sawfish complex has experienced significant population declines and range contractions; particularly on the Queensland east coast (D'Anastasi *et al.*, 2013; Kyne *et al.*, 2013a; Kyne *et al.*, 2013b; Simpfendorfer, 2013; Department of the Environment, 2015). The key drivers behind these declines/contractions include fishing activities (commercial and recreational), habitat loss and habitat degradation. In Queensland, sawfish mortalities resulting from commercial trawl fishing activities have contributed to historic population declines and range contractions (Kyne *et al.*, 2021; Espinoza *et al.*, 2022; Grant *et al.*, 2022; Harry *et al.*, 2022). While trawl-related risks have reduced, the *Action Plan for Australian Sharks and Rays* still classifies the collective commercial fisheries bycatch threat as moderate to high (Kyne *et al.*, 2021).

Range descriptions for the green sawfish (*Pristis zijsron*) are based on historical observations and suggest the species is found across a large expanse of the ECOTF. This information is now outdated and it is hypothesised that the east coast *P. zijsron* distribution has contracted to north Queensland

(Kyne *et al.*, 2021). Based on this information, interactions with the ECOTF are more likely to occur in areas north of the Whitsundays (Harry *et al.*, 2011). The species is now considered less abundant or regionally extirpated south of the Whitsundays, including in regions with higher trawl intensities *i.e.* southern Queensland (Department of the Environment, 2019c). For context, the last record of a green sawfish being caught in Moreton Bay dates back to the 1960s (Johnson, 1999; Simpfendorfer, 2013). In the ECOTF, 15 *P. zijsron* interactions have been reported through the logbook program since 2003; the last of these being in 2018 (Department of Agriculture and Fisheries, 2023). Without a mechanism to validate catch compositions, it is difficult to verify the accuracy of these reports and the potential for misidentifications.

The distribution of the narrow sawfish (*Anoxypristis cuspidata*) extends further south along the Queensland east coast. When compared to other sawfish, *A. cuspidata* has experienced less-severe range contractions and population declines (D'Anastasi *et al.*, 2013; Kyne *et al.*, 2021; Department of the Environment, 2022a). This is partly attributed to the fact that *A. cuspidata* is more abundant, has faster growth and improved fecundity (pers. comm. B. Wueringer, C. Simpfendorfer; D'Anastasi *et al.*, 2013; Department of Agriculture and Fisheries, 2019a; Kyne *et al.*, 2021; Espinoza *et al.*, 2022; Grant *et al.*, 2022; Harry *et al.*, 2022). These traits improve the robustness of regional *A. cuspidata* populations and increase the species capacity to absorb regional fishing mortalities. These factors were accounted for in the *productivity* component of the PSA (Table 4 & 6).

The life-history of *A. cuspidata* reduces but does not completely mitigate the risk posed by trawl fishing activities. There are ongoing concerns surrounding the long-term sustainability of the species and the health of regional populations (D'Anastasi *et al.*, 2013; Last *et al.*, 2016b; Kyne *et al.*, 2021; Department of the Environment, 2022a). In the ECOTF, *A. cuspidata* makes up around two-thirds of the sawfish reports; registering between one and 18 interactions per year over the 2003–2018 period (excluding 2011; Department of Agriculture and Fisheries, 2023). There are no reports of *A. cuspidata* interacting with the ECOTF in the post-2018 period and it is difficult to ascertain if this is a true reflection of the current fishing environment or the result of non-compliance and under-reporting.[27]

Historic data for the ECOTF includes interactions with the dwarf, wide and freshwater sawfish (Department of Agriculture and Fisheries, 2023). There are limited recent reports of the dwarf sawfish (*P. clavata*) occurring on the Queensland east coast and the species may now be extirpated from most if not all of this region (ECIF Bycatch Management Workshop, Townsville, 14–15 May 2019; Department of Agriculture and Fisheries, 2019a; Kyne *et al.*, 2021; Grant *et al.*, 2022). Records for the wide and freshwater sawfish are likely to be the largetooth sawfish (*P. pristis*) and cannot be verified without direct observation. If *P. pristis* still occurs on the east coast, it will be confined to northern Queensland where effort is lower and interactions are less likely to occur. This reduced interaction potential was a contributing factor in terms of *P. pristis* and *P. clavata* being excluded from this study and the two previous assessments (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015).

At a species level, life-history constraints were a key driver of risk for both species. For *P. zijsron*, all but one of the *productivity* attributes were assigned the highest risk rating (Table 6). In the corresponding *A. cuspidata* assessment, *age at maturity* and *maximum age* were the only attributes to receive scores of less than three (Table 6). These *productivity* assessments provided *P. zijsron* and *A.*

[27] *All commercial fishing operators are required to record interactions with sawfish (Family Pristidae) in the Threatened, Endangered and Protected Animals (TEPA) logbook. This is a mandatory reporting requirement in all commercial fisheries.*

cuspidata with baseline risk scores of 3.03 (medium risk) and 2.63 respectively.[28] This means that *P. zijsron*, would meet the threshold of a high-risk rating if a) just one *susceptibility* attribute was assigned the maximum score or b) two *susceptibility* attributes were assessed as a medium (2) risk. The threshold for a high-risk rating was greater for *A. cuspidata* as the species registered a lower *productivity* score (Table 6).

Within the *susceptibility* component, the drivers of risk were more varied and attribute assessments needed to account for a higher level of uncertainty. The use of a TED has proven effective at removing marine megafauna from a trawl net and, based on their maximum size, both species will derive some benefit from their use in the ECOTF; *maximum size* = ~350 cm TL for *A. cuspidata* and >700 cm TL for *P. zijsron* (Kyne *et al.*, 2021). With that said, results from research assessing the effectiveness of TEDs at removing sawfish from the prawn trawl catch have varied. For example, research showed that the use of a TED in the *Northern Prawn Fishery* did not reduce the number of sawfish being caught over the sample period. However, the same research also demonstrated that the use of the TED can reduce the number of *A. cuspidata* being caught (Brewer *et al.*, 2006).

The use of a TED has proven highly effective at excluding larger sharks and rays (>100 cm) from the prawn trawl catch (Brewer *et al.*, 2006; Wakefield *et al.*, 2017; Campbell *et al.*, 2020; National Oceanic and Atmospheric Administration Fisheries, 2021). While Australian sawfish fit into this category (Last *et al.*, 2016b), their morphological features will reduce the overall effectiveness of the TED (Appendix D). All sawfish possess a blade-like rostrum armed with enlarged, lateral, tooth-like denticles (Last & Stevens, 2009; Last *et al.*, 2016b). This rostrum is highly susceptible to net entanglements and may impede an animal's ability to escape through a TED opening. Examples of where this might occur include the rostrum becoming trapped within the TED or becoming entangled in the anterior of the net *i.e.* in front of the TED (Wakefield *et al.*, 2017). In the ECOTF SOCC ERA, this susceptibility to entanglement was accounted for in the *selectivity* attribute RRA (Table 6; Appendix D).

The entanglement risk for this complex will be higher in the *East Coast Inshore Fishery* and *Gulf of Carpentaria Inshore Fishery* where gillnets are the primary apparatus used (Jacobsen *et al.*, 2021b; Pidd *et al.*, 2021). Nonetheless, this risk will still be present in the ECOTF and it remains a key risk area for this subgroup (Table 6). This risk may be compounded by injuries incurred during the fishing event and/or when an individual attempts to extricate itself from the net. In the event that the animal is able to escape through the TED opening, these types of injuries have the potential to disrupt essential feeding behaviours and patterns (Wueringer *et al.*, 2012). This by extension elevates the risk that a contact without capture event will have longer-term implications for this subgroup. This was the catalyst behind the two sawfish being assigned more conservative risk ratings for *post-interaction mortality* (Table 6; Appendix D).

Pristis zijsron and *A. cuspidata* will derive benefit from observed declines in annual effort and the introduction of regional effort caps (Department of Agriculture and Fisheries, 2021e; d; h; f; g). However, any risk reduction resulting from declining effort and participation rates will be regionally dependent. As the distribution of *P. zijsron* and *A. cuspidata* is largely confined to northern Queensland, effort reductions in the central and northern regions will be the key determinates (Department of Agriculture and Fisheries, 2021d; f).

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

Going forward, the complex would benefit from additional information on sawfish catch compositions, interaction rates, locations and release fates. There remains a high level of uncertainty surrounding these parameters; stemming from the current inability to validate data submitted through the logbook program. In an ERA context, this uncertainty required the adoption of a more precautionary approach and may have led to the production of more conservative risk assessments. This was most evident in assessments involving the *encounterability*, *selectivity* and *post-interaction mortality* attributes (Table 6). With additional information and data, these aspects of the sawfish risk profiles could be further refined. The complex would also benefit from a closer examination of the risk posed to each species across the five management regions (Department of Agriculture and Fisheries, 2021d; h; f; g; e).

A weight-of-evidence approach suggests that the ECOTF is a contributor of risk for this complex *versus* the main driver of risk. Interactions, while likely in this fishery, will be lower than in inshore net fisheries *e.g.* the *East Coast Inshore Fishery* and *Gulf of Carpentaria Inshore Fishery*. However, the ability of a species to tolerate or sustain trawl-related mortalities will be dependent on the health of regional populations. For species like *P. zijsron* which is listed as *Vulnerable* under the *EPBC Act* and *Critically Endangered* under the *Status of Australian Sharks and Rays*, this will be more difficult. This assessment would equally apply to *P. pristis* and *P. clavata* if still found on the Queensland east coast.[29] Some of the potential consequences being further range contractions, regional population fragmentation and a loss of genetic diversity. This highlights the importance of improving information on sawfish catch rates, compositions and locations within the ECOTF and establishing a long-term mechanism to monitor interactions with this complex.

Species-specific recommendations

1. ***Identify avenues/mechanisms that can be used to monitor sawfish interactions and validate data submitted through the Threatened, Endangered and Protected Animals (TEPA) logbook and minimise the risk of non-compliance with mandatory reporting requirements.***

   The risk profiles of both *P. zijsron* and *A. cuspidata* had to account for a range of uncertainties relating to interaction rates and release fates. These uncertainties and deficiencies contributed to the production of more conservative risk assessments. Improving the level of information on sawfish interactions and (overall) confidence in data submitted through the TEPA logbook would help refine the risk profiles of both species.

   Improving the level of information on sawfish interaction rates and compositions would assist in terms of quantifying the extent of any trawl-related impacts (*i.e.* none, low, medium or high). This information will be of some importance when considering the cumulative fishing risks, particularly in central and northern Queensland where sawfish interactions are more likely.

2. ***Review resources relating to sawfish identification and handling protocols to improve current practices across the fishery.***

   Depending on the size of the animal and its manoeuvrability, sawfish may be injured (inadvertently or intentionally) during the handling and release process. Research is being undertaken in the Gulf of Carpentaria to improve handling and release practices in the gillnet fishery. There may however

[29] *The extinction risk for P. pristis has been assessed as Critically Endangered and the species has a threatened species listing of Vulnerable under the EPBC Act. The extinction risk for P. clavata has been assessed as Endangered and the species has a threatened species listing of Vulnerable under the EPBC Act.*

be some benefit in reviewing the suitability and applicability of information made available to industry on the Queensland east coast.

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

   The TEPA logbooks are the primary source of information in terms of interaction rates and mortalities. With the continued implementation of the *Queensland Sustainable Fisheries Strategy 2017–2027*, there will be greater capacity to monitor and validate catch rates for these species. However, it is also recommended that alternate avenues be explored to improve the level of information for this subgroup *e.g.* via StrandNET, improved collaboration with regional universities and researchers. The viability of this recommendation would need to be considered in consultation with the *Department of Environment and Science* (Queensland) who are the gatekeepers of the StrandNET database.

7 Summary

The ECOTF SOCC ERA provides additional depth to the risk profiles of these species and further differentiates between potential and actual risks (Department of Agriculture and Fisheries, 2018b). Outputs from this assessment 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, 2017a).

Precautionary elements included in the methodology combined with data deficiencies have contributed to the development of more conservative risk profiles. For some of the species, the final risk ratings were considered precautionary and are unlikely to result in significant species-specific reforms. There were, however, a number of species where the risk requires further attention and the management of the risk is viewed as a higher priority. This will need to occur at both a whole-of-fishery and species-specific level. The outputs of the current ERA though, when combined with recent management reforms and annual effort reductions, indicate that there has been an overall improvement in the management of risk in this fishery. This is partly reflected in the fact that nine of the 12 species at higher risk had *precautionary* ratings.

Going forward, QDAF anticipates that further refinements and (likely) risk score reductions will be achieved through the harvest strategy program and the Data Validation Plan *e.g.* Independent Data Validation (IDV) / catch monitoring.

8 References

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9 Appendices

Appendix A – Species Rationalisation Process Overview.

Appendix B – Species Rationalisation Process: Justifications & Considerations.

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

Appendix D – Residual Risk Analysis.

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

Appendix A—Species Rationalisation Process Overview

1. Overview

The *East Coast Otter Trawl Fishery* (ECOTF) interacts with a diverse range of target and non-target species ranging from marine megafauna to benthic invertebrates. For key target and byproduct species, long-term risks are managed through regional harvest strategies (Department of Agriculture and Fisheries, 2021e; d; f; g; h) and detailed stock assessments (Department of Agriculture and Fisheries, 2020b). This process is supported by ancillary programs like the *National Status of Australian Fish Stocks* or SAFS (Fisheries Research and Development Corporation, 2021b).

The five regional ECOTF harvest strategies were introduced in 2021 and the broader effectiveness of these measures are still being explored within an active fishing environment. However, each harvest strategy includes decision rules, reference points and trigger limits to guide the management of key species (Department of Agriculture and Fisheries, 2021e; d; f; g; h). These measures minimise fishing-related risks for target and byproduct species and reduce the immediate need to undertake an Ecological Risk Assessment (ERA) for these subgroups. The premise being that long-term sustainability risks for target and byproduct species are being effectively managed under the current framework. For these reasons, target and byproduct species were not included in this phase of the ECOTF ERA update. When and where appropriate, these species will be considered for inclusion in subsequent ERAs involving this fishery.

In Phase 1 of the ECOTF ERA update, species classified as *Threatened*, *Endangered* and *Protected* (TEP) were prioritised for assessment. These species are afforded additional legislative protections and are subject to mandatory reporting requirements *via* the *Threatened, Endangered and Protected Animals* (TEPA) logbook (Queensland Government, 2022a). Often central in discussions surrounding prawn-trawl bycatch, TEP species will also form the framework of any *Protected Species Management Plan* (Department of Agriculture and Fisheries, 2020c; 2022f). In the ECOTF, marine turtles, sea snakes, syngnathids and sawfish are the main TEP subgroups (Department of Agriculture and Fisheries, 2023).

In addition to TEP species, Phase 1 of the ECOTF ERA update includes a range of elasmobranchs that are caught as bycatch. The elasmobranch complex encompasses sharks, stingrays, stingarees and skates and they are a focal point for research on prawn trawl bycatch (e.g. Courtney *et al.*, 2007b; Kyne *et al.*, 2007b; Courtney *et al.*, 2014; Campbell *et al.*, 2017; Campbell, 2022). Few elasmobranchs are classified as *Threatened, Endangered* or *Protected* and, as a consequence, most are not subject to mandatory reporting requirements (Queensland Government, 2022a). There are however notable concerns surrounding the long-term sustainability of regional populations and the broader status of some species (Last & Stevens, 2009; Last *et al.*, 2016b; Fisheries Research and Development Corporation, 2021a; Kyne *et al.*, 2021). These ongoing conservation concerns were the catalyst behind the decision to include elasmobranchs in Phase 1 of the ECOTF ERA update.

Outside TEP species and elasmobranchs, trawl operations will interact with a diverse range of non-target teleosts and invertebrates. Datasets for general bycatch have not improved significantly since the completion of the two qualitative ERAs. With that said, there are a number of broader developments that may have reduced the risk across this subgroup. These developments include a general reduction in trawl effort over the post-2009 period[30] and the introduction of regional effort caps (refer to main report). It is recognised though that risk levels across this complex will vary and cumulative fishing pressures may be higher for some species. For example, the ECOTF interacts with species that are targeted and retained in other commercial fisheries and sectors *e.g.* juvenile snapper, whiting, flathead *etc*. In these instances, the ECOTF will be a contributing factor in terms of the total rates of fishing mortality and cumulative fishing pressures.

While noting the above considerations, teleosts and invertebrates are viewed as a lower assessment priority when compared to TEP species and elasmobranchs. When and where appropriate, these species will be considered for inclusion in subsequent phases of the ECOTF ERA update. The scope and extent of these ERAs will depend on a range of factors including feedback provided by the Fisheries Working Groups (Department of Agriculture and Fisheries, 2017b; 2021b), previous assessments (e.g. Courtney *et al.*, 2007b; Pitcher *et al.*, 2007a; Pears *et al.*, 2012a; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015) and the outputs of any bycatch monitoring initiatives instigated under the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2018a).

While marine habitats and species assemblages have been considered in previous assessments (Pears *et al.*, 2012a; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015), information levels for these two ecological components (*e.g. Habitat 10*) have shown little improvement. Some of these deficiencies are now being actively addressed as part of a broader survey being undertaken by the *Commonwealth Scientific and Industrial Research Organisation* (CSIRO). This program has yet to progress to a point where the outputs would support the inclusion of either ecological component in Phase 1 of the ECOTF ERA update.

2. Preliminary Species List

As Phase 1 of the ERA update focuses specifically on species with ongoing conservation concerns, both the main report and the appendices reference it as the *ECOTF Species of Conservation Concern* (SOCC) *Ecological Risk Assessment*.

The scope of the ECOTF SOCC ERA was initially based on a broad list of species that had the potential to interact with the fishery. The preliminary list was based on the species included within the TEPA logbook and the former *Species of Conservation Interest* (SOCI) logbook. It was then expanded through a review of commonwealth and state legislation and international conventions with the potential to influence fishing activities in Queensland. Legislation, international instruments and reports considered as part of this included:

- *Fisheries Act 1994* and the subordinate legislation (Qld).
- *Nature Conservation Act 1992* (Qld).
- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth).
- *Great Barrier Reef Marine Park Regulations 1983* (Commonwealth).

[30] *2009 was used as the reference year for Ecological Risk Assessments undertaken by Pears et al. (2012b) and Jacobsen et al. (2015).*

- *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES; International Convention).

- *Convention on the Conservation of Migratory Species of Wild Animals* (CMS; International Convention).

- *The Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021).

- *An Ecological Risk Assessment of trawl fishing activities in the Great Barrier Reef Marine Park* (Pears *et al.*, 2012a; Pears *et al.*, 2012b).

- *The Southern Queensland East Coast Otter Trawl Fishery and River and Inshore Beam Trawl Fishery* (Jacobsen *et al.*, 2015).

- *Estimating the Impacts of Management Changes on Bycatch Reduction and Sustainability of High-risk Bycatch Species in the Queensland East Coast Otter Trawl Fishery* (Campbell *et al.*, 2017).

- *Bycatch Weight, Composition and Preliminary Estimates of the Impact of Bycatch Reduction Devices in Queensland's Trawl Fishery* (Courtney *et al.,* 2007b).

- *Mapping and characterisation of key biotic & physical attributes of the Torres Strait ecosystem* (Pitcher *et al.*, 2007b).

This review was further supplemented using information from key source materials including but not limited to *Sharks and Rays of Australia* (Last & Stevens, 2009), *Rays of the World* (Last *et al.*, 2016b); the *Queensland Marine Turtle Conservation Strategy 2021–2031* (Department of Environment and Science, 2021), *Seahorses: A Life-Size Guide to Every Species* (Lourie, 2016) and various conservation-based recovery plans (Department of the Environment and Energy, 2017).

Once compiled, the preliminary list of SOCC was refined using the following steps. These steps were applied with a degree of flexibility to account for uncertainty (*e.g.* distributional data gaps) and in accordance with the precautionary nature of the *Productivity & Susceptibility Analysis* (PSA).

1. Any species whose distribution does not incorporate the prescribed ECOTF fishing area was excluded from the analysis.

2. The distributions of the remaining species were then compared with the prescribed area of fishing symbols used in the ECOTF. Species with distributions demonstrating low to negligible overlap with the fishing effort footprint, had a low to negligible interaction potential, or low likelihood of capture within the apparatus, were excluded.

3. Any species where there was uncertainty surrounding the distribution and interaction potential were retained in the assessment and further advice sought from scientific experts and key stakeholders.

4. The revised list was then reviewed to remove:

    - Species with a *maximum total length* (TL) equal or greater than three metres or a *maximum disc width* (DW) equal or greater than two metres. The assumption being that these species will have limited interactions with the ECOTF and/or an increased probability of being excluded from the codend by the Turtle Excluder Device (TED).[31].

- Species with a vertical distribution commencing at 400 m or greater as this exceeds the general depth range of otter trawls.

- Species previously assigned a low risk rating in Campbell *et al.* (2017) where a) Queensland distribution was wholly encapsulated by the study and b) evidence did not support further analysis.[32]

5. The preliminary species assessment list was then reviewed by the *Trawl Fisheries Working Group* (Department of Agriculture and Fisheries, 2022f) and, where and when appropriate, feedback was incorporated into the analysis. The *Trawl Fisheries Working Group* was consulted on the scope of the ECOTF and the species list at a workshop held on 18–19 October 2022 (Department of Agriculture and Fisheries, 2022f).

3. Summary Tables

Once completed full justifications were provided as to why a species was included or omitted from the final analysis. When and where appropriate, species that were omitted from the ECOTF SOCC ERA will be considered for inclusion in subsequent assessments involving this fishery.

A detailed summary of the species rationalisation process has been provided in Appendix A: Table 1 (below). A full account of the species rationalisation process including species-specific justifications and considerations have been provided in Appendix B.

[31] *Evidence demonstrates that TEDs are effective at excluding species with a TL and DW greater than one metre (Brewer et al., 2006; Campbell et al., 2020; National Oceanic and Atmospheric Administration Fisheries, 2021). The adoption of more conservative measures aligns with the precautionary approach applied by the PSA. A similar approach was applied in the depth profile considerations which excluded species found predominantly in water depths greater than 400 m.*

[32] *The Campbell et al. (2017) analysis applied the Sustainability Assessment for Fishing Effects or SAFE. As a quantitative assessment, SAFE provides an absolute measure of risk versus an indicative estimate. Research has shown that SAFE produces fewer false positives when compared to semi-quantitative methods like the Productivity & Susceptibility Analysis (Zhou et al., 2016).*

Appendix A cont.—

***Table 1**—Summary of the species that were considered for inclusion in the East Coast Otter Trawl Fishery (ECOTF) Species of Conservation Concern (SOCC) Ecological Risk Assessment (ERA).*

All species with green squares and a 'Y' were included in the ECOTF SOCC ERA. Red squares with an 'N' are those that were considered for inclusion but omitted from the analysis. The list of species considered for inclusion in the ECOTF ERA was compiled from a range of sources and refined through consultation with the *Trawl Fisheries Working Group* and members of the scientific community. '*' is used to identify species that have historically been referred to or reported with an alternative scientific or common name.

Common name	Species name	CAAB	Inc.	Consideration
Sharks				
Sharpnose sevengill shark	*Heptranchias perlo*	37 005001	**N**	Has an affinity for deeper water environments and limited interaction potential, *Heptranchias perlo* and *Hexanchus nakamurai* are less likely to interact with the ECOTF at levels which may pose significant long-term threats to regional populations.
Bigeye sixgill Shark*	*Hexanchus nakamurai**	37 005004	**N**	
Australian sharpnose shark	*Rhizoprionodon taylori*	37 018024	**N**	*Rhizoprionodon taylori*, *R. acutus* and *Loxodon macrorhinus* were not included for further assessment as they were all assigned a low-intermediate or intermediate risk rating in two previous qualitative ERAs, and low-risk ratings when assessed using a quantitative SAFE method.
Milk shark	*Rhizoprionodon acutus*	37 018006	**N**	
Sliteye shark	*Loxodon macrorhinus*	37 018005	**N**	
Hardnose shark	*Carcharhinus macloti*	37 018025	**N**	There is limited evidence to suggest that *Carcharhinus macloti* frequently interacts with the ECOTF and/or in quantities that will impact regional population numbers.

Common name	Species name	CAAB	Inc.	Consideration
Whitecheek shark*	*Carcharhinus coatesi**	37 018009	**N**	*Carcharhinus coatesi* was considered a lower assessment priority. Consideration will be given to including this species in future iterations of the ECOTF ERA update.
School shark	*Galeorhinus galeus*	37 017008	**N**	The distribution of *Galeorhinus galeus* only includes a small portion of the Queensland coastline and is expected to have low to negligible interactions with Queensland-managed fisheries.
Silvertip shark	*Carcharhinus albimarginatus*	37 018027	**N**	A review of the available data indicates that these species will have limited to negligible interactions with the ECOTF. If an interaction were to occur, these species would more likely experience a contact without capture event *i.e.* excluded from the net through the TED opening.
Grey reef shark	*Carcharhinus amblyrhynchos*	37 018030	**N**	
Blacktip reef shark	*Carcharhinus melanopterus*	37 018036	**N**	
Whitetip reef shark	*Triaenodon obesus*	37 018038	**N**	
Spinner shark	*Carcharhinus brevipinna*	37 018023	**N**	*Carcharhinus brevipinna* was not included for further assessment as it was assigned a low-intermediate risk rating in two qualitative ERAs, and a low-risk rating when assessed using a quantitative SAFE method.
Nervous shark	*Carcharhinus cautus*	37 018034	**N**	*Carcharhinus cautus* was not assessed due to a low interaction potential and limited evidence of significant interactions with the ECOTF.
Common blacktip shark	*Carcharhinus limbatus*	37 018039	**N**	

Common name	Species name	CAAB	Inc.	Consideration
Australian blacktip shark	*Carcharhinus tilstoni*	37 018014	**N**	A review of the available data indicates that these species interact infrequently with the ECOTF and are rarely caught as bycatch. If *Carcharhinus limbatus*, *C. tilstoni* or *C. sorrah* interacts with a trawl net, there is an increased probability that subadult and mature animals will be excluded from the net through the TED opening.
Spot-tail shark*	*Carcharhinus sorrah**	37 018013	**N**	
Pigeye shark	*Carcharhinus amboinensis*	37 018026	**N**	*Carcharhinus amboinensis* was not included for further assessment as it was assigned a low-risk rating when assessed using a quantitative SAFE method across its southern Queensland distribution.
Bull shark	*Carcharhinus leucas*	37 018021	**N**	Interactions with the ECOTF are likely infrequent. In the unlikely event that a *Carcharhinus leucas* interacts with the ECOTF the animal will most likely experience a contact without capture event.
Sandbar shark	*Carcharhinus plumbeus*	37 018007	**N**	There is limited evidence to suggest that this species frequently interacts with the ECOTF and/or in quantities that will impact regional population numbers.
Speartooth shark	*Glyphis glyphis*	37 018041	**N**	*Glyphis glyphis* is a euryhaline species with juveniles and subadults frequenting tropical macrotidal rivers. Therefore, interactions with the ECOTF are highly unlikely/improbable. Anecdotal evidence also suggests that this species may now be extirpated from the Queensland east coast (Pillans *et al.*, 2009).
Gummy shark*	*Mustelus antarcticus**	37 017001	**N**	Due to its morphological features, most subadults and mature *Mustelus antarcticus* are expected to experience contact without capture events during a trawl interaction.

Common name	Species name	CAAB	Inc.	Consideration
Australian weasel shark	*Hemigaleus australiensis*	37 018020	**Y**	One of the more prominent shark species in the prawn trawl bycatch. Lower conservation concerns and assessment is precautionary.
Fossil shark	*Hemipristis elongata*	37 018011	**N**	Due to its morphological features, most subadults and mature *Hemipristis elongata* are expected to experience contact without capture events during a trawl interaction.
Colclough's shark*	*Brachaelurus colcloughi**	37 013013	**Y**	Rare species with data deficiencies and ongoing conservation concerns. ECOTF has an increased potential to impact regional populations.
Blind shark*	*Brachaelurus waddi**	37 013007	**N**	*Brachaelurus waddi* was not assessed further due to its known low interaction potential and limited evidence of significant interactions with the ECOTF.
Brownbanded bambooshark*	*Chiloscyllium punctatum**	37 013008	**Y**	One of the more prominent shark species in the prawn trawl bycatch. Lower conservation concerns and assessment is precautionary.
Tasselled wobbegong	*Eucrossorhinus dasypogon*	37 013011	**N**	*Eucrossorhinus dasypogon* was not included for further assessment as it was assigned a low-intermediate risk rating when assessed using a conservative method in two previous ERAs.
Gulf wobbegong	*Orectolobus halei*	37 013020	**N**	Due to its morphological features, most subadults and mature *Orectolobus halei* are expected to experience contact without capture events during a trawl interaction.
Spotted wobbegong	*Orectolobus maculatus*	37 013003	**N**	*Orectolobus maculatus* was not included for further assessment as it was assigned a low and low-intermediate risk rating when assessed using a quantitative SAFE method and conservative methods

Common name	Species name	CAAB	Inc.	Consideration
				respectively (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017).
Banded wobbegong	*Orectolobus ornatus*	37 013001	**N**	*Orectolobus ornatus* was not included for further assessment as it was assigned a low and low-intermediate risk rating when assessed using a quantitative SAFE method and a conservative method respectively (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017).
Northern wobbegong	*Orectolobus wardi*	37 013017	**N**	*Orectolobus wardi* was excluded due to its restricted range in far north Queensland. This region is fished with less frequency in the ECOTF and interactions are less likely.
Collar carpetshark	*Parascyllium collare*	37 013002	**Y**	Lower conservation concerns and assessment is precautionary.
Zebra shark*	*Stegostoma tigrinum**	37 013006	**Y**	Included in the assessment as a precautionary measure.
Eastern banded catshark	*Atelomycterus marnkalha*	37 015037	**Y**	Species with limited information and may be infrequently observed in prawn trawl bycatch. Included in the assessment as a precautionary measure.
Crested hornshark	*Heterodontus galeatus*	37 007003	**Y**	Interactions limited to southern Queensland but has lower conservation concerns. Included in the assessment as a precautionary measure.
Eastern angelshark	*Squatina albipunctata*	37 024004	**Y**	Deepwater species that will interact with the ECOTF. Extent of the interaction potential and longer-term implications requires further investigation.

Common name	Species name	CAAB	Inc.	Consideration
Grey spotted catshark	*Asymbolus analis*	37 015027	**Y**	Deepwater species that will interact with the ECOTF. Extent of the interaction potential and longer-term implications requires further investigation.
Orange spotted catshark	*Asymbolus rubiginosus*	37 015024	**Y**	Deepwater species that will interact with the ECOTF. Extent of the interaction potential and longer-term implications requires further investigation.
Pale spotted catshark	*Asymbolus pallidus*	37 015025	**Y**	Deepwater species that will interact with the ECOTF. Extent of the interaction potential and longer-term implications requires further investigation.
Smalleye pygmy shark	*Squaliolus aliae*	37 020017	**N**	Due to an affinity for deeper water environments and limited interaction potential, *Squaliolus aliae* is less likely to interact with the ECOTF at levels that may pose significant long-term threats to regional populations.
Black shark	*Dalatias licha*	37 020002	**N**	Due to its preference for deeper water environments which are less conducive to trawl fishing, *Dalatias licha* was considered a lower priority for reassessment.
Blackfin ghostshark*	*Chimaera ogilbyi**	37 042001	**N**	Due to evidence suggesting low interaction rates with the ECOTF and a depth profile that are largely inaccessible due to operational constraints, this species was considered a lower assessment priority.
Endeavour dogfish	*Centrophorus moluccensis*	37 020001	**N**	

Common name	Species name	CAAB	Inc.	Consideration
Gulper shark	*Centrophorus granulosus*	37 020023	**N**	These species were not included as there is limited evidence that they have frequent interactions with the ECOTF and/or are caught as bycatch in this fishery.
Harrison's dogfish	*Centrophorus harrissoni*	37 020010	**N**	
Longsnout dogfish	*Deania quadrispinosa*	37 020004	**N**	
Eastern longnose spurdog	*Squalus grahami*	37 020041	**N**	*Squalus grahami* and *S. montalbani* were not included for further assessment as they were both assigned low-risk ratings when assessed using a quantitative SAFE method across their southern Queensland distribution (Campbell *et al.*, 2017).
Philippine spurdog	*Squalus montalbani*	37 020047	**N**	
Southern mandarin dogfish	*Cirrhigaleus australis*	37 020049	**N**	The vertical distribution of this species has minimal crossover with the effort footprint of the ECOTF. Therefore, potential for interaction is heavily limited.
Eastern highfin spurdog	*Squalus albifrons*	37 020038	**N**	Interactions between this species and the ECOTF are expected to be infrequent and are reduced further by spatial protections afforded by the Coral Sea Marine Park.
Piked spurdog*	*Squalus megalops**	37 020006	**Y**	Deepwater species that will interact with the ECOTF. Extent and potentially implications requires further investigation.
Sawtail catshark*	*Figaro boardmani**	37 015009	**N**	*Figaro boardmani* was not included for further assessment as it was assigned a low-risk rating when assessed using a quantitative SAFE method across its known Queensland distribution. Interactions would only occur at the margins of its depth range and *F. boardmani* is expected to be a relatively fecund/productive species.

Common name	Species name	CAAB	Inc.	Consideration
Tawny shark	*Nebrius ferrugineus*	37 013010	**N**	Due to its morphological features, most subadults and mature *Nebrius ferrugineus* are expected to be excluded from a trawl net through the TED opening.
Tropical sawshark	*Pristiophorus delicatus*	37 023004	**N**	Due to an affinity for deeper water environments, *Pristiophorus delicatus* is less likely to interact with the ECOTF at levels that may pose significant long-term threats to regional populations.
Batoids				
Eastern numbfish*	*Narcinops nelsoni**	37 028008	**N**	Due to an affinity for deeper water environments and limited interaction potential, *Narcinops nelsoni* is less likely to interact with the ECOTF at levels that may pose significant long-term threats to regional populations.
Bentfin devilray	*Mobula thurstoni*	37 041003	**N**	Mobulid rays were considered low assessment priorities as their morphological features and habitat preferences reduce the interaction potential with trawl fishing in the ECOTF.
Giant devilray	*Mobula mobular*	37 041002	**N**	
Giant manta ray*	*Mobula birostris**	37 041004	**N**	
Kuhl's devilray*	*Mobula kuhlii**	37 041007	**N**	
Long-horned pygmy devilray*	*Mobula eregoodoo**	37 041001	**N**	
Reef manta ray*	*Mobula alfredi**	37 041005	**N**	
Sydney skate*	*Dentiraja australis**	37 031041	**Y**	Skate species with higher potential to interact with the ECOTF.

Common name	Species name	CAAB	Inc.	Consideration
Endeavour skate	*Dentiraja endeavouri**	37 031043	Y	Included in the assessment as a precautionary measure.
Argus skate	*Dentiraja polyommata**	37 031042	Y	Included in the assessment as a precautionary measure.
Blacktip skate	*Dipturus melanospilus*	37 031033	N	*Dipturus apricus* and *D. melanospilus* were not included for further assessment as they were considered to be lower assessment priorities due to their preference for deeper water environments resulting in limited interactions with the ECOTF.
Pale tropical skate	*Dipturus apricus*	37 031032	N	
Common stingaree	*Trygonoptera testacea*	37 038006	Y	Stingaree species with higher potential to interact with the ECOTF, particularly in southern Queensland.
Yellowback stingaree	*Urolophus sufflavus*	37 038005	Y	Stingaree species with higher potential to interact with the ECOTF, particularly in southern Queensland.
Kapala stingaree	*Urolophus kapalensis*	37 038018	Y	Stingaree with a higher interaction potential.
Greenback stingaree	*Urolophus viridis*	37 038007	Y	Stingaree species with the potential to interact with the ECOTF, particularly in southern Queensland. The species was included in the assessment as a precautionary measure and due (in part) to it having higher conservation concerns (Kyne *et al.*, 2021).
Sandyback stingaree	*Urolophus bucculentus*	37 038001	Y	Stingaree with a higher interaction potential.
Patchwork stingaree	*Urolophus flavomosaicus*	37 038010	Y	Included as a precautionary measure.
Australian butterfly ray	*Gymnura australis*	37 037001	Y	High interaction potential.
Coffin ray	*Hypnos monopterygius*	37 028001	N	*Hypnos monopterygius* was not included for further assessment as it was assigned a low-risk rating when assessed using a quantitative

Common name	Species name	CAAB	Inc.	Consideration
				SAFE method across the southern extent of its Queensland distribution (Campbell *et al.*, 2017).
Short-tail torpedo ray*	*Tetronarce nobiliana**	37 028003	**N**	*Tetronarce nobiliana* was not included for further assessment as it was assigned a low-intermediate risk rating when assessed using a qualitative ERA across a portion of its known Queensland distribution.
Australian cownose ray	*Rhinoptera neglecta*	37 040001	**N**	*Aetobatus ocellatus* and *Rhinoptera neglecta* were considered to be lower assessment priorities as their morphological features reduce the interaction potential with trawl fishing in the ECOTF. Any interactions are expected to be contact without capture events.
Spotted eagle ray	*Aetobatus ocellatus*	37 039003	**N**	
Southern eagle Ray*	*Myliobatis tenuicaudatus**	37 039001	**N**	These rays were considered to be lower assessment priorities as their morphological features and habitat preferences reduce the interaction potential with trawl fishing in the ECOTF.
Banded eagle ray	*Aetomylaeus caeruleofasciatus*	37 039002	**N**	
Ornate eagle ray	*Aetomylaeus vespertilio*	37 039005	**N**	
Purple eagle ray	*Myliobatis hamlyni*	37 039004	**N**	
Bottlenose wedgefish	*Rhynchobatus australiae*	37 026005	**Y**	Recent upgrade of listing under international listings. Some potential for this species to interact with the ECOTF.
Eyebrow wedgefish	*Rhynchobatus palpebratus*	37 026004	**Y**	Recent upgrade of listing under international listings. Some potential for this species to interact with the ECOTF.
Shark ray	*Rhina ancylostoma*	37 026002	**N**	Due to its morphological features, most subadults and mature *Rhina ancylostoma* interacting with the ECOTF are expected to experience

Common name	Species name	CAAB	Inc.	Consideration
				contact without capture events. *Rhina ancylostoma* is known to be rarely encountered, therefore, it was considered a lower priority for assessment.
Giant guitarfish*	*Glaucostegus typus**	37 027010	**Y**	Recent upgrade of listing under international listings. Some potential for this species to interact with the ECOTF.
Eastern shovelnose ray	*Aptychotrema rostrata*	37 027009	**Y**	One of the more common species caught as bycatch in the ECOTF.
Eastern fiddler ray	*Trygonorrhina fasciata*	37 027006	**N**	*Trygonorrhina fasciata* was not included for further assessment as it was assigned a low-risk rating when assessed using a quantitative SAFE method across its known Queensland distribution (Campbell *et al.*, 2017).
Bluespotted maskray	*Neotrygon australiae*	37 035004	**N**	*Neotrygon australiae* was excluded due to its restricted range in far north Queensland. This region is fished with less frequency in the ECOTF, and interactions are less likely.
Coral sea maskray	*Neotrygon trigonoides*	37 035031	**Y**	Smaller ray with increased potential to interact with and be caught in the ECOTF.
Speckled maskray	*Neotrygon picta*	37 035029	**Y**	Smaller ray with increased potential to interact with and be caught in the ECOTF.
Brown stingray*	*Bathytoshia lata**	37 035002	**N**	*Bathytoshia lata* was not included for further assessment as it was assigned a medium-risk rating when assessed using a quantitative SAFE method across the southern extent of its Queensland distribution (Campbell *et al.*, 2017).

Common name	Species name	CAAB	Inc.	Consideration
Smooth stingray*	*Bathytoshia brevicaudata**	37 035001	**N**	*Bathytoshia brevicaudata* was not included for further assessment as it was assigned a low-risk rating when assessed using a quantitative SAFE method across the southern extent of its Queensland distribution (Campbell *et al.*, 2017).
Jenkins' whipray	*Pateobatis jenkinsii*	37 035025	**N**	*Pateobatis jenkinsii* was excluded due to its restricted range in far north Queensland. This region is fished with less frequency in the ECOTF, and interactions are less likely.
Australian whipray*	*Himantura australis**	37 035003	**Y**	Included as a precautionary measure.
Blackspotted whipray*	*Maculabatis astra**	37 035020	**Y**	One of the more common rays interacting with the ECOTF.
Brown whipray*	*Maculabatis toshi**	37 035022	**Y**	One of the more common rays interacting with the ECOTF.
Leopard whipray*	*Himantura leoparda**	37 035026	**N**	*Himantura leoparda* was excluded due to its restricted range in far north Queensland. This region is fished with less frequency in the ECOTF and interactions are less likely.
Mangrove whipray*	*Urogymnus granulatus**	37 035019	**N**	Due to its morphological features and habitat preferences, most subadults and mature *Urogymnus granulatus* interacting with the ECOTF are expected to experience contact without capture events.
Porcupine ray	*Urogymnus asperrimus*	37 035027	**N**	Due to its habitat preference which is less conducive to trawl fishing and lack of ECOTF interactions, *Urogymnus asperrimus* was considered a lower priority for reassessment.
Broad cowtail whipray*	*Pastinachus ater**	37 035011	**N**	Due to its morphological features, most subadult and mature *Pastinachus ater* are expected to experience contact without capture events during interactions.

Common name	Species name	CAAB	Inc.	Consideration
Pink whipray	*Pateobatis fai*	37 035024	**N**	Due to its morphological features, most subadult and mature *Pateobatis fai* are expected to experience contact without capture events during interactions.
Bluespotted fantail Ray	*Taeniura lymma*	37 035009	**N**	Due to its habitat preference, which is less conducive to trawl fishing, *Taeniura lymma* was considered a lower priority for assessment.
Blotched fantail ray	*Taeniurops meyeni*	37 035017	**N**	Due to its morphological features, most subadult and mature *Taeniurops meyeni* are expected to experience contact without capture events during interactions.
Smalleye stingray	*Megatrygon microps*	37 035028	**N**	Due to its morphological features, mature *Megatrygon microps* are expected to experience contact without capture events during interactions.
Estuary stingray*	*Hemitrygon fluviorum**	37 035008	**Y**	One of the few batoids with a legislative listing. Listed as *Near Threatened* under the *Nature Conservation Act 1992.*
Dwarf sawfish	*Pristis clavata*	37 025004	**N**	Due to its habitat preference and restricted Queensland distribution, *Pristis clavata* was excluded from the assessment.
Green sawfish	*Pristis zijsron*	37 025001	**Y**	Species with significant conservation concerns and increased entanglement potential. The ECOTF has the potential to contribute to the ongoing decline of regional populations.
Largetooth sawfish*	*Pristis pristis**	37 025003	**N**	Due to an affinity for river habitats during early life stages, *Pristis pristis* was excluded from the assessment. Evidence suggests that if this species does occur on the east coast, it will be confined to northern Queensland where effort levels are lower.

Common name	Species name	CAAB	Inc.	Consideration
Narrow sawfish	*Anoxypristis cuspidata*	37 025002	Y	Species with significant conservation concerns and increased entanglement potential. The ECOTF has the potential to contribute to the ongoing decline of regional populations.
Syngnathids				
Bentstick pipefish*	*Trachyrhamphus bicoarctatus**	37 282006	Y	Species most likely to interact with the ECOTF. *Solegnathus dunckeri* and *S. hardwickii* are retained as byproduct in this fishery.
Duncker's pipehorse	*Solegnathus dunckeri*	37 282098	Y	
White's seahorse*	*Hippocampus whitei**	37 282027	Y	
Pallid pipehorse*	*Solegnathus hardwickii**	-	Y	
Spiny seahorse*	*Hippocampus spinosissimus**	37 282110	Y	
Great seahorse*	*Hippocampus kelloggi**	37 282117	Y	
Straightstick pipefish	*Trachyrhamphus longirostris*	37 282101	Y	
Tiger pipefish	*Filicampus tigris*	37 282064	Y	
Ribboned seadragon*	*Haliichthys taeniophorus**	37 282007	Y	
Thorny seahorse	*Hippocampus histrix*	37 282134	N	
Common seahorse*	*Hippocampus kuda**	37 282033	N	

Common name	Species name	CAAB	Inc.	Consideration
Low-crown seahorse*	*Hippocampus dahli**	37 282114	**N**	These *Syngnathidae* species were not progressed as part of the current ECOTF ERA as they were considered to be secondary assessment priorities.
Wide-bodied pipefish	*Stigmatopora nigra*	37 282018	**N**	
Double-ended pipefish	*Syngnathoides biaculeatus*	37 282100	**N**	
Zebra seahorse	*Hippocampus zebra*	37 282080	**N**	
Narrow-bellied seahorse*	*Hippocampus angustus**	37 282005	**N**	
Scribbled pipefish*	*Corythoichthys intestinalis**	37 282049	**N**	These *Syngnathidae* species were not progressed as part of the current ECOTF ERA as a result of additional consultation.
Ornate pipefish*	*Halicampus macrorhynchus**	37 282067	**N**	
Banded pipefish*	*Dunckerocampus dactyliophorus**	37 282057	**N**	
Short-pouch pygmy pipehorse*	*Acentronura breviperula**	37 282035	**N**	
Bargibant's seahorse	*Hippocampus bargibanti*	37 282106	**N**	
Denise's pygmy seahorse	*Hippocampus denise*	37 282136	**N**	
Spotted pipefish*	*Stigmatopora argus**	37 282017	**N**	
Three-spot seahorse	*Hippocampus trimaculatus*	-	**N**	

Common name	Species name	CAAB	Inc.	Consideration
Sea snakes				
Beaked sea snake*	*Hydrophis zweifeli **	39 125013	**Y**	Species of sea snake most likely to interact with the ECOTF and be caught as bycatch.
Dubois' sea snake*	*Aipysurus duboisii**	39 125003	**Y**	
Elegant sea snake*	*Hydrophis elegans**	39 125021	**Y**	
Horned sea snake*	*Hydrophis peronii**	39 125001	**Y**	
Olive sea snake*	*Aipysurus laevis*	39 125007	**Y**	
Olive-headed sea snake*	*Hydrophis major**	39 125011	**Y**	
Spotted sea snake*	*Hydrophis ocellatus**	39 125028	**Y**	
Small-headed sea snake*	*Hydrophis macdowelli**	39 125025	**Y**	
Spectacled sea snake*	*Hydrophis kingii**	39 125010	**Y**	
Spine-bellied sea snake*	*Hydrophis curtus**	39 125031	**Y**	
Mosaic sea snake*	*Aipysurus mosaicus**	39 125004	**Y**	
Stoke's sea snake	Hydrophis stokesii	39 125009	**Y**	
Turtle-headed sea snake*	*Emydocephalus annulatus**	39 125012	**Y**	

Common name	Species name	CAAB	Inc.	Consideration
Yellow-bellied sea snake*	*Hydrophis platurus**	39 125033	**N**	This species was not progressed as part of the current ECOTF ERA as it is unlikely to interact with the fishery based on its habitat preferences.
Large-headed sea snake	*Hydrophis pacificus*	39 125029	**N**	This species was not progressed as part of the current ECOTF ERA as it is unlikely to interact with the fishery based on its distribution.
Marine turtles				
Green turtle	*Chelonia mydas*	39 020002	**Y**	Species of turtles likely to interact with the ECOTF.
Loggerhead turtle	*Caretta caretta*	39 020001	**Y**	
Hawksbill turtle	*Eretmochelys imbricata*	39 020003	**Y**	
Flatback turtle	*Natator depressus*	39 020005	**Y**	
Olive ridley turtle	*Lepidochelys olivacea*	39 020004	**Y**	
Leatherback turtle	*Dermochelys coriacea*	39 021001	**Y**	
Dolphins (Cetaceans)				
Australian snubfin dolphin	*Orcaella heinsohni*	41 116010	**N**	The direct capture of a dolphin or whale within a trawl net is considered to be highly unlikely. Interactions are expected to be contact without capture events and are unlikely to have a detrimental impact on the individual and/or the long-term conservation status of regional populations.
Common bottlenose dolphin*	*Tursiops truncatus* *	41 116019	**N**	
Indo-Pacific bottlenose dolphin*	*Tursiops aduncus* *	41 116020	**N**	

Common name	Species name	CAAB	Inc.	Consideration
Common dolphin	*Delphinus delphis*	41 116001	**N**	
False killer whale	*Pseudorca crassidens*	41 116013	**N**	
Spinner dolphin	*Stenella longirostris*	-	**N**	

Appendix B—Species Rationalisation Process: Justifications and Considerations

The following provides a detailed overview of the key justifications and considerations used to omit or include a species in the *ECOTF SOCC* ERA. All species with green squares and a 'Y' were included in the SOCC ERA. Red squares with an 'N' are those that have been omitted from the analysis. The list of species was compiled from a range of sources and refined through consultation with the *Trawl Fisheries Working Group* and members of the scientific community. '*' used to identify species that have historically been referred to by an alternative name.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Marine turtles				
Green turtle	*Chelonia mydas*	39 020002	**Y**	**Included**—The ECOTF effort footprint overlaps with the known distribution of six marine turtle species. Turtle interactions have also been reported from the fishery through the *Threatened, Endangered and Protected Animals* logbook and the previous *Species of Conservation Interest* (SOCI) logbook (Queensland Government, 2022a). Data compiled through these logbooks show that the number of marine turtle interactions reported from this fishery each season have declined through time (Department of Agriculture and Fisheries, 2023). The data shows that marine turtle interactions are more prevalent in the inshore net fishery (Department of Agriculture and Fisheries, 2023). Observed declines in turtle capture rates are attributed to risk mitigation strategies implemented in the fishery. One of the more significant and successful strategies to be implemented was mandating the use of Turtle Excluder Devices (TEDs). Turtle Excluder Devices are designed to prevent turtles entering the codend of the net and have been highly effective in terms of reducing the number of turtles caught within the net. The effectiveness of these measures was reflected in the two previous ERAs where marine turtles were assigned a low to intermediate risk rating (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015).
Loggerhead turtle	*Caretta caretta*	39 020001	**Y**	
Hawksbill turtle	*Eretmochelys imbricata*	39 020003	**Y**	
Flatback turtle	*Natator depressus*	39 020005	**Y**	
Olive ridley turtle	*Lepidochelys olivacea*	39 020004	**Y**	
Leatherback turtle	*Dermochelys coriacea*	39 021001	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				The two previous ERAs were based on the 2009 season where the ECOTF recorded 38,970 effort days (Department of Agriculture and Fisheries, 2022b). Since the updated ERA, effort levels have remained below 2009 levels with the 2010–2020 period registering an average of 35,276 days fished (*range* = 32,832–38,035 days fished). While not universal, a reduction in effort levels suggests that the risk posed to the marine turtle complex is at least equal to or lower than the 2009 assessments (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). This hypothesis though has yet to be fully tested and will (likely) be subject to key caveats surrounding regional trawl intensities. Given the outputs of the previous assessments, risk mitigation measures already in place, and the introduction of regional harvest strategies, the marine turtle complex could be viewed as a secondary reassessment priority. With that said, a considerable period of time has passed since the last assessment and the complex may benefit from re-evaluation using the *Productivity & Susceptibility Analysis* (PSA). Accordingly, the marine turtle complex was included in the ECOTF ERA update. The decision to include marine turtles in the ECOTF ERA update is viewed as precautionary and future assessments will need to consider the potential for false-positive results. Under the ERA framework used in Queensland, this potential will be considered as part of the Residual Risk Analysis.
Sea snakes				
Beaked sea snake (synonym: Hooked-nosed sea snake,	*Hydrophis zweifeli* (synonym: *Enhydrina*	39 125013	**Y**	**Included**—Reported effort in the ECOTF overlaps with the known distribution of several sea snake species and the complex is responsible for most of the trawl-based *Threatened*, *Endangered* and *Protected* species interactions reported through the

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Sepic beaked sea snake)	*schistosa* or *H. schistosus*)			logbook system (Queensland Government, 2022a) (*n* = >30,000 reported interactions since 2003; *range* = 336 to 4,789 per year, 2003–2021 inclusive) (Department of Agriculture and Fisheries, 2017a). Due to their morphology and habitat preferences, sea snakes will continue to be caught by trawl operations on the Queensland east coast. For this reason, the sea snake complex was progressed and will be assessed as part of the ECOTF ERA update. This assessment will complement two previous qualitative ERAs where they were assigned low-intermediate risk ratings (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). The ECOTF ERA update will provide the complex with a more comprehensive, whole-of-fishery assessment. It is recognised though that the risk posed to these species will display both regional and inter-specific variance. As risk levels will not be uniform across the ECOTF, future assessments will need to take into consideration regional distributions, the management regions that each species will interact with and the potential for false-positive results. Future assessments will need to consider management initiatives that have been instigated since the last assessment *e.g.* the establishment of regional harvest strategies (Department of Agriculture and Fisheries, 2020a; 2021d; f; e; g; h). ***Note***—The Australian population of the spotted sea snake (*Hydrophis ocellatus*) has historically been referred to as both *H. ornatus* and *H. ornatus ocellatus*. Taxonomic and genetic analyses have since indicated that *H. ocellatus* is heterospecific from these two species (Rasmussen *et al.*, 2014). While *H. ocellatus* is the current adopted nomenclature for this species occurring in Australian waters, it is noted that some
Dubois' sea snake (synonym: Reef shallows sea snake)	*Aipysurus duboisii*	39 125003	**Y**	
Elegant sea snake (synonym: Bar-bellied sea snake)	*Hydrophis elegans*	39 125021	**Y**	
Horned sea snake	*Hydrophis peronii* (synonym: *Acalyptophis peronii*)	39 125001	**Y**	
Olive sea snake (synonym: Golden sea snake)	*Aipysurus laevis*	39 125007	**Y**	
Olive-headed sea snake (synonym: Greater sea snake)	*Hydrophis major* (synonym: *Disteira major*)	39 125011	**Y**	
Spotted sea snake (Historical: Ornate reef sea snake)	*Hydrophis ocellatus* (Historical: *Hydrophis ornatus*,	-	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
	Chitulia ornata) (Department of the Environment, 2022c)			Australian authors continue to utilise the historical synonym *H. ornatus* (Rasmussen *et al.*, 2014). For the purposes of this PSA, this species will be referred to as *H. ocellatus*. The Australian population of the mosaic sea snake (*Aipysurus mosaicus*) has historically been referred to as *A. eydouxii*. Taxonomic and genetic analyses have since indicated that *A. mosaicus* is heterospecific from *A. eydouxii* which primarily occurs in Asia (Sanders *et al.*, 2012). For the purposes of this PSA, the nomenclature *A. mosaicus* will be utilised. The Australian population of the beaked sea snake (*H. zweifeli*) has historically been referred to as *H. schistosus*, *Enhydrina schistosa* and *E. zweifeli*. Taxonomic and genetic analyses have since indicated that *H. zweifeli* is convergent from *H. schistosus* (Ukuwela *et al.*, 2013; Rasmussen *et al.*, 2014). For the purposes of this PSA, the nomenclature *H. zweifeli* will be utilised.
Small-headed sea snake	*Hydrophis macdowelli* (synonym: *H. macdowelli*)	39 125025	**Y**	
Spectacled sea snake	*Hydrophis kingii* (synonym: *Disteira kingii*)	39 125010	**Y**	
Spine-bellied sea snake	*Hydrophis curtus* (synonym: *Lapemis curtus, L. hardwickii, Hydrophis hardwickii*)	39 125031	**Y**	
Stokes' sea snake	*Hydrophis stokesii* (synonym: *Astrotia stokesii*)	39 125009	**Y**	
Mosaic sea snake (synonym: Spine-tailed sea snake,	*Aipysurus mosaicus* (synonym: *A.*	39 125004	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Stagger-banded sea snake)	*eydouxii, A. eydouxi*)			
Turtle-headed sea snake (synonym: Banded sea snake)	*Emydocephalus annulatus*	39 125012	**Y**	
Yellow-bellied sea snake	*Hydrophis platurus* (synonym: *Pelamis platurus*)	39 125033	**N**	**Not included**—The yellow-bellied sea snake (*Hydrophis platurus*) was identified to occur within Queensland waters and therefore have a distribution overlapping with the ECOTF effort footprint. However, this species demonstrates a preference for pelagic and surface environments, providing it with refuge from operations within the ECOTF. For reference, *H. platurus* was not observed in an extensive study on the capture of sea snakes in trawl bycatch (Courtney *et al.*, 2007b), which indicates that interactions between this species and the ECOTF will be low or negligible. As a result, this species is viewed as a lower assessment priority when compared to other species.
Large-headed sea snake	*Hydrophis pacificus*	39 125029	**N**	**Not included**—The large-headed sea snake (*Hydrophis pacificus*) was identified to occur within Queensland waters and therefore have a distribution overlapping with the ECOTF effort footprint. However, based on this species range, which is restricted to the northern extent of the fishery, it is more likely to be caught as bycatch in adjacent jurisdictions *e.g.* the *Northern Prawn Fishery*. For reference, *H. pacificus* was not observed in a study on the capture of sea snakes in trawl bycatch (Courtney *et al.*, 2007b), and anecdotal evidence suggests that this species has limited interactions with the ECOTF. Therefore, this species is viewed as a lower assessment priority when compared to other species. When and where

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				appropriate, *H. pacificus* will be considered for inclusion in future ERAs involving the ECOTF.
Syngnathidae				
Bentstick pipefish (synonym: Banded pipefish)	*Trachyrhamphus bicoarctatus*	37 282006	**Y**	**Included**—The cryptic lifestyle of syngnathid species makes it difficult to quantify interaction rates in the ECOTF. However, a number of species have been reported through the logbook program and the complex will have frequent interactions with the ECOTF (Dodt, 2005). While the fishery may interact with other syngnathids, the nine listed species provide a solid baseline to assess the risk posed to this complex. All species, excluding the ribboned seadragon, were assessed as part of the Southern Queensland ECOTF ERA and five were included in the GBRMP ERA (Pears *et al*., 2012b; Jacobsen *et al*., 2015). In both reports, assessed species were assigned an intermediate risk rating. These two assessments employed a qualitative ERA and identified high net selectivity and post-interaction mortalities as the key drivers of risk. However, information gaps increased the level of uncertainty in the risk profiles of individual species. This was of particular relevance to discussions surrounding interaction rates and discards. As the complex has previously registered intermediate risk ratings, other subgroups may be viewed as higher reassessment priorities. There will, however, be some benefit in updating the risk profiles of these species. Reassessment using the PSA will, at the very least, provide each species with a risk profile that covers the entire ECOTF. Updated risk profiles will inform discussions surrounding the need to include syngnathids in a dedicated trawl fishery *Protected Species Management Plan*.
Duncker's pipehorse	*Solegnathus dunckeri*	37 282098	**Y**	
White’s seahorse (Historical: Highcrown seahorse)	*Hippocampus whitei* (Historical: *H. procerus*)	37 282027	**Y**	
Pallid pipefish (synonym: Hardwicke’s pipehorse)	*Solegnathus hardwickii*	-	**Y**	
Spiny seahorse (synonym: Hedgehog seahorse; historical:	*Hippocampus spinosissimus* (synonym: *Hippocampus queenslandicus*)	37 282110	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Queensland seahorse)				
Great seahorse (Historical: Sad seahorse)	*Hippocampus kelloggi* (Historical: *H. tristis*)	37 282117	**Y**	
Straightstick pipefish	*Trachyrhamphus longirostris*	37 282101	**Y**	
Tiger pipefish	*Filicampus tigris*	37 282064	**Y**	
Ribboned seadragon (synonym: Ribboned pipehorse)	*Haliichthys taeniophorus*	37 282007	**Y**	
Thorny seahorse	*Hippocampus histrix*	37 282134	**N**	**Not included**—These *Syngnathidae* occur within Queensland waters and therefore have a distribution that overlaps with the ECOTF effort footprint. However, these syngnathids are viewed as lower assessment priorities. The interaction potential for these species will be limited by a) sufficient reliable scientific data on their distributions and b) habitat preferences. When and where appropriate, additional species will be considered for inclusion in future ERAs involving the ECOTF. The need to undertake an assessment for these species may be dependent on the outputs of initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a). ***Note***—There is uncertainty surrounding the Queensland distribution of the narrow-bellied seahorse (*Hippocampus angustus*). However, this species was included in a
Common seahorse	*Hippocampus kuda* (synonym: *H. taeniopterus*)	37 282033	**N**	
Low-crown seahorse	*Hippocampus dahli* (synonym: *H. planifrons*)	37 282114	**N**	
Wide-bodied pipefish	*Stigmatopora nigra*	37 282018	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Double-ended pipefish	*Syngnathoides biaculeatus*	37 282100	**N**	recently published seahorse identification guide, indicating a distribution overlapping with the east coast of Queensland (Lourie, 2016). Considering this, *H. angustus* was included in the initial rationalisation process.
Zebra seahorse	*Hippocampus zebra*	37 282080	**N**	
Narrow-bellied seahorse (synonym: Western spiny seahorse)	*Hippocampus angustus* (synonyms: *H. hendriki, H. grandiceps* and *H. multispinus*)	37 282005	**N**	
Scribbled pipefish (synonym: Banded pipefish or Messmate pipefish)	*Corythoichthys intestinalis*	37 282049	**N**	**Not included**—Through additional consultation it was determined that the extent of interactions between these species and the ECOTF will be low and/or negligible (*pers. comm.* J. Johnson). Therefore, these species were not progressed as part of the ECOTF ERA update.
Ornate pipefish (synonym: Whiskered pipefish)	*Halicampus macrorhynchus*	37 282067	**N**	
Banded pipefish	*Dunckerocampus dactyliophorus* (synonym: *Doryrhamphus dactyliophorus*)	37 282057	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Short-pouch pygmy pipehorse	*Acentronura breviperula* (synonym: *A. tentaculata*)	37 282035	**N**	
Bargibant's seahorse	*Hippocampus bargibanti*	37 282106	**N**	**Not included**—Through additional consultation it was determined that the extent of interactions between these species and the ECOTF will be negligible due to their habitat preference for reef slopes (*pers. comm.* J. Johnson). Therefore, these species were not progressed as part of the ECOTF ERA update.
Denise's pygmy seahorse	*Hippocampus denise*	37 282136	**N**	
Spotted pipefish	*Stigmatopora argus* (synonym: *S. olivacea*)	37 282017	**N**	**Not included**—Through additional consultation it was determined that this species does not have a Queensland distribution, and it is probable to suggest that historical records within this jurisdiction are misidentifications of the wide-bodied pipefish (*Stigmatopora nigra*) (*pers. comm.* J. Johnson). Therefore, this species was not progressed as part of the ECOTF ERA update.
Three-spot seahorse	*Hippocampus trimaculatus*	-	**N**	**Not included**—Through additional consultation it was demonstrated that the presence of the three-spot seahorse (*Hippocampus trimaculatus*) within Queensland is undetermined (*pers. comm.* J. Johnson). Therefore, this species was not progressed as part of the ECOTF ERA update.
Cetaceans				
Australian humpback dolphin	*Sousa sahulensis*	41 116014	**N**	**Not included**—While a wide range of cetaceans are found in Queensland waters, the direct capture of a dolphin or whale within a trawl net is highly unlikely. When a dolphin

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Australian snubfin dolphin	*Orcaella heinsohni*	41 116010	**N**	does interact with a trawl net, it is more likely to be instigated by the animal (*e.g.* targeting trapped animals) with a contact without capture event considered the most likely outcome. These interactions are more likely to occur when a vessel is actively fishing and during the net retrieval or sorting process. These interactions will not have a detrimental impact on the individual and/or the long-term conservation status of regional populations. Overall, the cetacean complex is viewed as a low assessment priority and the complex was not progressed as part of the ECOTF ERA update.
Common bottlenose dolphin (synonym: Offshore or Atlantic bottlenose dolphin)	*Tursiops truncatus*	41 116019	**N**	
Indo-Pacific bottlenose dolphin (synonym: Indian, Inshore or Spotted bottlenose dolphin)	*Tursiops aduncus*	41 116020	**N**	
Common dolphin	*Delphinus delphis*	41 116001	**N**	
False killer whale	*Pseudorca crassidens*	41 116013	**N**	
Spinner dolphin	*Stenella longirostris*	-	**N**	
Sharks				
Family Hexanchidae				

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Sharpnose sevengill shark	*Heptranchias perlo* (synonym: *H. dakini*)	37 005001	**N**	**Not included**—The sharpnose sevengill shark (*Heptranchias perlo*) and the bigeye sixgill shark (*Hexanchus nakamurai*) were considered for inclusion in an updated ERA as their distribution partially overlaps with the ECOTF. Despite this, several factors reduce the interaction potential for these species. In Queensland, *H. perlo* and *H. nakamurai* are more likely to be caught as bycatch in deeper water environments. While not universal, deep-water environments attract lower levels of effort as trawlers are less likely to operate beyond 200 m (*pers. comm.* D. Roy). This, combined with the depth range of *H. perlo* (27–1,000 m) and *H. nakamurai* (60–621 m: Kyne *et al.,* 2021), suggests interactions with the ECOTF will be infrequent and/or at levels that are unlikely to pose a significant long-term risk to regional populations. Overall, there is limited evidence to suggest that the species frequently interacts with the ECOTF and/or in high numbers (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a; Rigby *et al.*, 2016b). For reference, *H. perlo* and *H. nakamurai* were not included in the three previous risk assessments and both were assessed as species of *Least Concern* in the *Action Plan for Australian Sharks and Rays* (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017; Kyne *et al.*, 2021). Given the above considerations, the species affinity for deeper water environments and limited interaction potential, *H. perlo and H. nakamurai* were not included in the updated ECOTF ERA. When and where appropriate, *H. perlo* and *H. nakamurai* will be considered for inclusion in subsequent ERAs involving the ECOTF. The need to include *H. nakamurai* in subsequent trawl ERAs will be dependent on the outputs of ancillary
Bigeye sixgill shark	*Hexanchus nakamurai*	37 005004	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				programs including initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a).
Family Carcharhinidae				
Australian sharpnose shark	*Rhizoprionodon taylori*	37 018024	**N**	**Not included**—The Australian sharpnose shark (*Rhizoprionodon taylori*), milk shark (*R. acutus*), hardnose shark (*Carcharhinus macloti*) and sliteye shark (*Loxodon macrorhinus*) are four carcharhinid species with similar risk profiles. All four are small species that have high biological productivity and relatively rapid growth (Last & Stevens, 2009; Kyne *et al.*, 2021). *Rhizoprionodon taylori* is the smallest of the four, attaining a maximum total length (TL) of 70 cm and *C. macloti* is the largest reaching 110 cm TL. *Rhizoprionodon acutus* and *L. macrorhinus* both register maximum lengths of around 100 cm TL (Last & Stevens, 2009; Kyne *et al.*, 2021). While research has shown that TEDs are effective at excluding larger sharks (Brewer *et al.*, 2006; Campbell *et al.*, 2020), *R. taylori*, *R. acutus*, *C. macloti* and *L. macrorhinus* will derive less benefit from the use of this apparatus. With maximum sizes at or around 100 cm TL and *sizes at maturity* ranging from 40–70 cm TL, there is an increased probability that immature and mature animals will be caught as bycatch in the ECOTF. This will be of particular relevance to *R. taylori* which matures at 40–45 cm TL and *L. macrorhinus* which matures at around 60 cm TL (Last & Stevens, 2009; Kyne *et al.*, 2021). These four species inhabit water depths from 0–200 m and are found in environments that are fished by operators in the ECOTF (Last & Stevens, 2009; Kyne *et al.*, 2021). All four species have also been reported as bycatch in low numbers in the ECOTF and adjacent jurisdictions *e.g.* the *Northern Prawn Fishery* (Stobutzki *et al.*, 2002; Griffiths *et al.*, 2006; Courtney *et al.*, 2007b; Campbell *et al.*, 2017). The extent of these interactions
Milk shark	*Rhizoprionodon acutus*	37 018006	**N**	
Hardnose shark	*Carcharhinus macloti*	37 018025	**N**	
Sliteye shark	*Loxodon macrorhinus*	37 018005	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				and capture events are much lower when compared to some of the benthic batoids being considered for inclusion in an updated ECOTF ERA. Three of the four species were included in previous ECOTF ERAs; the risk posed to *C. macloti* in the ECOTF has not been assessed. In the two qualitative assessments (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015), *R. acutus*, *R. taylori* and *L. macrorhinus* were all assigned a low-intermediate or intermediate risk rating. In a subsequent SAFE ERA examining the risk posed by trawl fishing in southern Queensland, all three species were classified as low risk (Campbell *et al.*, 2017). While not universal, research has shown that the quantitative SAFE method produces fewer false positives when compared to semi-quantitative methods like the PSA (Zhou & Griffiths, 2008; Hobday *et al.*, 2011; Zhou *et al.*, 2016). To this extent, outputs compiled by Campbell *et al.* (2017) may provide a more accurate representation of the risk posed to these species. As noted, the SAFE assessment only covered trawl fishing activities in southern Queensland. Consequently, it is difficult to ascertain if this inference (and ratings) holds true for the remainder of the ECOTF. Outside of the previous trawl ERAs, the regional extinction risk of all four species was evaluated as part of the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021). In each instance *R. taylori, R. acutus, C. macloti* and *L. macrorhinus* were classified as a species of *Least Concern*. As part of these assessments it was determined that a) there was no discernible (inferred, suspected or continuing) decline in their population status and b) the capture of these species as bycatch was a low-level threat (Kyne *et al.,* 2021). For reference, all four species were classified as *sustainable* under the *Shark Report Card*. These shark reports, in effect, apply an equivalency test to assign indicative sustainability estimates to species not assessed as part of the *Status of*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Australian Fish Stocks (Gutteridge & Simpfendorfer, 2019; Harry *et al.*, 2019; Simpfendorfer & Baje, 2019; Simpfendorfer *et al.*, 2019b). In determining if *R. taylori, R. acutus, C. macloti* and *L. macrorhinus* should be included in an updated ERA, several factors need to be considered. These include the comparatively low concern surrounding the long-term sustainability of these species (Leigh, 2015; Kyne *et al.*, 2021), outputs of the three previous assessments and the need to undertake a broader whole-of-fishery assessment. Based on the above considerations, it was determined that *R. taylori, R. acutus, C. macloti* and *L. macrorhinus* were low reassessment priorities and were omitted from the analysis. When and where appropriate, the species will be considered for inclusion in subsequent ERAs.
Whitecheek shark	*Carcharhinus coatesi* (synonym: *C. dussumieri*)	37 018009	**N**	**Not included**—The profile of the whitecheek shark (*Carcharhinus coatesi*) shares several similarities with *R. taylori, R. acutus, C. macloti* and *L. macrorhinus*. It is a small (*maximum length* = 88 cm TL), common species found in inshore continental and insular shelf waters down to 123 m (Kyne *et al.,* 2021). *Carcharhinus coatesi* is retained as byproduct across the known range and is caught as prawn trawl bycatch in adjacent jurisdictions *e.g.* the *Northern Prawn Fishery*. However, anecdotal evidence suggests that the species has limited interactions with the ECOTF. *Carcharhinus coatesi* was included in the two qualitative assessments and was assigned a low-intermediate risk rating (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). While the species was included in a GBRMP trawl ERA, this was done as a precautionary measure to account for potential interactions (*pers. comm.* I. Jacobsen). The species was not included in the SAFE assessment (Campbell *et al.,* 2017).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				There is evidence that *C. coatesi* will interact with the ECOTF along with other carcharhinids *e.g. C. tilstoni* (Campbell, 2022). Similarly, *C. coatesi* shares morphological similarities with other similar sized carcharhinids (*e.g. maximum size* <110 cm TL). However, *C. coatesi* is viewed as a lower assessment priority. When and where appropriate, *C. coatesi* will be considered for inclusion in future ERAs involving the ECOTF. The need to undertake an assessment for this species may be dependent on the outputs of initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a). For reference, *C. coatesi* was assessed as a species of *Least Concern* in the *Action Plan for Australian Sharks and Rays* with no discernible (inferred or detected) population decline (Kyne *et al.,* 2021). The capture of this species as bycatch is viewed as a low threat for this species *versus* a moderate threat for *R. taylori* and *R. acutus*. Scientific experts consulted on the scope and extent of the elasmobranch assessment list and supported *C. coatesi* being omitted from the initial assessment.
School shark	*Galeorhinus galeus*	37 017008	**N**	**Not included**—The school shark (*Galeorhinus galeus*) was considered for inclusion in an updated ECOTF ERA as it is listed as *Conservation Dependent* under the *Environment Protection and Biodiversity Conservation Act 1999* and has a distribution that overlaps with the ECOTF (Kyne *et al.,* 2021). However, a review of the available data indicates that *G. galeus* is a low assessment priority for the ECOTF. The distribution of *G. galeus* only includes a small portion of the Queensland coastline and is expected to have low to negligible interactions with Queensland-managed fisheries. Within Queensland, interactions with this species are more likely to occur in the *East Coast Inshore Fishery*. On this basis *G. galeus* was viewed as a low assessment priority and was not progressed as part of the ECOTF ERA update.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Silvertip shark	*Carcharhinus albimarginatus*	37 018027	**N**	**Not included**—The grey reef shark (*Carcharhinus amblyrhynchos*), silvertip shark (*C. albimarginatus*), blacktip reef shark (*C. melanopterus*) and whitetip reef shark (*Triaenodon obesus*) have wide geographical distributions and inhabit waters that can be fished in the ECOTF. As their common names suggest though, they are more commonly associated with reef systems. *Carcharhinus amblyrhynchos, C. albimarginatus, C. melanopterus* and *T. obesus* were considered for inclusion in an updated ECOTF ERA as they did not meet the broad exclusion criteria used to compile the preliminary list. A review of the available data indicates that these species will have limited to negligible interactions with the ECOTF (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a; Department of Agriculture Fisheries and Forestry, 2013). If an interaction were to occur, these species would more likely experience a contact without capture event *i.e.* excluded from the net through the TED opening. These four species are viewed as low assessment priorities for the ECOTF. They have not been included in previous trawl ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017) and bycatch in commercial fisheries is not considered one of their key threats (Kyne *et al.,* 2021). While one or more of these species may experience increased fishing pressures, these risks lie outside of the ECOTF.
Grey reef shark	*Carcharhinus amblyrhynchos*	37 018030	**N**	
Blacktip reef shark	*Carcharhinus melanopterus*	37 018036	**N**	
Whitetip reef shark	*Triaenodon obesus*	37 018038	**N**	
Spinner shark	*Carcharhinus brevipinna*	37 018023	**N**	**Not included**—The spinner shark (*Carcharhinus brevipinna*) has a distribution and depth profile (0–75 m) that overlaps with the effort footprint of the ECOTF (Kyne *et al.,* 2021). This species was considered for inclusion in an updated ECOTF ERA as it did not meet the broad exclusion criteria used to compile the preliminary list.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				A review of the available data indicates that this species will interact infrequently with the ECOTF and/or is more likely to experience contact without capture events *i.e.* excluded from the net through the TED opening. *Carcharhinus brevipinna* is a larger carcharhinid species attaining a *maximum size* of 300 cm TL and reaching maturity at or around 220 cm TL (Kyne *et al.,* 2021). Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019), there is a high probability that any subadult or mature *C. brevipinna* that interacts with a trawl net will be excluded through the TED opening. This inference is supported by research which shows that a TED can reduce the capture of larger sharks (>1 m) by up to 86 per cent (Brewer *et al.*, 2006). *Carcharhinus brevipinna* pups are born at ~65-70 cm, and are estimated to grow 33.4 cm and 29.9 cm for males and females respectively within the first year (Joung *et al.,* 2005). Therefore, it can be reasonably assumed that only small, immature sharks will (if applicable) be caught in the codend of a trawl net. Research suggests that this is more likely to occur in inshore sectors of the ECOTF *e.g.* banana prawn fishing (Courtney *et al.*, 2007b). These interactions were considered sufficient for *C. brevipinna* to be included in all three previous ECOTF ERAs. The species was assigned a low-intermediate risk using the qualitative method (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015) and a low-risk rating under SAFE (Campbell *et al.,* 2017). Overall, *C. brevipinna* was viewed as a lower priority for reassessment. While the species has been reported from sectors of the ECOTF (*e.g.* banana prawn fishing; Courtney *et al.*, 2007a), the frequency of these events do not pose a long-term sustainability risk for regional *C. brevipinna* populations. When compared, the risk posed to this group will be greater in the *East Coast Inshore Fishery* where sharks are retained

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				as key targets and as byproduct (Department of Agriculture and Fisheries, 2019b; Jacobsen *et al.*, 2021a). In line with the above assessment, *C. brevipinna* was not progressed as part of the ECOTF ERA update. When and where appropriate, *C. brevipinna* will be considered for inclusion in subsequent ERAs involving the ECOTF. The need to undertake further assessment of the risk posed to this species will be dependent on the outputs of initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a).
Nervous shark	*Carcharhinus cautus*	37 018034	**N**	**Not included**—While the Queensland distribution of the nervous shark (*Carcharhinus cautus*) overlaps with the ECOTF, several factors reduce the interaction potential for this species. *Carcharhinus cautus* has a limited vertical distribution (0–20 m; Kyne *et al.*, 2021), and a preference for mangrove-associated habitats (Escalle *et al.*, 2015). These preferences limit the extent of the overlap with the trawl effort footprint and reduces the probability of an interaction occurring in this fishery. *Carcharhinus cautus* was not included in the three previous ECOTF ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017) and has not been reported as bycatch in the ECOTF (Courtney *et al.*, 2007a; Kyne *et al.*, 2007a). While interactions with this species are possible in shallow-water environments, the extent of these interactions are not expected to pose a long-term or significant conservation risk. This inference is supported by the *Action Plan for Australian Sharks and Rays* which classified *C. cautus* as a species of *Least Concern* (Kyne *et al.,* 2021). This action plan assessed the regional extinction risks for sharks and rays inhabiting Australian waters.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Common blacktip shark	*Carcharhinus limbatus*	37 018039	**N**	**Not included**—The common blacktip shark (*Carcharhinus limbatus*), the Australian blacktip shark (*C. tilstoni*) and the spot-tail shark (*C. sorrah*) have similar risk profiles. All three are targets of the *East Coast Inshore Fishery* and the *Gulf of Carpentaria Inshore Fishery*, and most fishing-associated risks relate to these two fisheries (Pidd *et al.*, 2021; Walton *et al.*, 2021). *Carcharhinus limbatus*, *C. tilstoni* and *C. sorrah* were considered for inclusion in an updated ECOTF ERA as a) distribution and habitat preferences of all three overlap to varying degrees with the ECOTF effort footprint and b) they did not meet the broad exclusion criteria used to compile the preliminary species list. A review of the available data indicates that these three species interact infrequently with the ECOTF and are rarely caught as bycatch. Their capture as bycatch (outside of shark control programs) is not viewed as a key threat and trawl fishing will not pose a significant or long-term sustainability risk for these species. If *C. limbatus*, *C. tilstoni* or *C. sorrah* interacts with a trawl net, there is an increased probability that subadult and mature animals will be excluded from the net through the TED opening. This inference is supported by research showing the use of a TED can reduce the capture of larger sharks (>1 m) by up to 86 per cent (Brewer *et al.*, 2006). On this basis, all three were excluded from the ECOTF ERA update**.**
Australian blacktip shark	*Carcharhinus tilstoni*	37 018014		
Spot-tail shark / Sorrah shark / Blacktip shark	*Carcharhinus sorrah*	37 018013	**N**	
Pigeye shark	*Carcharhinus amboinensis*	37 018026	**N**	**Not included**—The pigeye shark (*Carcharhinus amboinensis*) and the bull shark (*C. leucas*) share a number of morphological similarities and differentiating between the two can be difficult; particularly with immature animals. For this reason, the commercial catch of this species is frequently reported as a complex *e.g.* pigeye & bull sharks (Queensland Government, 2022a).
Bull shark	*Carcharhinus leucas*	37 018021	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				A review of the available data indicates that these species will interact infrequently with the ECOTF and/or are more likely to experience contact without capture events *i.e.* excluded from the net through the TED opening. While not universal, these interactions are more likely to occur in inshore waters. This inference is supported by research on elasmobranch bycatch compositions which reports *C. leucas* interactions occurring in the banana prawn sector (Kyne *et al.*, 2007a). Of note, *C. leucas* and *C. amboinensis* were not viewed as assessment priorities in the two qualitative ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). However, *C. amboinensis* was included in the SAFE assessment examining trawl-related risks in southern Queensland. Outputs of this assessment indicated that the species was at low risk from regional trawl fishing activities (Campbell *et al.,* 2017). When compared to other elasmobranchs, *C. leucas* and *C. amboinensis* are viewed as low assessment priorities. Interaction rates for these species will (likely) be low and, as larger species (*maximum size* = 280 cm TL, *C. amboinensis*; 340 cm TL, *C. leucas*), they will derive considerable benefit from the use of a TED (Brewer *et al.*, 2006; Campbell *et al.*, 2020). For reference, both were classified as species of *Least Concern* in the *Action Plan for Australian Sharks and Rays* with nothing to infer or suspect a population decline (Kyne *et al.*, 2021).
Sandbar shark	*Carcharhinus plumbeus*	37 018007	**N**	**Not included**—The sandbar shark (*Carcharhinus plumbeus*) has a distribution and depth profile (0–280 m) that overlaps with the effort footprint of the ECOTF (Kyne *et al.,* 2021). The species was considered for inclusion in an updated ECOTF ERA as it did not meet the broad exclusion criteria used to compile the preliminary list.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Carcharhinus plumbeus is a larger species attaining 240 cm TL and maturing at ~130–180 cm and ~145–185 cm TL for males and females respectively (Last & Stevens, 2009; Kyne *et al.*, 2021). Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019), there is a high probability that subadult and mature *C. plumbeus* will be excluded through the TED opening. As *C. plumbeus* has comparatively large pups (52–65 cm; Last & Stevens, 2009), it is reasonable to assume that only small, immature sharks will (if applicable) be caught in the codend of a trawl net. This inference is supported by research which has shown that the use of a TED reduces the capture of larger sharks (>1 m) by up to 86 per cent (Brewer *et al.*, 2006). For reference, *C. plumbeus* was not included in the three previous risk assessments and was assessed as a species of *Least Concern* in the *Action Plan for Australian Sharks and Rays* (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017; Kyne *et al.*, 2021). There is limited evidence to suggest that the species frequently interacts with the ECOTF and/or in quantities that will impact regional population numbers (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a).
Speartooth shark	*Glyphis glyphis*	37 018041	**N**	**Not included**—The distribution of the speartooth shark (*Glyphis glyphis*) remains uncertain with research suggesting that speartooth sharks are extirpated from the majority (if not all) of the Queensland east coast (Peverell *et al.*, 2006; Compagno *et al.*, 2009; Last & Stevens, 2009; Pillans *et al.*, 2009). If *G. glyphis* had viable east coast populations, it would more likely occur in far north Queensland where there are smaller amounts of ECOTF effort (Peverell *et al.*, 2006; Kyne *et al.*, 2021; Department of Agriculture and Fisheries, 2022b; 2023). *Glyphis glyphis* is a euryhaline species with juveniles and subadults frequenting tropical macrotidal rivers. Adults, it is assumed, occur in coastal inshore waters. Interactions

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				between *G. glyphis* and the ECOTF are highly unlikely/improbable and the species was not progressed as part of the ECOTF ERA update.
Family Triakidae				
Gummy shark	*Mustelus antarcticus* (synonym: *M. walkeri*)	37 017001	**N**	**Not included**—The gummy shark (*Mustelus antarcticus*) has a more complex profile in Queensland waters. The species has a somewhat broad vertical distribution, inhabiting water depths from 0–400 m (Kyne *et al.,* 2021). In Queensland, *M. antarcticus* is more likely to be encountered in deeper water environments *e.g.* 50–400 m (Campbell *et al.,* 2021). This limits the interaction potential for this species and it is more likely to be caught as bycatch in operations targeting deepwater eastern king prawns (southern Queensland) and tiger/endeavour prawns (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a). The species was not included in either of the qualitative assessments, although Pears *et al.* (2012b) did recommend that it be included in future assessments. *Mustelus antarcticus*, identified by the *M. walkeri* synonym, was included in a SAFE analysis. The outputs of this assessment indicated that trawl fishing activities posed a medium risk to this species. When assessed under a more conservative/precautionary scenario, the risk rating for this species increased to precautionary extreme high (Campbell *et al.,* 2017). While a SAFE may provide a more accurate representation of the risk posed to the species, this assessment only covered trawl fishing activities in southern Queensland. Consequently, it is difficult to ascertain if this inference (and rating) holds true for the remainder of the ECOTF. In the event that *M. antarcticus* interacts with the ECOTF, most mature animals will be excluded from the catch. The species reaches at least 185 cm TL with males and females reaching maturity at around 80 cm and 85 cm TL respectively (Bray, 2021d;

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Kyne *et al.*, 2021). Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019) and size at birth (30–35 cm; Bray, 2021d), there is an increased probability that juvenile *M. antarcticus* juveniles will pass through the TED and into the codend. The frequency of these events are difficult to quantify but are expected to be (comparatively) low. The Queensland *M. antarcticus* population was previously classified as a separate species, *M. walkeri*. *Mustelus walkeri* had a distribution that was largely confined to Queensland waters (Last & Stevens, 2009; Ebert *et al.*, 2021) and commercial fishing would have been a risk factor for this species. Taxonomic and genetic analyses have since indicated that *M. antarcticus* is conspecific with *M. walkeri*. This resulted in a broader nomenclature change and *M. walkeri* is now classified as a synonym of *M. antarcticus* (*pers. comm.* P. Kyne). This change resulted in a substantial increase in the known distribution of species formally classified as *M. walkeri*. For instance, the distribution of *M. antarcticus* now includes the Queensland east coast, New South Wales, southern Australia and southern Western Australia (Kyne *et al.,* 2021). While commercial fishing still poses a risk for these species, these risks are more prevalent in other jurisdictions. In the *Action Plan for Australian Sharks and Rays*, it was noted that *M. antarcticus* was a commercially important species in southern Australia (Kyne *et al.*, 2021). The species is actively targeted in this region and fisheries operating in southern Australia are the primary source of fishing mortality. However, the report noted that the species is caught in several Queensland-managed fisheries and further information is required from this region. This inference relates to retention as target and byproduct, of which the *East*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Coast Inshore Fishery is expected to be the largest contributor of risk in Queensland waters. When compared to benthic sharks and batoids, *M. antarcticus* is considered a lower assessment priority. While the genus has been reported from sectors of the ECOTF (*e.g.* banana prawn fishing; Courtney *et al.*, 2007a), the frequency of these events are not expected to pose a long-term sustainability risk for regional *M. antarcticus* populations. When compared, the risk posed to this group will be far greater in the *East Coast Inshore Fishery* where sharks are retained as key target species and as byproduct (Department of Agriculture and Fisheries, 2019b; Jacobsen *et al.*, 2021a). In line with the above assessment, *M. antarcticus* was not progressed as part of the ECOTF ERA update. When and where appropriate, *M. antarcticus* will be considered for inclusion in subsequent ERAs involving the ECOTF. The need to undertake further assessment of the risk posed to this species will be dependent on the outputs of initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a). ***Additional Consultation***—Additional consultation on the scope and extent of the SOCC ERA resulted in mixed opinions regarding the inclusion of *M. antarcticus*. However, considering the above assessment, it was deemed as a secondary assessment priority. This species will be considered for inclusion in subsequent ERAs examining the trawl-related risks across the ECOTF.
Family Hemigalidae				

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Australian weasel shark	*Hemigaleus australiensis*	37 018020	**Y**	**Included**—The risk profile of the Australian weasel shark (*Hemigaleus australiensis*) shares similarities with *R. taylori*. The Queensland distribution of *H. australiensis* overlaps with the ECOTF and the species occupies inshore bays and water depths trawled in the fishery (12–170 m; Kyne *et al.,* 2021). Available research suggests that on a national scale, the capture of *H. australiensis* as bycatch may also be a contributor of risk for this species (Kyne *et al.*, 2021; Bray, Undated-a). However, rates of fishing mortality (bycatch and targeted) are not expected to have a significant impact on regional populations (Kyne *et al.,* 2021; Pidd *et al.,* 2021). In the event that *H. australiensis* does interact with the ECOTF, its morphological features provide it with some protection. *Hemigaleus australiensis* is larger than *R. taylori*, reaching sexual maturity at ~60 cm and ~65 cm TL for males and females respectively (Last & Stevens, 2009; Ebert *et al.*, 2021). The *maximum size* for this species is estimated at 110 cm TL (Kyne *et al.,* 2021). Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019), a proportion of mature individuals will be prevented from entering the codend and expelled from the net. However, *H. australiensis* are born at ~30 cm TL (Last & Stevens, 2009) and it can be inferred that both immature and mature sharks will be caught in the ECOTF. This inference is supported by bycatch composition and weight analysis conducted in the ECOTF (Courtney *et al.,* 2007b; Jacobsen, 2007). This research was the catalyst behind their inclusion in all three previous ECOTF ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). Risk ratings for *H. australiensis* varied with the assessment methodology, with the species assigned an intermediate rating in the qualitative assessment and a low-risk rating when using SAFE (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). The species was classified as *Least Concern* with no discernible (inferred or

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				suspected) population reduction in the most recent *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021). This action plan examined the regional extinction risk for a range of sharks and rays inhabiting Australian waters. A weight-of-evidence approach suggests that the ECOTF will pose a lower risk to regional *H. australiensis* populations. The species will be caught periodically as bycatch and may incur mortalities because of this interaction. Evidence suggests that these interactions will not have a significant or long-term impact on the conservation status of this species. While noting this, the decision to include this species is precautionary and it is recognised that *H. australiensis* is one of a small number of sharks that will be caught as bycatch in the ECOTF.
Fossil shark	*Hemipristis elongata*	37 018011	**N**	**Not included**—The fossil shark (*Hemipristis elongata*) has a broad geographical distribution that includes the Queensland east coast, northern Australia and western Australia. This species is found in water depths down to 132 m and it occurs in areas fished in the ECOTF. When compared to *H. australiensis* (*maximum size* = 110 cm TL), *H. elongata* is larger, with mature sharks reaching 240 cm TL (Last & Stevens, 2009; Ebert *et al.*, 2021; Kyne *et al.*, 2021). While not universal, research has shown that TED effectiveness increases with body size (Brewer *et al.*, 2006; Griffiths *et al.*, 2006; Campbell *et al.*, 2020). From an interaction/capture potential, these factors increase the probability that *H. elongata* interacting with a trawl net will be excluded through the TED opening. As the species has an estimated size at birth of 42–52 cm TL, expectations are that the TED will help prevent the capture of both immature and mature animals.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Overall, there are few concerns surrounding the long-term sustainability of regional *H. elongata* populations and/or their capture as prawn trawl bycatch (Kyne *et al.,* 2021). This inference is supported by the *Action Plan for Australian Sharks and Rays* which classified *H. elongata* as a species of *Least Concern* (Kyne *et al.,* 2021). While the species may be caught (infrequently) as bycatch in the ECOTF, there is a higher probability that *H. australiensis* will be caught in the codend. Given the above considerations, *H. elongata* was viewed as a lower assessment priority and excluded from the analysis.
Family Brachaeluridae				
Colclough's shark (synonym: Blue-grey carpetshark)	*Brachaelurus colcloughi*	37 013013	**Y**	**Included**—Information on the abundance and distribution of the Colclough's shark (*Brachaelurus colcloughi*) is based on a limited number of samples. *Brachaelurus colcloughi* is a relatively rare species and it has a restricted eastern Australian range. The species has been recorded as bycatch in the ECOTF and, as a smaller species, it will derive less benefit from the use of a TED. For reference, current estimates place the *maximum size* of *B. colcloughi* at or around 75 cm TL with *size at maturity* estimated at or around 60 cm and 55 cm TL for males and females respectively (Last & Stevens, 2009; Kyne *et al.*, 2015; Ebert *et al.*, 2021; Kyne *et al.*, 2021). While further information is required on the age and growth development of this species, current estimates place the size at birth between 17 and 19 cm TL (Kyne *et al.*, 2011a; Ebert *et al.*, 2021). As a smaller shark species, the use of a TED will be less effective for this species (Brewer *et al.*, 2006; Campbell *et al.*, 2020). A lack of information on interaction rates across its known distribution makes it difficult to quantify the extent of fishing-related

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				risks in the ECOTF. However, a weight-of-evidence approach suggests that regional populations have declined due to habitat modification, habitat loss and fishing interactions (commercial and recreational; Kyne *et al.*, 2011a; Kyne *et al.*, 2021). This inferred or suspected population decline was one of the reasons *B. colcloughi* was assessed as *Vulnerable* under the IUCN Red List Criteria (Kyne *et al.,* 2015; Kyne *et al.,* 2021). Results from previous ERAs have shown variation, with *B. colcloughi* assigned a low-risk rating under the SAFE methodology (Campbell *et al.,* 2017) and an intermediate rating under a more conservative qualitative assessment (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). As data-sets for this species have not improved extensively over the proceeding years, the risk rating compiled using SAFE arguably provides the most up-to-date account of the risk posed to this species (Campbell *et al.,* 2017). With that said, the species will likely benefit from additional assessment across its known range. Any future risk assessments will need to be cognisant of how data deficiencies may influence the risk profile of this species. This will be of some relevance to this species as studies have shown that the SAFE method produces fewer false positives when compared to the PSA. The PSA being the preferred method for assessing risk across the entire ECOTF.
Blind shark	*Brachaelurus waddi*	37 013007	**N**	**Not included**—The blind shark (*Brachaelurus waddi*) is a relatively common endemic shark species that has a restricted eastern Australian distribution. The extent of the *B. waddi* Queensland distribution is smaller than *B. colcloughi,* with interactions confined to southern Queensland (Last & Stevens, 2009; Bray, 2019a; Kyne *et al.*, 2021).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Brachaelurus waddi is found in waters up to 140 m (Kyne *et al.*, 2021) and it may inhabit areas fished by trawl operators. However, the species typically inhabits rocky shorelines, reefs and areas adjacent to sea grass beds. These habitat preferences reduce the interaction potential and make regular trawl interactions unlikely. This inference is supported by research on trawl bycatch compositions (Courtney *et al.,* 2007b) and the decision to exclude *B. waddi* from all three previous assessments (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). Available research suggests that on a national scale, commercial fisheries pose a low threat to the bycatch of *B. waddi* (Kyne *et al.,* 2021). This risk is primarily driven by activities in the New South Wales commercial trap fishery. The extent of this risk is comparatively small and there are fewer concerns surrounding the long-term conservation status of *B. waddi*; particularly when compared to *B. colcloughi* (Kyne *et al.,* 2021). With a low interaction potential, limited evidence of significant interactions and low concern surrounding the long-term sustainability of regional populations, *B. waddi* was viewed as a low assessment priority.
Family Hemiscylliidae				
Brownbanded bambooshark (synonym: Grey carpetshark)	*Chiloscyllium punctatum*	37 013008	**Y**	**Included**—The Queensland distribution of the brownbanded bambooshark (*Chiloscyllium punctatum*) overlaps with the ECOTF and several factors increase the interaction potential for this species. *Chiloscyllium punctatum* is found in waters up to 85 m (Kyne *et al.*, 2021) and it inhabits areas fished by trawl operations. This species prefers coral and rocky-associated habitats, which provides some refuge from commercial operations (Kyne *et al.*, 2021). However, evidence shows that *C. punctatum*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				interacts with the ECOTF and is caught as bycatch (Courtney *et al.*, 2007b; Jacobsen, 2007; Kyne *et al.*, 2007a). This interaction potential was the catalyst behind the inclusion of *C. punctatum* in all three previous ECOTF ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In each of these assessments, the species was assigned a low-risk rating. It was also assessed as a species of *Least Concern* in the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021). When a *C. punctatum* does interact with the ECOTF, the use of a TED will be less effective for this species. In other species, total size and size at maturity can be used as an indicator of TED effectiveness. The assumption being that as the total length increases, so too does the probability of the shark being excluded from the net (Brewer *et al.*, 2006; Campbell *et al.*, 2020). While this assumption holds true for *C. punctatum*, the species has an elongated caudle fin region. This type of morphology tends to exaggerate the total length (TL) to body-width ratio and increases the probability that longer (TL) sharks will pass through the TED and into the codend including mature (>80 cm TL) *C. punctatum* (Last & Stevens, 2009; Ebert *et al.*, 2021). For reference, *C. punctatum* hatch between 13–18 cm TL and the species reaches at least 130 cm TL (Last & Stevens, 2009; Ebert *et al.*, 2021; Kyne *et al.*, 2021). There are fewer conservation concerns surrounding *C. punctatum*. The species is highly fecund and significant sections of the known distribution are lightly fished or unfished (Kyne *et al.,* 2021). It is not classified as a *Threatened, Endangered or Protected* species under state or commonwealth waters and it was classified as a species of *Least Concern* in the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021). While noting these factors, this species will interact with a wide range of trawl operations. It is one of the more prominent benthic shark species caught in the ECOTF and would benefit from further assessment at a whole-of-fishery level. Therefore *C. punctatum* was

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				included in the update of the ECOTF ERA. The decision to include *C. punctatum* is precautionary and further consideration will need to be given to the potential or likelihood of the PSA producing a false-positive result.
Family Orectolobidae				
Tasselled wobbegong	*Eucrossorhinus dasypogon*	37 013011	**N**	**Not included**—The tasselled wobbegong (*Eucrossorhinus dasypogon*) is primarily found in waters off central and far north Queensland. *Eucrossorhinus dasypogon* has a shallower depth profile (0–50 m; Kyne *et al.*, 2021) and is often associated with reef habitats and environments less conducive to trawl fishing (Last & Stevens, 2009; Kyne *et al.*, 2021). The species will also derive benefits from provisions implemented as part of the marine national parks program (Kyne *et al.*, 2021; Great Barrier Reef Marine Park Authority, 2022b). In the unlikely event that *E. dasypogon* interacts with the ECOTF, there is an increased probability that the animal will be excluded from the net via the TED. *Eucrossorhinus dasypogon* obtains 125 cm TL (Kyne *et al.,* 2021) and the family has a broad, flattened head which will assist in terms of preventing the animal to pass through the bars of the TED. As the current TED bars are spaced at 12 cm (State of Queensland, 2019), it is reasonable to assume that most subadult and mature *E. dasypogon* will be excluded from the net via the TED opening. While smaller *E. dasypogon* (size at birth = ~20 cm TL; Last & Stevens, 2009) may still be caught in the ECOTF, these interactions are not expected to pose a long-term sustainability risk for regional populations. Evidence also suggests that this subgroup has reasonable post-interaction survival rates. Given the above considerations, *E. dasypogon* was viewed as a lower assessment priority and excluded from the analysis.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				This inference is supported by the results of two previous, conservative risk assessments which classified *E. dasypogon* as a low-intermediate risk (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015).
Gulf wobbegong	*Orectolobus halei*	37 013020	**N**	**Not included**—Of the five *Orectolobidae* species considered, the gulf wobbegong (*Orectolobus halei*) had the lowest potential to interact with the ECOTF. The Queensland distribution of *O. halei* is restricted to south-east Queensland and the species will only interact (if applicable) with the southern trawl regions and potentially the Moreton Bay trawl fishery (Last & Stevens, 2009; Department of Agriculture and Fisheries, 2020a; Kyne *et al.*, 2021). The species will be caught with more regularity in New South Wales fisheries where it is retained as byproduct in non-trawl fisheries (Kyne *et al.,* 2021). *Orectolobus halei* is one of the largest wobbegong species, maturing at around 115–120 cm TL and attaining 206 cm TL (Last & Stevens, 2009; Kyne *et al.*, 2021). Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019), most subadult and mature *O. halei* will be excluded from the net. While smaller/immature animals could pass through the TED, the extent of this capture risk is minimised by the general morphology of the wobbegong head and pectoral fins. That is, the width of the wobbegong head will exceed the TED bar spacing width comparatively quickly. If caught, post-interaction survival rates for the wobbegong subgroup are expected to be high (Kyne *et al.,* 2021). The *Action Plan for Australian Sharks and Rays* classified *O. halei* as a species of *Least Concern* with no inferred or suspected population decline (Kyne *et al.,* 2021). While the

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				species will be subject to fishing pressures, fisheries in Queensland including the ECOTF will be a minor contributor of risk.
Spotted wobbegong	*Orectolobus maculatus*	37 013003	**N**	**Not included**—The Queensland distribution of the spotted wobbegong (*Orectolobus maculatus*) extends into central Queensland and it is found in waters up to and including Swain Reefs (Last & Stevens, 2009). The species is found in water depths down to 218 m and it may be encountered by ECOTF operations. However, there are several factors that minimise the interaction and capture potential for this species. *Orectolobus maculatus* is frequently found in habitats with more complex substrates including shallow waters on reefs or sand and in caves (Last & Stevens, 2009; Bray, 2021b; Kyne *et al.*, 2021) which attract smaller amounts of trawl effort. If *O. maculatus* is caught in a trawl net, the morphological construct of the head and pectoral region will prevent most, if not all subadult and mature animals (*sexual maturity* = 115–120 cm TL; *maximum length* = 170 cm TL) from passing through the TED (Brewer *et al.*, 2006; Campbell *et al.*, 2020). Available research suggests that *O. maculatus* is retained as byproduct throughout Australian waters. However, this occurs with less prevalence in Queensland waters and rates of fishing mortality are likely to be higher in other jurisdictions *e.g.* in the *New South Wales Ocean Trawl and Line Fishery* and *the Southern and Eastern Scalefish and Shark Fishery*. If an *O. maculatus* interacts with the ECOTF, capture rates will be more pronounced in smaller individuals (size at birth = 20–25 cm TL; Last & Stevens, 2009). Most subadult and mature animals will be excluded from the net via the TED. In these instances (*i.e.*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				contact without capture events), there is a high probability that the animal will survive the fishing event (Kyne *et al.,* 2021). While noting the low interaction potential, *O. maculatus* was included in all three previous ERAs examining the risk posed by trawl fishing activities (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In each instance the species was assessed as a low or low-intermediate risk. More recently, the regional extinction risk for this species was assessed as part of the *Action Plan for Australian Sharks and Rays* (Kyne *et al.*, 2021). This assessment classified *O. maculatus* as a species of *Least Concern*; albeit noting the presence of historical population declines in some regions (Kyne *et al.,* 2021). In line with the above considerations, *O. maculatus* was considered a low priority for reassessment and not progressed as part of the ECOTF ERA update. When and where appropriate *O. maculatus* will be considered for inclusion in subsequent ERAs.
Banded wobbegong	*Orectolobus ornatus*	37 013001	**N**	**Not included**—The Queensland distribution of the banded wobbegong (*Orectolobus ornatus*) overlaps with the ECOTF and it is occasionally caught as bycatch. While *O. ornatus* has a depth profile that incorporates trawled waters (0–100 m; Kyne *et al.,* 2021) it is also found in clear water on inshore reefs and offshore islands (Last & Stevens, 2009; McGrouther, 2022). These habitat preferences may limit the species exposure to trawl fishing activities. Available research suggests that the risk posed to this species is greater in non-trawl fisheries and in adjacent jurisdictions (*i.e.* New South Wales). A weight-of-evidence approach though suggests that fishing pressures exerted on *O. ornatus* have not

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				translated to a discernible decrease (inferred or suspected) decline in regional populations (Kyne *et al.,* 2021). If and when *O. ornatus* interacts with the ECOTF, there is an increased probability that the animal will be excluded from the net and/or survive the interaction (Kyne *et al.,* 2021). *Orectolobus ornatus* reaches sexual maturity at ~80 cm (Last & Stevens, 2009), and obtains a maximum TL of at least 110 cm (Kyne *et al.,* 2021). The ability of the animal to fit between the TED bar spacings (12 cm) will also be limited by the broad morphology of the wobbegong's head (Last & Stevens, 2009; State of Queensland, 2019; McGrouther, 2022). These factors suggest that a high proportion of subadult and mature individuals will be excluded from the catch. As *O. ornatus* pups are born at ~20 cm (Last & Stevens, 2009), the incidental capture of this species is unlikely to be mitigated completely. Smaller, non-mature individuals may still pass through the TED and into the codend of the net. Post-interaction survival rates for these animals are expected to be high (Kyne *et al.,* 2021). Of note, *O. ornatus* was in two previous ECOTF ERAs. In these assessments, the species was assigned a low (Campbell *et al.,* 2018) and a low-intermediate risk rating (Jacobsen *et al.*, 2015). This rating is consistent with analogous assessments examining the regional extinction risk. For example, the *Action Plan for Australian Sharks and Rays* classified *O. ornatus* as a species of *Least Concern* with evidence of an inferred or suspected population decline (Kyne *et al.,* 2021). While noting the potential for smaller *O. ornatus* to be caught as bycatch, the species was viewed as a lower assessment priority and was not progressed as part of the ECOTF ERA update.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Northern wobbegong	*Orectolobus wardi*	37 013017	**N**	**Not included**—The northern wobbegong (*Orectolobus wardi*) was considered for inclusion in an updated trawl ERA as a precautionary measure. The distribution of *O. wardi* is primarily based in northern Australia, with the extent of the eastern distribution restricted to far north Queensland (Last & Stevens, 2009; Kyne *et al.*, 2021). Trawl effort in this region is negligible and there is a low probability that the ECOTF will interact with this species. *Orectolobus wardi* was not progressed as part of the ECOTF ERA update.
Family Paracyllidae				
Collar carpetshark	*Parascyllium collare*	37 013002	**Y**	**Included**—The collar carpetshark (*Parascyllium collare*) has a restricted range in Queensland which extends from the New South Wales border through to Mooloolaba (Bray, 2021e). This (restricted) range will limit the extent of interactions between *P. collare* and the broader ECOTF. Evidence suggests though that commercial fisheries pose a moderate threat in terms of the capture of *P. collare* as bycatch (Kyne *et al.,* 2021). In this broader context, the ECOTF is viewed as a contributor of risk *versus* the main driver of risk. In Queensland, the species has been reported as bycatch in the eastern king prawn sector of the ECOTF (Courtney *et al.,* 2007b). When *P. collare* interacts with the ECOTF, there is an increased probability that the species will pass through the TED and be retained in the codend of the net. As *P. collare* is a smaller species (*maximum size* = 87 cm TL; Kyne *et al.*, 2021), both mature and immature animals would be caught as bycatch in the ECOTF. To date, there is little evidence to suggest that these types of interactions have had a detrimental, long-term impact on population numbers (Kyne *et al.,* 2021).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Parascyllium collare has been the subject of two separate ERAs. Results of the previous ERAs are somewhat mixed with the species assigned a low-intermediate risk using the qualitative method (Jacobsen *et al*., 2015) and a medium-risk rating under SAFE (Campbell *et al*., 2017). While the species was assigned a medium-risk rating using the SAFE method, this rating increased to a precautionary high rating under a more conservative (precautionary) scenario (Campbell *et al.,* 2017). The SAFE assessment compiled by Campbell *et al.* (2017) covered most, if not all of the Queensland *P. collare* distribution. In this study the base-case scenario (medium risk) provides a more accurate assessment of fishing-related risks in this region. This assessment though is regionally specific and will not apply to the entire east coast. Comparisons have shown that SAFE produces fewer false positives when compared to the PSA (Zhou *et al.,* 2016) and, data permitting, it is the preferred assessment method (Department of Agriculture and Fisheries, 2018b). With biological data for *P. collare* still limited, there is an increased probability that the PSA will produce a false-positive result or a risk overestimate. While noting this potential, *P. collare* will be considered for inclusion in the ECOTF ERA update as a precautionary measure. Any future assessment will need to consider the likelihood of the output being a false-positive result and avenues to refine the *P. collare* risk profile *i.e.* through a Residual Risk Analysis.
Family Stegostomatidae				
Zebra shark	*Stegostoma tigrinum* (synonym:	37 013006	**Y**	**Included—**The zebra shark (*Stegostoma tigrinum*) is a benthic shark species whose distribution and depth profile shows considerable overlap with the ECOTF effort footprint. The species has been reported as bycatch in the ECOTF and in adjacent

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
	Stegostoma fasciatum)			jurisdictions (Campbell *et al.,* 2020; Kyne *et al.,* 2021). Promisingly, research has shown that the use of a TED is highly effective in terms of excluding *S. tigrinum* from the trawl catch (Campbell *et al.,* 2020). This research suggests that a higher percentage of trawl-caught *S. tigrinum* will experience a contact without capture event. As these events do not involve the shark being brought to the surface, it is anticipated that the majority will survive this type of interaction (Kyne *et al.,* 2021). Evidence suggests that *S. tigrinum* is a lower assessment priority for the ECOTF. Research has demonstrated the effectiveness of TEDs at reducing capture rates (Campbell *et al.,* 2020) and there are limited reports of the species making a substantial contribution to the elasmobranch prawn trawl bycatch (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a; Salini *et al.*, 2007). Similarly, previous ERAs have assessed the species as either a low-intermediate (Jacobsen *et al.*, 2015) or low risk (Campbell *et al.,* 2017). While noting the above, previous risk assessments involving this species only cover the southern regions of the ECOTF (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). This contrasts with the known distribution of *S. tigrinum* which extends along the entire Queensland east coast, into the Torres Strait and across northern Australia (Kyne *et al.,* 2021). In these areas the species inhabits water depths between 0–62 m (Kyne *et al.*, 2021) and will likely be exposed to some level of trawl fishing activity. Given these factors, *S. tigrinum* may benefit from additional assessment of the risk posed to trawl fishing across its entire range. The decision to consider *S. tigrinum* for inclusion in an updated ECOTF ERA is precautionary and future assessments will need to consider the potential for false-positive results. Under the ERA framework used in Queensland, this potential will be considered as part of the Residual Risk Analysis.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Family Scyliorhinidae				
Eastern banded catshark	*Atelomycterus marnkalha*	37 015037	**Y**	**Included**—The eastern banded catshark (*Atelomycterus marnkalha*) is a small catshark (*maximum length* = 49 cm TL) that is found along the Queensland east coast and the Gulf of Carpentaria (Jacobsen & Bennett, 2007; Kyne *et al.,* 2021). Information on this species is based on a small number of specimens and further information is required on the biology and life-history constraints of this species (*pers. comm.* I. Jacobsen). The species is found in water depths up to 75 m and it will be caught as bycatch in inshore trawl operations. As it is a small catshark, the use of a TED and BRD will provide limited benefits for this species. It will, however, be afforded some protection from trawl fishing activities within the Great Barrier Reef Marine Park (GBRMP) *Representative Areas Program*. The available evidence suggests that interactions with this species will be less frequent in waters south of the GBRMP (Kyne *et al.,* 2021). The species was previously assessed as an intermediate risk in an ERA examining the risk posed by trawl fishing in the GBRMP (Pears *et al.*, 2012b). *Atelomycterus marnkalha* was not included in either of the southern Queensland trawl ERAs (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In the more recent *Action Plan for Australian Sharks and Rays*, *A. marnkalha* was classified as a species of *Least Concern* (Kyne *et al.*, 2021). It is unlikely that the risk posed by trawl fishing has increased significantly for this species. With that said, the *A. marnkalha* risk profile is at least 10 years old (Pears *et al.*, 2012b). As such, the species would benefit from reassessment using the PSA. As such, it was included for assessment in an updated trawl ERA. The decision to include

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				this species in the assessment is viewed as precautionary and future assessments will need to consider the potential for false-positive results.
Family Heterodontidae				
Crested hornshark	*Heterodontus galeatus*	37 007003	**Y**	**Included**—The crested hornshark (*Heterodontus galeatus*) has a limited Queensland distribution, stopping well south of K'gari (formerly Fraser Island) (Last & Stevens, 2009; Kyne *et al.*, 2021). This (restricted) range in Queensland waters will limit the extent of interactions between *H. galeatus* and ECOTF operations. Previous research indicates that *H. galeatus* interactions in the ECOTF tend to be (comparatively) low in number and confined to the eastern king prawn sector (Courtney *et al.*, 2007b; Campbell *et al.*, 2017). This is largely due to the species having a restricted distribution in Queensland waters and a general preference for rocky-reef environments and larger macroalgae assemblages near sandy and seagrass areas (Bray, 2020c; Kyne *et al.*, 2021). The species will also derive benefit from spatial closures implemented as part of the *Moreton Bay Marine Park* (Department of National Parks Sport and Racing, 2015; Department of Environment and Science, 2020b). Interactions with *H. galeatus* are more likely to occur at night when the species moves out of sheltered environments to feed. If a *H. galeatus* is caught within the sweep of the net, there is an increased probability that the shark will be caught in the codend of the net. *Heterodontus galeatus* attains a *maximum length* of 130 cm TL and matures at around 60–70 cm TL (Kyne *et al.*, 2021). Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019), it can be inferred that both immature and mature *H. galeatus* will be caught as bycatch. While further information is required,

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				anecdotal evidence indicates that *H. galeatus* is a robust species with reasonable post-interaction survival rates (Kyne *et al.,* 2021). Previous ERAs classified *H. galeatus* as being at a low-intermediate (Jacobsen *et al.*, 2015) and medium risk (Campbell *et al.,* 2017) from trawl fishing activities in southern Queensland. While Campbell *et al.* (2017) assigned a marginally higher risk rating, the study recognised that data deficiencies may have exerted some influence on the final risk rating (Campbell *et al.*, 2017). These deficiencies included information on escapement rates and post-trawl survival; two parameters that are difficult to assess or quantify within a marine environment. *Heterodontus galeatus* has undergone further assessment since the completion of the trawl ERAs. In the *Action Plan for Australian Sharks and Rays* (Kyne *et al.*, 2021), the regional extinction risk for *H. galeatus* was assessed using the broader IUCN Red List criteria. This assessment classified *H. galeatus* as a species of *Least Concern*, detecting no discernible (inferred, suspected or observed) population decline (Kyne *et al.*, 2021). While the interaction potential for this species will be limited by a) its distributional limits and b) habitat preferences, the decision was made to include *H. galeatus* in the ECOTF ERA update. Under the ERA framework (Department of Agriculture and Fisheries, 2018b), issues associated with false-positive results and intra-fishery variability will be addressed through a Residual Risk Analysis. While *H. galeatus* is viewed as a lower assessment priority when compared to other species it will be progressed to the ECOTF SOCC ERA as a precautionary measure.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Additional consultation—Additional consultation on the scope and extent of the SOCC ERA indicated that species *H. galeatus* should be included, even if it is as a precautionary measure.
Family Squatinidae				
Eastern angelshark	*Squatina albipunctata*	37 024004	**Y**	**Included**—The eastern angelshark (*Squatina albipunctata*) is an Australian endemic species with a wide distribution on the Queensland east coast. The *S. albipunctata* distribution/depth profile (Kyne *et al.*, 2021) overlaps with the trawl effort footprint and it has been reported as bycatch in the ECOTF (Courtney *et al.*, 2007b; Rigby *et al.*, 2016b). While difficult to quantify without additional monitoring, research suggests that *S. albipunctata* will mostly interact with the deepwater eastern king prawn sector (Rigby *et al.*, 2016b). *Squatina albipunctata* is considered a data-poor species and further information is required on its biology and propensity to interact with commercial fisheries. These deficiencies were noted in the *Action Plan for Australian Sharks and Rays,* however, capture as 'byproduct' and 'bycatch' were viewed as lower threat elements (Kyne *et al.,* 2021). When *S. albipunctata* interacts with the ECOTF, its morphological features may assist in terms of TED effectiveness. A species with a similar body shape to wobbegongs, *S. albipunctata* grows to at least 130 cm TL and reaches sexual maturity at >90 cm TL (Kyne *et al.*, 2021; Bray, Undated-b). Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019) and the general *Squatinidae* morphology, a notable portion of the mature sharks will be excluded from the catch. As *S. albipunctata* pups are born between 27–30 cm TL (Bray, Undated-b) it is assumed that the use of a TED will be less effective in terms of excluding juvenile and subadults.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				When compared to other elasmobranchs, *S. albipunctata* is viewed as a lower assessment priority. Interactions with this species are unlikely to occur across the ECOTF, with encounters more likely to be observed in deeper water environments (Kyne *et al.*, 2021). This was the main reason why *S. albipunctata* was only included in the Campbell *et al.* (2017) assessment. In this quantitative assessment, the species was assessed as a low risk from trawl fishing activities in southern Queensland (Campbell *et al.*, 2017). While noting the low interaction potential, *S. albipunctata* will benefit from additional assessment. The challenge being how best to address intra-fishery risk variability and the potential for a false-positive result. Accordingly, any future assessment will need to consider a) the distribution of the species being assessed, b) the management regions that the species will interact with and c) the potential for false-positive results. In the ECOTF SOCC ERA, these factors will primarily be addressed as part of the Residual Risk Analysis.
Family Pentanchidae				
Grey spotted catshark	*Asymbolus analis*	37 015027	**Y**	**Included**—The risk profile of the grey spotted catshark (*Asymbolus analis*) and the orange spotted catshark (*A. rubiginosus*) share several similarities. While their distribution overlaps with the ECOTF, they are primarily found in waters south of K'gari (formerly Fraser Island) (Last & Stevens, 2009; Bray, 2018a; b; Kyne *et al.*, 2021). Data further suggests that interactions with *A. analis* and *A. rubiginosus* will be (mostly) confined to deeper water operations targeting eastern king prawns (Courtney *et al.,* 2007b; Kyne *et al.,* 2011b).
Orange spotted catshark	*Asymbolus rubiginosus*	37 015024	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019), there is a high probability that most trawl interactions with *A. analis* and *A. rubiginosus* will result in their capture as bycatch. Given their *size at maturity* (~40–60 cm TL; Bray, 2018a; b), this portion of the catch will include both immature and mature animals. While difficult to quantify without further monitoring, discard mortality will likely be higher for both species (Kyne *et al.,* 2021). *Asymbolus analis* and *A. rubiginosus* have been reported as bycatch from the ECOTF and were included in two previous assessments examining the risk posed by trawl fishing in southern Queensland. In the qualitative ERA, both were assigned a high-risk rating (Jacobsen *et al.*, 2015). These ratings are viewed as more conservative as they partly reflect data availability (*pers. comm.* I. Jacobsen). This ERA has since been updated, with Campbell *et al.* (2017) reassessing the regional risk using a SAFE methodology. SAFE provides an absolute measure of risk and research has shown that it produces fewer false positives when compared to other methods (Zhou & Griffiths, 2008; Hobday *et al.*, 2011; Zhou *et al.*, 2016). Under the SAFE assessment, *A. analis* and *A. rubiginosus* were both assigned low-risk ratings (Campbell *et al.,* 2017). While the interaction potential for this species will be limited by a) its distributional limits and b) habitat preferences, the decision was made to include both *A. analis* and *A. rubiginosus* in the ECOTF ERA update. Under the ERA framework (Department of Agriculture and Fisheries, 2018b), issues associated with false-positive results and intra-fishery variability will be addressed through a Residual Risk Analysis. While these species are viewed as lower assessment priorities when compared to other species, they will be progressed to the SOCC ECOTF ERA as a precautionary measure.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Additional consultation—Additional consultation on the scope and extent of the ECOTF SOCC ERA indicated that species *A. analis* and *A. rubiginosus* should be included, even if it is as a precautionary measure.
Pale spotted catshark	*Asymbolus pallidus*	37 015025	**Y**	**Included**—The pale spotted catshark (*Asymbolus pallidus*) is an Australian endemic species with a somewhat wide distribution on the Queensland east coast. The distribution/depth profile of *A. pallidus* overlaps with the trawl effort footprint and there is some evidence that it is caught as bycatch in the ECOTF (Rigby *et al.*, 2016b). Though, without additional monitoring, interactions with this species are expected to be largely confined to deeper waters. Of significance, *A. pallidus* was not included in the three previous ECOTF ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). However, *A. pallidus* has been identified as bycatch of the deepwater eastern king prawn fishery (EKP) (Rigby *et al.*, 2016b). While this species was the third highest bycatch contributor in a study observing deepwater Chondrichthyan bycatch within the EKP, depths beyond 200 m are fished with less frequency due to operational constraints (Rigby *et al.*, 2016b). A preference for deeper water environments minimises the interaction potential and ensures that a portion of the population is protected from trawl fishing activities. When compared to other elasmobranchs, *A. pallidus* is probably viewed as a lower assessment priority for the ECOTF. Interactions with this species are unlikely to occur across the entire ECOTF and there is a low probability of it being encountered in shallower waters. The decision was made to include *A. pallidus* in the ECOTF ERA update. Under the ERA framework (Department of Agriculture and Fisheries, 2018b), issues associated

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				with false-positive results and intra-fishery variability will be addressed through a Residual Risk Analysis. While *A. pallidus* will be reassessed, the decision to include it in the ECOTF ERA update was viewed as precautionary. For reference, the most recent assessment involving *A. pallidus*, was a regional evaluation of the extinction risk. This assessment was undertaken as part of the *Action Plan for Australian Sharks and Rays* and *A. pallidus* was classified as a species of *Least Concern.* This assessment did not identify a discernible (inferred, suspected or ongoing) population decline but classified 'bycatch' as a high-threat element for this species.
Family Dalatiidae				
Smalleye pygmy shark	*Squaliolus aliae*	37 020017	**N**	**Not included**—While the Queensland distribution of the smalleye pygmy shark (*Squaliolus aliae*) overlaps with the ECOTF, several factors reduce the interaction potential for this species. In Queensland, this species is more likely to be caught as bycatch in deeper water environments during the day. While not universal, these deeper water environments attract lower levels of effort as trawlers are less likely to operate beyond 200 m (*pers. comm.* D. Roy). Combined with the depth range of *S. aliae* (150–2,000 m: Kyne *et al.,* 2021), this suggests interactions will be infrequent and/or at levels that are unlikely to pose a significant long-term risk to regional populations. Overall, there is limited evidence to suggest that the species frequently interacts with the ECOTF and/or in high numbers (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a; Rigby *et al.*, 2016b). *Squaliolus aliae* was viewed as a lower assessment priority and was not progressed as part of the ECOTF ERA update. For reference, *S. aliae* was not included in the three previous risk assessments and it was assessed as a species of *Least*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Concern in the *Action Plan for Australian Sharks and Rays* (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017; Kyne *et al.*, 2021). Given the above considerations, the species affinity for deeper water environments and limited interaction potential, *S. aliae* was not included in the updated ECOTF ERA.
Black shark	*Dalatias licha*	37 020002	**N**	**Not included**—The black shark (*Dalatias licha*) has a broad-ranging southern Australian distribution and it is relatively common in Australian waters (Kyne *et al.,* 2021). On the Australian east coast, the *D. licha* distribution extends as far north as central Queensland. While the species is found in water depths from 30 m to 1,800 m, anecdotal evidence suggests that it mostly occurs between 450 and 850 m (Bray & White, Undated). *Dalatias licha* was considered for inclusion in an updated trawl ERA due to its broad distribution and depth profile. A review of the available data suggests that interactions between *D. licha* and the ECOTF are highly unlikely and/or at a level that does not pose a long-term conservation risk. While the species will experience notable fishing-related mortalities, these largely occur in adjacent jurisdictions and non-trawl fisheries. The species was considered a lower assessment priority for the ECOTF and was not progressed further. For reference, *D. licha* was not considered an assessment priority for any of the three previous ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). The species was classified as *Near Threatened* in the *Action Plan for Australian Sharks and Rays* with their retention as bycatch identified as a moderate threat; particularly in areas where there has been historical population declines *e.g.* upper shelf environments in New South Wales (Kyne *et al.,* 2021).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Family Chimaeridae				
Blackfin ghostshark / Ogilby's chimaera	*Chimaera ogilbyi* (synonym: *Hydrolagus lemures* and *Hydrolagus ogilbyi*)	37 042001	**N**	**Not included**—The blackfin ghostshark (*Chimaera ogilbyi*) was considered for inclusion in an updated ECOTF ERA as it did not meet the exclusion criteria used to compile the broader species list. However, a review of the available data indicates that *C. ogilbyi* is a lower assessment priority for the ECOTF. The Queensland proportion of the *C. ogilbyi* distribution overlaps with the ECOTF and evidence suggests that chimaerids are infrequently caught as bycatch (Courtney *et al.*, 2007b). *Chimaera ogilbyi* has a depth profile (139–872 m) that exceeds inshore trawl operations, a large expanse of the deepwater eastern king prawn sector and into areas that are not accessible due to operational constraints. This preference for deeper water environments minimises the interaction potential and ensures that a portion of the population is protected from trawl fishing activities. *Chimaera ogilbyi* (identified by a synonym *Hydrolagus lemures*) was included in a qualitative ERA examining the risk posed by trawl fishing activities in southern Queensland (Jacobsen *et al.*, 2015). This study determined that trawl fishing activities posed an intermediate risk to this species (Jacobsen *et al.*, 2015). This study though provided limited context on the extent of this risk and/or how much it varied across the ECOTF. A subsequent review of the available data suggests that this risk, if applicable, would be confined to the deepwater eastern king prawn sector (Rigby *et al.*, 2016b). As this sector (mostly) operates in south-east Queensland, the outputs of the previous qualitative ERA may overestimate the risk for this species (*pers. comm.* I. Jacobsen). This inference is supported by the outputs of a subsequent ERA compiled using the quantitative SAFE

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				ERA method (Hobday *et al.*, 2011; Zhou *et al.*, 2011; Campbell *et al.*, 2017). This study focused on southern Queensland and determined that *C. ogilbyi* (identified by a synonym *Hydrolagus ogilbyi*) was at a low risk from trawl fishing activities in this area (Campbell *et al.*, 2017). As SAFE provides an absolute measure of risk (*versus* an indicative estimate), it arguably provides a more accurate account of the risk posed by regional trawl fishing activities. *Chimaera ogilbyi* interacts infrequently with the ECOTF and is less likely to be caught as bycatch. Their capture is not viewed as a major threat, and otter trawl fishing is not expected to pose a significant or long-term sustainability risk for these species within Queensland. On this basis, *C. ogilbyi* was not included in the ECOTF ERA update**.** For further information on the risk posed by trawl fishing in Queensland-managed waters refer to Campbell *et al.* (2017).
Family Centrophoridae				
Endeavour dogfish	*Centrophorus moluccensis*	37 020001	**N**	**Not included**—The endeavour dogfish (*Centrophorus moluccensis*), gulper shark (*C. granulosus*), Harrison's dogfish (*C. harrissoni*) and the longsnout dogfish (*Deania quadrispinosa*) were all considered for inclusion in the updated ECOTF ERA as a) they did not meet the broad exclusion criteria, and b) they have distributions that partially overlap with the prescribed fishing grounds. *Centrophorus harrissoni* is also classified as *Conservation Dependent* in the *Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2022b). While they were considered for inclusion in the updated ECOTF ERA, the available evidence suggests that all four are low assessment priorities. This inference is supported by the fact that none of the four species were included in previous risk
Gulper shark	*Centrophorus granulosus*	37 020023	**N**	
Harrison's dogfish	*Centrophorus harrissoni*	37 020010	**N**	
Longsnout dogfish	*Deania quadrispinosa*	37 020004	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				assessments involving the ECOTF (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). There is limited evidence that these species have frequent interactions with the ECOTF and/or are caught as bycatch in this fishery (Kyne *et al.*, 2007a; Pears *et al.*, 2012b; Courtney *et al.*, 2014; Jacobsen *et al.*, 2015; Rigby *et al.*, 2016b). A likely explanation for this is that *C. moluccensis* (125–825 m), *C. granulosus* (250–1,500 m), *C. harrissoni* (220–1,500 m) and *D. quadrispinosa* (150–1,360 m) inhabit deep-water environments that are less conducive to trawl fishing and/or are not accessed with great regularity *i.e.* due to operational constraints (Last *et al.*, 2016b; Kyne *et al.*, 2021; Department of Agriculture and Fisheries, 2022b). A review of the available information indicates that these species interact infrequently with the ECOTF and are less likely to be caught as bycatch. Their capture as bycatch in the ECOTF is not viewed as a major threat and the extent of these interactions will not pose a significant or long-term sustainability risk. Given the low interaction potential and lack of evidence that they interact with the ECOTF, *C. moluccensis*, *C. granulosus*, *C. harrissoni* and *D. quadrispinosa* were not progressed as part of the ECOTF ERA update.
Family Squalidae				
Eastern longnose spurdog	*Squalus grahami*	37 020041	**N**	**Not included**—Trawl profiles for the eastern longnose spurdog (*Squalus grahami*), Philippine spurdog (*S. montalbani*), eastern highfin spurdog (*S. albifrons*) and southern Mandarin spurdog (*Cirrhigaleus australis*) will mirror members from the *Family Centrophoridae*. Each of the four species were considered for inclusion in the ERA as
Philippine spurdog	*Squalus montalbani*	37 020047	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Southern mandarin dogfish	*Cirrhigaleus australis*	37 020049	**N**	they did not meet the broad exclusion criteria and have distributions that partially overlap with the prescribed grounds of the ECOTF.
Eastern highfin spurdog	*Squalus albifrons*	37 020038	**N**	The available data provides little insight into the interaction potential and capture rates of these four species. Expectations are that *S. grahami*, *S. montalbani*, *S. albifrons* and *C. australis* will have limited interactions with the ECOTF and be caught in low quantities (Kyne *et al.*, 2007a; Pears *et al.*, 2012b; Courtney *et al.*, 2014; Jacobsen *et al.*, 2015; Rigby *et al.*, 2016b). This inference is supported by a depth profile data that shows *S. grahami* (148–504 m), *S. montalbani* (154–1,370 m), *S. albifrons* (131–450 m) and *C. australis* (360–640 m) all inhabit deeper water environments (Ebert *et al.*, 2021; Kyne *et al.*, 2021). Of note, both *S. grahami* and *S. montalbani* were included in a quantitative SAFE assessment examining the risk posed by trawl fishing activities in southern Queensland (Campbell *et al.*, 2017). This assessment included fishing operations targeting deepwater eastern king prawns; the sector most likely to interact with the *Family Squalidae* and *Family Centrophoridae*. This assessment indicated that trawl fishing activities in southern Queensland presented a low risk to both *S. grahami* and *S. montalbani* (Campbell *et al.*, 2017). None of the four species were included in the two qualitative ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). A review of the available information indicates that these species interact infrequently with the ECOTF and are less likely to be caught as bycatch. Their capture in the ECOTF is not viewed as a major threat and the extent of these interactions will not pose a significant or long-term sustainability risk. This hypothesis is supported by the *Action Plan for Australian Sharks and Rays* which indicated 'bycatch' represented a low-level threat for *S. grahami*, *S. montalbani*, *S. albifrons* and *C. australis* (Kyne *et al.*, 2021).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				While some dogfish species may experience increased fishing pressures, these lie outside Queensland-managed waters and the ECOTF. Accordingly, *S. grahami*, *S. montalbani*, *S. albifrons* and *C. australis* were not progressed as part of the ECOTF ERA update. For more insight into the risk posed to members of the *Family Squalidae* most likely to interact with the deepwater eastern king prawn sector refer to Campbell *et al.* (2017).
Piked spurdog (synonym: Shortnose spurdog)	*Squalus megalops*	37 020006	Y	**Included**—The piked spurdog (*Squalus megalops*) is an Australian endemic species with a wide distribution on the Queensland east coast. The distribution/depth profile of *S. megalops* (Kyne *et al.*, 2021) overlaps with the trawl effort footprint and there is some evidence that it is caught as bycatch in the ECOTF (Rigby *et al.*, 2016b; Campbell *et al.*, 2017). While difficult to quantify without additional monitoring, interactions with this species are largely confined to deeper waters (Rigby *et al.*, 2016b). *Squalus megalops* was not included in the two previous qualitative ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). However, a SAFE assessment examining the risk posed by trawl fishing in southern Queensland assigned *S. megalops* with a high-risk rating. This rating increased to precautionary extreme high when the species was assessed using a more conservative (precautionary) scenario that accounted for parameter estimate uncertainty (Campbell *et al.*, 2017). As a quantitative assessment, SAFE provides an absolute measure of risk *versus* an indicative estimate. Research has also shown that SAFE produces fewer false positives when compared to semi-quantitative methods like the PSA (Zhou *et al.,* 2016). When compared to other elasmobranchs, *S. megalops* is probably viewed as a lower assessment priority for the ECOTF. Interactions with this species are unlikely to occur

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				across the entire ECOTF and there is a low probability of it being encountered in shallower waters. This was the main reason why it was assessed by Campbell *et al.* (2017) and not in the two qualitative assessments (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). While noting the above points, the depth profile for *S. megalops* (0–732 m) covers a more expansive area of the ECOTF; particularly when compared to other *Squalus* species *e.g. S. grahami* (148–504 m), *S. montalbani* (154–1,370 m) and *S. albifrons* (131–450 m; Kyne *et al.*, 2021). This depth profile increased the probability that *S. megalops* will interact with operations not covered by the SAFE assessment (Campbell *et al.*, 2017). For this reason, the species would benefit from further assessment of the risk posed by trawl fishing across its entire range. The challenge being how best to address intra-fishery risk variability and the potential for a false-positive result. Similarly, future assessments will need to consider a) the distribution of the species being assessed, b) the management regions that the species will interact with and c) the potential for false-positive results. The decision was made to include *S. megalops* in the ECOTF ERA update. Under the ERA framework (Department of Agriculture and Fisheries, 2018b), issues associated with false-positive results and intra-fishery variability will be addressed through a Residual Risk Analysis. While *S. megalops* will be reassessed, the decision to include it in the ECOTF ERA update was viewed as precautionary. For reference, the most recent assessment involving *S. megalops*, was a regional evaluation of the extinction risk. This assessment was undertaken as part of the *Action Plan for Australian Sharks and Rays* and *S. megalops* was classified as a species of *Least Concern.* This assessment did not identify a discernible (inferred, suspected or

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				ongoing) population decline but classified ‘bycatch’ as a high-threat element for this species.
Family Scyliorhinidae				
Sawtail catshark	*Figaro boardmani* (synonym: *Galeus boardmani*)	37 015009	**N**	**Not included**—Queensland comprises a comparatively small component of the sawtail catshark (*Figaro boardmani*) distribution. *Figaro boardmani* is only found in southern Queensland waters and it will be more prevalent in temperate waters (Kyne *et al.*, 2021). This distribution limits the encounterability potential for this species and the probability that *F. boardmani* will be caught across the entire ECOTF. This potential is further reduced by the *F. boardmani* depth profile which incorporates deeper water environments from 130–640 m (Kyne *et al.,* 2021). Given the ECOTF effort footprint, interactions with *F. boardmani* are more likely to occur in other areas of its range. Data from the ECOTF shows that *F. boardmani* will be caught as bycatch in operations targeting eastern king prawns in deeper waters (Courtney *et al.*, 2007a; Kyne *et al.*, 2007a). As the ECOTF typically operates in waters <200 m (*pers. comm.* D. Roy), interactions with this species will be on the outer periphery of the *F. boardmani* depth range (*pers. comm.* I. Jacobsen). While the species has a low interaction potential in the ECOTF, it was included in two previous ERAs (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In the qualitative ERAs, *F. boardmani* was assigned a high-risk rating (Jacobsen *et al.*, 2015). This approach though may not have adequately accounted for false positives resulting from (*e.g.*) data deficiencies and the use of proxies (*pers. comm.* I. Jacobsen). These issues were reflected in key sections of the report including in the executive summary of the Southern Queensland East Coast Otter Trawl ERA (Jacobsen *et al.*, 2015) which stated:

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				"Of the ecological components included in this analysis, bycatch species and the species of conservation concern were arguably most affected by data deficiencies. This was most evident in those fishery impact profile characteristics relating to catch, interaction and mortality rates i.e. level of interaction and survival after interaction. All characteristics with low information were assigned more conservative scores (i.e. higher impact or lower resilience) and consequently this study may have overestimated the risk from trawling for some species including elasmobranchs." When compared to qualitative ERAs, the SAFE assessment arguably provides a more accurate representation of the risk posed to this species (Campbell *et al.*, 2017). Research has shown that the SAFE method produces fewer false positives when compared to semi-qualitative ERA methods like the PSA. It also provides an absolute value of risk *versus* an indicative estimate (Hobday *et al.*, 2011; Zhou *et al.*, 2016). In the case of *F. boardmani*, the SAFE ERA examined trawl-related risk across their known distributions (Kyne *et al.*, 2021) and concluded trawl fishing activities in southern Queensland posed a low risk to this species (Campbell *et al.*, 2017). Outside of the Queensland-based ERAs, *F. boardmani* was the subject of a regional extinction risk assessment (Kyne *et al.*, 2021). This assessment used the IUCN Red List criteria and classified *F. boardmani* as a species of *Least Concern* (Kyne *et al.*, 2021). This assessment did not identify a discernible (inferred, suspected or ongoing) population decline but classified 'bycatch' as a moderate threat for this species. *Figaro boardmani* was also classified as *sustainable* under the *Shark Report Card*. These shark reports, in effect, apply an equivalency test to assign indicative sustainability

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				estimates to species not assessed as part of the *Status of Australian Fish Stocks* (Kyne & Bennett, 2019). Given the above considerations, the species restricted range in Queensland and limited interaction potential, *F. boardmani* was not included in the updated ECOTF ERA. When and where appropriate, *F. boardmani* will be considered for inclusion in subsequent ERAs involving the ECOTF. The need to include *F. boardmani* in subsequent trawl ERAs will be dependent on the outputs of ancillary programs including initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a). For further information on the risk posed by trawl fishing in Queensland-managed waters refer to Campbell *et al.* (2017).
Family Ginglymostomatidae				
Tawny shark	*Nebrius ferrugineus*	37 013010	**N**	**Not included**—The tawny shark (*Nebrius ferrugineus*) was considered for inclusion in the ECOTF ERA update as it has a distribution and depth profile (0–70 m) that overlaps with the ECOTF in central and northern Queensland (Last & Stevens, 2009; Kyne *et al.*, 2021). *Nebrius ferrugineus* has not been observed in trawl bycatch and it was excluded from all three previous ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). If a *N. ferrugineus* interacts with a trawl net, it will benefit from the use of a TED. While further information is required on the growth and development of this species, length at maturity estimates for *N. ferrugineus* range from 230-290 cm TL (Bray, 2019b; Kyne *et al.*, 2021). This species reaches a maximum total length of at least 320 cm (Kyne *et al.*, 2021).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019), most interactions will result in subadult and mature individuals being excluded from the net. Total length estimates for *N. ferrigineus* though will be exaggerated by the morphology of the caudal region which is typified by an elongated/extended caudal lobe (Last *et al.*, 2016b; Irschick *et al.*, 2017). This is of some importance as it means individuals >1 m may still be caught in the codend of the net; something that is less likely to occur in (*e.g.*) carcharhinids (Brewer *et al.*, 2006; Campbell *et al.*, 2020). Similarly, *N. ferrugineus* are born between 40–80 cm (Bray, 2019b) and smaller individuals may still be caught in the codend of a trawl net. There is, however, limited evidence that the ECOTF operates in areas where smaller *N. ferrugineus* are more prevalent and/or that they are caught with great regularity in this fishery. Applying a weight-of-evidence approach indicates that *N. ferrugineus* has limited interactions with the ECOTF and is a lower assessment priority in this ERA update. Accordingly, the species was not progressed as part of the ECOTF ERA update.
Family Pristiophoridae				
Tropical sawshark	*Pristiophorus delicatus*	37 023004	**N**	**Not included**—The tropical sawshark (*Pristiophorus delicatus*) was considered for inclusion in an updated ERA as it has a distribution that partially overlaps with the ECOTF and has been reported as bycatch in the ECOTF (Pears *et al.*, 2012b). While the Queensland distribution of *P. delicatus* overlaps with the ECOTF, several factors reduce the interaction potential for this species. In Queensland, this species is more likely to be caught as bycatch in deeper water environments (176–405 m; Kyne *et al.*, 2021). While not universal, these deeper water environments attract lower levels of effort as trawlers are less likely to operate beyond 200 m (*pers. comm.* D. Roy). This,

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				combined with the depth range of *P. delicatus* (176–405 m: Kyne *et al.,* 2021), suggests interactions with *P. delicatus* will be infrequent and/or at levels that are unlikely to pose a significant long-term risk to regional populations. Overall, there is limited evidence to suggest that the species frequently interacts with the ECOTF and/or in high numbers (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a). *Pristiophorus delicatus* was viewed as a lower assessment priority and was not progressed as part of the ECOTF ERA update. For reference, *P. delicatus* was not included in the three previous risk assessments and it was assessed as a species of *Least Concern* in the *Action Plan for Australian Sharks and Rays* (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017; Kyne *et al.*, 2021). While excluded from the main assessment, it was noted in Pears *et al.* (2012b) that *P. delicatus* was observed in the trawl fishery by Fisheries observers between 2005–2010. With the continued role out of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018a), there may be further observations of *P. delicatus* being caught in the ECOTF. If this occurs, the decision to exclude *P. delicatus* from the ECOTF ERA will be reviewed.
Batoids				
Family Narcinidae				
Eastern numbfish	*Narcinops nelsoni* (synonym: *Narcine nelsoni*)	37 028008	**N**	**Not included**—The eastern numbfish (*Narcinops nelsoni*) is an endemic ray that was considered for inclusion in an updated ERA as it has a distribution that partially overlaps with the ECOTF.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				While the Queensland distribution of *N. nelsoni* overlaps with the ECOTF, several factors reduce the interaction potential for this species. In Queensland, this species is more likely to be caught as bycatch in deeper water environments (176–405 m; Kyne *et al.*, 2021). While not universal, these deeper water environments attract lower levels of effort as trawlers are less likely to operate beyond 200 m (*pers. comm.* D. Roy). This, combined with the depth range of *N. nelsoni* (140–540 m: Kyne *et al.,* 2021), suggests interactions with this species will be infrequent and/or at levels that are unlikely to pose a significant long-term risk to regional populations. Overall, there is limited evidence to suggest that the species frequently interacts with the ECOTF and/or in high numbers (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a; Rigby *et al.*, 2016b). *Narcinops nelsoni* was viewed as a lower assessment priority and was not progressed as part of the ECOTF ERA update. For reference, *N. nelsoni* was not included in the three previous risk assessments and it was assessed as a species of *Least Concern* in the *Action Plan for Australian Sharks and Rays* (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017; Kyne *et al.*, 2021). Given the above considerations, the species affinity for deeper water environments and limited interaction potential, *N. nelsoni* was not included in the updated ECOTF ERA. When and where appropriate, *N. nelsoni* will be considered for inclusion in subsequent ERAs involving the ECOTF. The need to include *N. nelsoni* in subsequent trawl ERAs will be dependent on the outputs of ancillary programs including initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a).
Family Mobulidae				

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Bentfin devilray	*Mobula thurstoni*	37 041003	**N**	**Not included**—Manta and Mobula rays (*Family Mobulidae*) were considered for inclusion in an updated ERA as their depth profiles and distributions have considerable overlap with the ECOTF. However, a review of the available data indicates that interactions with this complex are unlikely or (if applicable) will occur at levels that will not contribute to a broader decline in their conservation status. Mobulid rays are more likely to be found in habitats and water depths (*i.e.* pelagic, semi-pelagic) less conducive to trawl fishing activities. These factors reduce the likelihood that a trawl fishing operation will encounter, interact or capture a mobulid ray. In the unlikely event that a manta or mobulid ray is caught during a trawl fishing event, they will be prevented from entering the codend of the net by the TED. This inference is supported by morphological data for each species: - *Mobula thurstoni*: *maximum size* = 189 cm DW, size at birth = 68–85 cm DW (Bray, 2021c; Kyne *et al.*, 2021). - *M. mobular*: *maximum size* = 520 cm DW, size at birth = ~ 90 cm TL (Last *et al.*, 2016b; Kyne *et al.*, 2021). - *M. birostris*: *maximum size* = 700 cm DW, size at birth = unknown (Last *et al.*, 2016b; Bray, 2020h; Kyne *et al.*, 2021). - *M. kuhlii*: *maximum size* = 135 cm DW, size at birth = ~ 31–34 cm DW (Last *et al.*, 2016b; Kyne *et al.*, 2021). - *M. eregoodoo*: *maximum size* = 130 cm DW, size at birth = unknown (Kyne *et al.*, 2021). - *M. alfredi*: *maximum size* = 550 cm DW, size at birth = ~ 130–150 cm DW (Last *et al.*, 2016b; Bray, 2020g; Kyne *et al.*, 2021).
Giant devilray	*Mobula mobular*	37 041002	**N**	
Giant manta ray	*Mobula birostris* (synonym: *Manta birostris*)	37 041004	**N**	
Kuhl's devilray	*Mobula kuhlii* (Historic synonym: *M. eregoodoo*)	37 041007	**N**	
Long-horned pygmy devilray	*Mobula eregoodoo* (Historic synonym: *Mobula kuhlii*)	37 041001	**N**	
Reef manta ray	*Mobula alfredi* (synonym: *Manta alfredi*)	37 041005	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				The entire *Family Mobulidae* was excluded from the updated ECOTF ERA as low assessment priorities.
Family Rajidae				
Sydney skate	*Dentiraja australis* (synonym: *Dipturus australis*)	37 031041	**Y**	**Included**—While the Queensland distribution of the Sydney skate (*Dentiraja australis*) and the endeavour skate (*D. endeavouri*) overlaps with the ECOTF, several factors reduce the interaction potential for these species. In Queensland, the distribution of both species is restricted to a small section of the south-east coast (Last *et al.*, 2016b; Kyne *et al.*, 2021). This limits their encounterability potential and reduces the probability that they will be caught across the entire ECOTF. When compared to Queensland, fishing interactions with *D. australis* and *D. endeavouri* are more likely to occur in adjacent jurisdictions, namely New South Wales (Kyne *et al.,* 2021). While further information on elasmobranch catch compositions is required, evidence suggests that *D. australis* and *D. endeavouri* are caught with less frequency in the ECOTF. For example, the presence of *D. australis* in Queensland waters was only confirmed in 2007 when it was caught as part of a broader survey of trawl catch compositions (Courtney *et al.*, 2007b). Similarly, there is limited evidence that *D. endeavouri* is caught as bycatch in the ECOTF in significant quantities. This, in part, can be attributed to the species having a low degree of overlap with the fishery. This absence of reports though may also be due to a current inability to monitor catch compositions and interaction rates in sectors where it might be encountered *e.g.* the deepwater eastern king prawn sector. As a precautionary measure, *D. endeavouri* was included in all three previous ECOTF ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). *Dentiraja*
Endeavour skate	*Dentiraja endeavouri* (synonym: *Dipturus endeavouri*)	37 031043	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				australis was only included in the two ERAs examining the risk posed by trawl fishing in southern Queensland (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In the qualitative ERAs, *D. australis* and *D. endeavouri* were assigned a high-risk rating (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). This approach though may not have adequately accounted for false positives resulting from (*e.g.*) data deficiencies and the use of proxies (*pers. comm.* I. Jacobsen). These issues were reflected in key sections of the report including in the executive summary of the Southern Queensland East Coast Otter Trawl ERA (Jacobsen *et al.*, 2015) which stated: *"Of the ecological components included in this analysis, bycatch species and the species of conservation concern were arguably most affected by data deficiencies. This was most evident in those fishery impact profile characteristics relating to catch, interaction and mortality rates i.e. level of interaction and survival after interaction. All characteristics with low information were assigned more conservative scores (i.e. higher impact or lower resilience) and consequently this study may have overestimated the risk from trawling for some species including elasmobranchs."* And: *"… the use of proxies has the potential to mask interspecific differences and as a consequence increases the likelihood that a species complex will be over-represented in a particular risk category. The use of proxies may also extend the influence of more conservative risk assessments and/or estimates based on smaller sample sizes. This in itself provides a credible alternate hypothesis as to*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				why stingarees (Family Urolophidae) and skates (Family Rajidae) were more prominent in the higher risk category (p. 57).” Given their distribution in Queensland waters and their interaction potential, the quantitative SAFE ERA provides a better representation of the risk posed to this species. Research has shown that the SAFE method produces fewer false positives when compared to semi-qualitative ERA methods like the PSA. It also provides an absolute value of risk *versus* an indicative estimate (Hobday *et al.*, 2011; Zhou *et al.*, 2016). In the case of *D. australis* and *D. endeavouri*, the SAFE ERA examined trawl-related risk across their known distributions (Kyne *et al.*, 2021) and concluded trawl fishing activities in southern Queensland posed a low risk to these species (Campbell *et al.*, 2017). Outside of the Queensland-based ERA, *D. australis* and *D. endeavouri* have been the subject of a regional extinction risk assessment (Kyne *et al.*, 2021). This assessment used the IUCN Red List criteria and classified *D. australis* as *Vulnerable* and *D. endeavouri* as *Near Threatened.* This assessment determined that both species had experienced a suspected, inferred or ongoing population decline over the last three generations (Kyne *et al.*, 2021). These population declines were reported from New South Wales where they are exposed to more significant fishing pressures. While *D. australis* and *D. endeavouri* were viewed as low priorities for reassessment, they are being considered for inclusion as part of the ECOTF ERA update. Future assessments would benefit from additional information on interaction rates; particularly within the deepwater eastern king prawn sector. This is already being explored through

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				the *Data Validation Plan* and the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017a; 2018a). ***Additional consultation***—Additional consultation on the scope and extent of the ECOTF SOCC ERA indicated that species *D. australis* and *D. endeavouri* should be considered for inclusion, even if it is as a precautionary measure.
Argus skate	*Dentiraja polyommata* (synonym: *Dipturus polyommata, Dipturus polyommatus*)	37 031042	**Y**	**Included**—The risk profile of the argus skate (*Dentiraja polyommata*) shares some similarities with other *Rajidae* species such as the pale tropical skate (*Dipturus apricus*) and the blacktip skate (*D. melanospilus*). Similar to these species *D. polyommata* is also a deepwater elasmobranch with a depth profile and habitat preference which limits their exposure to trawl fishing activities *i.e.* areas of the continental shelf and slope that are not readily accessed by prawn trawl operations. *Dentiraja polyommata* was included in two of the three previous ecological risk assessments (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In the qualitative ERAs, *D. polyommata* was assigned high-risk ratings (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). This approach though may not have adequately accounted for false positives resulting from (*e.g.*) data deficiencies and the use of proxies. While the interaction potential for this species will be limited by a) its distributional limits and b) habitat preferences, the decision was made to include *D. polyommata* in the ECOTF ERA update. Under the ERA framework (Department of Agriculture and Fisheries, 2018b), issues associated with false-positive results and intra-fishery variability will be addressed through a Residual Risk Analysis. While this species is viewed as a lower assessment priority when compared to other species, it will be progressed to the ECOTF SOCC ERA as a precautionary measure.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Additional consultation—Additional consultation on the scope and extent of the ECOTF SOCC ERA indicated that species *D. polyommata* should be considered for inclusion, even if it is as a precautionary measure.
Blacktip skate	*Dipturus melanospilus*	37 031033	**N**	**Not included**—The risk profile of the pale tropical skate (*Dipturus apricus*) and the blacktip skate (*D. melanospilus*) share several similarities. Both species are deepwater elasmobranchs that have depth profiles and habitat preferences which limit their exposure to trawl fishing activities *i.e.* areas of the continental shelf and slope that are not readily accessed by prawn trawl operations. For example, *D. apricus*, 195–605 m and *D. melanospilus* 240–695 m (Last *et al.*, 2016b; Bray, 2018d; e; Kyne *et al.*, 2021). As a precautionary measure, *D. melanospilus* was included in two of the three previous ECOTF ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). *Dipturus apricus* was only included in the one ERA examining the risk posed by trawl fishing in the GBRMP (Pears *et al.*, 2012b). In the qualitative ERAs, both species were assigned a high-risk rating (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). This approach though may not have adequately accounted for false positives resulting from (*e.g.*) data deficiencies and the use of proxies (*pers. comm.* I. Jacobsen). These issues were reflected in key sections of the report including in the executive summary of the Southern Queensland East Coast Otter Trawl ERA (Jacobsen *et al.*, 2015) which stated: *“Of the ecological components included in this analysis, bycatch species and the species of conservation concern were arguably most affected by data deficiencies. This was most evident in those fishery impact profile characteristics relating to catch, interaction and mortality rates i.e. level of interaction and survival after interaction. All characteristics with low information were assigned more conservative scores (i.e. higher impact or*
Pale tropical skate	*Dipturus apricus*	37 031032	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				lower resilience) and consequently this study may have overestimated the risk from trawling for some species including elasmobranchs." And: *"… the use of proxies has the potential to mask interspecific differences and as a consequence increases the likelihood that a species complex will be over-represented in a particular risk category. The use of proxies may also extend the influence of more conservative risk assessments and/or estimates based on smaller sample sizes. This in itself provides a credible alternate hypothesis as to why stingarees (Family Urolophidae) and skates (Family Rajidae) were more prominent in the higher risk category* (p. 57)." Given their distribution in Queensland waters and their interaction potential, the quantitative SAFE ERA provides a better representation of the risk posed to this species. Research has shown that the SAFE method produces fewer false positives when compared to semi-qualitative ERA methods like the PSA. It also provides an absolute value of risk *versus* an indicative estimate (Hobday *et al.*, 2011; Zhou *et al.*, 2016). In the case of *D. melanospilus*, the SAFE ERA examined trawl-related risk across their known distributions (Kyne *et al.*, 2021) and concluded trawl fishing activities in southern Queensland posed a low risk to this species (Campbell *et al.*, 2017). Outside of the Queensland-based ERA, both species have been the subject of a regional extinction risk assessment (Kyne *et al.*, 2021). This assessment used the IUCN Red List criteria and classified both, *D. melanospilus* and *D. apricus* as species of *Least Concern.* This assessment determined that both species had no suspected or inferred population declines (Kyne *et al.*, 2021). It was also recognised that both species have

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				significant refuge at depth due to their preference for deeper water environments and broad depth profiles. In the case of *D. apricus*, trawling occurs at less than 1 per cent of its distribution and this species is most commonly found between 300 and 500 m (Campbell *et al.*, 2017). Overall, *D. melanospilus* and *D. apricus* were viewed as low priorities for reassessment and were not progressed as part of the ECOTF ERA update. When and where appropriate, both species will be considered for inclusion in subsequent ERAs. Any future assessments would benefit from additional information on interaction rates; particularly within the deepwater eastern king prawn sector. This is already being explored through the *Data Validation Plan* and the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017a; 2018a). For further information on the risk posed by trawl fishing in Queensland-managed waters refer to Campbell *et al.* (2017).
Family Urolophidae				
Common stingaree	*Trygonoptera testacea*	37 038006	**Y**	**Included**—The risk profile of the common stingaree (*Trygonoptera testacea*) and the yellowback stingaree (*Urolophus sufflavus*) shares several similarities. While the distribution of both species overlaps with the ECOTF, the extent of this overlap is limited to a small section of the south-east coast. This limits both their interaction potential and the probability that they will be caught by a subset of otter trawl operations. Available data indicates that *T. testacea* is a prominent component of the elasmobranch catch in southern Queensland. Reflecting the species preference for shallower water environments (0–135 m; Kyne *et al.*, 2021), *T. testacea* is more frequently observed in the shallow-water eastern king prawn sector (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a;
Yellowback stingaree	*Urolophus sufflavus*	37 038005	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Campbell *et al.*, 2018). While *U. sufflavus* has also been reported from the ECOTF, records for this species are mostly confined to deeper water environments *i.e.* the deepwater eastern king prawn sector (Courtney *et al.*, 2007a; Kyne *et al.*, 2007a). This again reflects the habitat preferences of the species with estimates placing its depth range of *U. sufflavus* from 45–320 m (Kyne *et al.*, 2021). *Trygonoptera testacea* was included in all three previous ecological risk assessments (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). While the northern extent of the known *T. testacea* distribution lies below the GBRMP, it was included in this assessment as a precautionary measure and in response to its capture in research trawls (*pers. obs.* I. Jacobsen; Jacobsen, 2007). *Urolophus sufflavus* was only included in assessments of trawl fishing activities in southern Queensland waters (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In the qualitative ERAs, *T. testacea* and *U. sufflavus* were assigned respective risk ratings of high and intermediate (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). This approach though may not have adequately accounted for false positives resulting from (*e.g.*) data deficiencies and the use of proxies. These issues were reflected in key sections including in the executive summary of the Southern Queensland East Coast Otter Trawl ERA (Jacobsen *et al.*, 2015) which stated: *"Of the ecological components included in this analysis, bycatch species and the species of conservation concern were arguably most affected by data deficiencies. This was most evident in those fishery impact profile characteristics relating to catch, interaction and mortality rates i.e. level of interaction and survival after interaction. All characteristics with low information were assigned more conservative scores (i.e. higher impact or*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				lower resilience) and consequently this study may have overestimated the risk from trawling for some species including elasmobranchs." And: *"… the use of proxies has the potential to mask interspecific differences and as a consequence increases the likelihood that a species complex will be over-represented in a particular risk category. The use of proxies may also extend the influence of more conservative risk assessments and/or estimates based on smaller sample sizes. This in itself provides a credible alternate hypothesis as to why stingarees (Family Urolophidae) and skates (Family Rajidae) were more prominent in the higher risk category* (p. 57)." Of significance, both *T. testacea* and *U. sufflavus* were included in a SAFE assessment examining the risk posed by trawl fishing activities in southern Queensland (Campbell *et al.,* 2017). Research has shown that the SAFE method produces fewer false positives when compared to semi-qualitative ERA methods like the PSA. It also provides an absolute value of risk *versus* an indicative estimate (Hobday *et al.*, 2011; Zhou *et al.*, 2016). In the case of *T. testacea* and *U. sufflavus*, the SAFE ERA covered their known distribution in Queensland (Kyne *et al.*, 2021) and incorporated new information on post-interaction mortalities for at least one of the species (*T. testacea*). The outputs of this assessment classified both species as being at a low risk; although *U. sufflavus* was assigned a precautionary medium-risk rating under a more conservative (precautionary) scenario (Campbell *et al.,* 2017). Assessments conducted after the qualitative ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015) support the hypothesis that outputs of these initial ERAs were false-positives or

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				risk overestimates. To this extent, the SAFE assessment compiled by Campbell *et al.* (2017) may provide a more accurate account of the risk posed by trawl fishing in Queensland. Subjecting the species to further assessment using the semi-quantitative PSA increases the probability of the ERA producing a false-positive result (Zhou *et al.*, 2016). There may, however, be some benefit in updating the risk profiles for both species. Updating the risk profiles of *T. testacea* and *U. sufflavus*, at the very least, will provide further context on how conservative the two previous qualitative ERAs were. Any future ERAs involving these species though will need to consider a) the probability that the output is a false-positive, b) how it relates to previous assessments and c) how data deficiencies will influence the final outcomes. While noting these caveats, the decision was made to include both species in the ECOTF ERA update. ***Note***—Both *T. testacea* and *U. sufflavus* were included in a broader regional extinction risk assessment (Kyne *et al.*, 2021). This assessment used the IUCN Red List criteria and classified *T. testacea* as *Near Threatened* in response to a suspected population decline approaching 30 per cent over the last three generations. *Urolophus sufflavus* was classified as *Vulnerable* in response to an inferred population reduction of >30 per cent over the last three generations (Kyne *et al.*, 2021). These population declines were reported from New South Wales and fishing activities in Queensland are viewed as contributors of risk *versus* the main driver of risk.
Kapala stingaree	*Urolophus kapalensis*	37 038018	**Y**	**Included**—The distribution and depth profile of the kapala stingaree (*Urolophus kapalensis*, 0–250 m) overlaps with the ECOTF in southern Queensland (Last *et al.*, 2016b; Kyne *et al.*, 2021). Within these areas, the species has been identified as one of

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				the more prominent components of the elasmobranch bycatch; particularly in shallow-water environments (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a). *Urolophus kapalensis* was included in a previous ERA involving the ECOTF was assigned a high-risk rating (Jacobsen *et al.*, 2015). However, caveats identified in the risk profiles of *T. testacea* and *U. sufflavus* (see above) would also apply to this species *e.g.* risk profile influenced by data deficiencies and/or the use of proxies, an increased potential for a false-positive result *etc*. When *U. kapalensis* was assessed using the quantitative SAFE method, the species was assigned a low-risk rating. This rating increased to precautionary high when assessed using a more conservative (precautionary) scenario that accounted for parameter estimate uncertainty (Campbell *et al.*, 2017). The last and most recent assessment involving *U. kapalensis*, was an evaluation of the regional extinction risk (Kyne *et al.*, 2021). This assessment used the IUCN Red List criteria and was undertaken as part of the *Action Plan for Australian Sharks and Rays.* This assessment classified *U. kapalensis* as a *Near Threatened* species with a suspected population reduction approaching 30 per cent over the last 3 generations (Kyne *et al.*, 2021). The capture of *U. kapalensis* as bycatch was also identified as a high-threat element. *Urolophus kapalensis* displays a preference for sandy substrates adjacent to reef-associated habitats (Bray, 2021f), increasing the likelihood of prawn trawl interactions. As a relatively small batoid (*maximum total length* = 52 cm: Kyne *et al.*, 2021), the use of a TED and BRD also yields limited benefits for this species. This inference is supported by research on elasmobranch catch compositions and TED effectiveness (Brewer *et al.*, 2006; Courtney *et al.*, 2007b; Kyne *et al.*, 2007a; Campbell *et al.*, 2020).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				The species is likely to remain a key component of elasmobranch bycatch in the ECOTF and further information is required on interaction rates and post-interaction mortalities. Going forward, *U. kapalensis* would benefit from additional assessment of the risk posed by trawl fishing across the entire ECOTF. An updated ERA based on a PSA (with a supporting Residual Risk Analysis) will provide insight into the sensitivity of the qualitative assessment and refine the risk profile of this species on the Queensland east coast. Any future assessment though will need to be cognisant of the potential for false-positive results and the influence of confounding factors *e.g.* data deficiencies.
Greenback stingaree	*Urolophus viridis*	37 038007	**Y**	**Included**—The Queensland distribution of the greenback stingaree (*Urolophus viridis*) is limited to the south-east coast and it displays a general symmetry with *U. sufflavus*. However, the broader distribution of *U. viridis* extends further south, incorporating areas of Victoria and Tasmania; *U. sufflavus* is only found in Queensland and New South Wales. Within Queensland, the distribution of both species (*U. viridis* and *U. sufflavus*) is more restricted when compared to *U. kapalensis* (Last *et al.*, 2016b; Kyne *et al.*, 2021). *Urolophus viridis* was included in two previous assessments examining trawl-related risks in Southern Queensland (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). Within these assessments, the species was assigned lower risk ratings; reflecting a comparatively low interaction potential. In the qualitative ERA, *U. viridis* was assigned an intermediate-risk rating (Jacobsen *et al.*, 2015). This was marginally higher than what was assigned in a quantitative SAFE assessment (low to precautionary medium risk; Campbell *et al.*, 2017). Interaction rates for this species will be lower than *T. testacea* and *U. kapalensis*. While difficult to quantify without further monitoring, it is anticipated that interaction rates for *U.*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				viridis will be equal to or lower than *U. sufflavus* (see above). While consideration was given to this species (comparatively) low interaction potential, *U. viridis* was included in the updated ECOTF ERA. The decision to consider *U. viridis* for inclusion in an updated ECOTF ERA is precautionary and future assessments will need to consider the potential for false-positive results. Under the ERA framework used in Queensland, this potential will be considered as part of the Residual Risk Analysis. For reference, *U. viridis* was assessed as *Vulnerable* in a regional evaluation of the extinction risk and with commercial bycatch identified as a threat (Kyne *et al*., 2021). The key drivers of risk for this species (*e.g.* inferred population reduction of >30 per cent) occur outside of Queensland waters. The ECOTF, at most, is viewed as a contributor of risk *versus* the main driver of risk.
Sandyback stingaree	*Urolophus bucculentus*	37 038001	**Y**	**Included**—The sandyback stingaree (*Urolophus bucculentus*) has a Queensland distribution and depth profile (65–274 m; Kyne *et al*., 2021) that overlaps with a limited proportion of the ECOTF. The Queensland distribution is restricted to the south-east coast, which limits the extent of interactions with the ECOTF and the probability that *U. bucculentus* will be caught in significant quantities across the entire fishery. When compared, the fishery is more likely to interact with species like *T. testacea* and *U. kapalensis.* Interactions with *U. bucculentus* are more likely in adjacent jurisdictions, namely New South Wales (Kyne *et al*., 2021). There is limited evidence that *U. bucculentus* has substantial interactions with south-east Queensland trawl operations. This lack of evidence can be partly attributed to the absence of a long-term mechanism to monitor catch compositions in the ECOTF. However, there are other factors that limit the encounterability potential of this species and (by extension) interaction rates. As noted, *U. bucculentus* has a very limited

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				distribution in Queensland waters. This distribution is further limited by the species preference for deeper water and continental shelf environments (Bray, 2018g). As these areas attract lower levels of effort and/or are not accessed by the ECOTF, a portion of the *U. bucculentus* population will be protected from trawl fishing activities. If and when *U. bucculentus* interacts with a trawl operation there is an increased probability that it will be caught and brought to the surface. As a relatively small batoid (*maximum size* = 89 cm TL; Kyne *et al.*, 2021), the use of a TED and BRD will provide limited benefits for this species. Once caught in the codend, there is an increased probability that it will be landed and discarded in a dead or moribund state (Stobutzki *et al.*, 2002; Jacobsen *et al.*, 2015). Without a mechanism to validate the catch of non-target species, it is difficult to ascertain the extent of these mortalities or its potential to impact regional populations. As *U. bucculentus* has a comparatively small overlap with the ECOTF, it is unlikely to be a key source of mortality for this species. *Urolophus bucculentus* has experienced historic population declines that have been attributed to commercial fishing activities. These declines contributed to the species receiving a rating of *Vulnerable* in the most recent *Action Plan for Australian Sharks and Rays* (Kyne *et al.*, 2021). These declines were reported from other jurisdictions (Kyne *et al.*, 2021) and fishing activities in these regions will be more instrumental in terms of the long-term sustainability risk. *Urolophus bucculentus* was included in both ERAs examining the risk posed by trawl fishing activities in southern Queensland (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In a qualitative assessment *U. bucculentus* was assigned a qualified rating of high risk. For example, Jacobsen *et al.* (2015) used *U. bucculentus* as a case study demonstrating the difficulties in developing risk profiles for data-poor species. The

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				premise being that data-poor species are more likely to be assigned conservative risk estimates and/or assigned precautionary ratings that may over-estimate the level of risk. This is directly reflected in the Southern Queensland ECOTF ERA which stated: *"….This result though was largely due to the aforementioned data deficiencies and the default approach of the ERA to assign more conservative estimates to parameters with limited or no information (Table 3.8). In reality, the risk to U. bucculentus due to trawl fishing activities in southern Queensland would be well below that reported in the current study."* (Jacobsen *et al.*, 2015)." Research has demonstrated that the SAFE ERA method produces fewer false positives when compared to semi-quantitative methods like the PSA (Zhou *et al.*, 2016). In Campbell *et al.* (2017), where risk was evaluated using SAFE, *U. bucculentus* was classified as being at medium risk from trawl fishing activities in southern Queensland. This rating increased to a precautionary extreme-high risk under a more conservative assessment scenario which factored in parameter estimate uncertainty (Campbell *et al.*, 2017). While noting the low interaction potential, *U. bucculentus* will benefit from additional assessment. Reassessing risk using the PSA will, at the very least, provide further context of the outputs of the previous qualitative ERA. It will also allow for further comparisons to be made between SAFE and the PSA. The challenge with any future assessment being how best to address intra-fishery risk variability and the potential for a false-positive result. Accordingly, any future assessment will need to consider a) the distribution of the species being assessed, b) the management regions that the species

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				will interact with and c) the potential for false-positive results. In the ECOTF SOCC ERA, these factors will primarily be addressed as part of the Residual Risk Analysis.
Patchwork stingaree	*Urolophus flavomosaicus*	37 038010	**Y**	**Included**—The east coast distribution of the patchwork stingaree (*Urolophus flavomosaicus*) is confined to Queensland and overlaps with sections of the ECOTF. However, the depth profile for *U. flavomosaicus* extends into deeper water environments (60–320 m) and a portion of the population will be protected from trawl fishing activities (Kyne *et al.*, 2021). In the ECOTF, *U. flavomosaicus* has only been reported from the eastern king prawn sector (Courtney *et al.*, 2007b; Pears *et al.*, 2012b; Kyne *et al.*, 2021). When this species is caught in the sweep of the net, the use of a TED will provide little benefit as the species reaches around 32 cm TL, 59 cm DW and matures at around 38 cm TL (Last *et al.*, 2016b; Kyne *et al.*, 2019c; Kyne *et al.*, 2021). At present, there is limited information on the extent of these interactions or the fate of the animals caught as bycatch in the ECOTF. *Urolophus flavomosaicus* was included in all three previous ECOTF ERAs. In the two qualitative assessments, *U. flavomosaicus* was assigned risk ratings of intermediate (Jacobsen *et al.*, 2015) and high (Pears *et al.*, 2012b). These risk profiles were subject to the same caveats outlined for other stingarees (see *T. testacea* and *U. sufflavus*). These caveats include the need to account for data deficiencies, the use of proxies, the production of more conservative risk ratings and difficulties addressing false positives within the methodological framework (refer p. 57 of Jacobsen *et al.*, 2015). In a more recent assessment using the SAFE method, *U. flavomosaicus* was assigned a medium-risk rating using the base-case scenario. This rating increased to precautionary

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				extreme high under a more conservative (precautionary) scenario that accounted for parameter estimate uncertainty (Campbell *et al.*, 2017). SAFE is a quantitative ERA methodology and provides a more accurate assessment of the risk posed by trawl fishing activities in southern Queensland. This study though did not cover the entire distribution of *U. flavomosaicus* and risk levels outside southern Queensland requires further investigations. An updated ERA based on a PSA (with supporting Residual Risk Analysis) would provide further insight into the risk posed by trawl fishing across the known distribution of *U. flavomosaicus* in Queensland-managed waters. It would also provide insight into how sensitive the two previous qualitative ERAs were to data deficiencies (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). For these reasons, *U. flavomosaicus* was progressed and included in the ECOTF ERA update. The decision to include this species is precautionary and future assessments will need to be cognisant of the potential for false-positive results and the influence of confounding factors *e.g.* data deficiencies.
Family Gymnuridae				
Australian butterfly ray	*Gymnura australis*	37 037001	**Y**	**Included**—The Australian butterfly ray (*Gymnura australis*) has a distribution and depth profile (0–250 m; Kyne *et al.,* 2021) that overlaps with a significant proportion of the ECOTF. While the species was included in all three ERAs, previous results show considerable variability. In the two qualitative assessments *G. australis* was assessed as high risk (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). Key factors that contributed to *G. australis* receiving a higher risk rating included higher interaction rates, lower TED effectiveness (*i.e.* increased capture potential) and a higher probability of post-capture mortalities. While

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				noting this assessment and the criteria used, the risk rating assigned to *G. australis* as part of the quantitative/semi-quantitative assessment is precautionary (*pers. comm.* I. Jacobsen). Further, this rating does not reflect the current (low) level of concern surrounding the long-term sustainability or conservation status of regional populations (Jacobsen & White, 2015; Kyne *et al.*, 2021). In the quantitative SAFE assessment, *G. australis* was assessed as being at a low risk from trawl fishing activities in southern Queensland (Campbell *et al.,* 2017). This assessment method produces fewer false positives and may provide a better indication of the risk posed by the ECOTF. This assessment though only covers a portion of the *G. australis* distribution in Queensland waters (Jacobsen, 2007; Jacobsen & Bennett, 2009; Last *et al.*, 2016b). *Gymnura australis* is caught as bycatch in the ECOTF and it inhabits environments that are readily accessed by prawn trawl operations. The species also displays feeding/predator avoidance strategies which increases the likelihood that it will be caught if located in the sweep of the net *i.e.* ambush predator, avoids detection from predators by burying itself in sandy substrate (Jacobsen & Bennett, 2009; Jacobsen *et al.*, 2009; Jacobsen & White, 2015). Once caught, there is an increased probability that both immature and mature rays will be caught in the codend of the net. The main reason for this is that *G. australis* has a (comparatively) shallow body depth which allows a wide range of size classes to pass through the bars of a TED (*pers. comm.* I. Jacobsen; Jacobsen & Bennett, 2009). *Gymnura australis* will benefit from additional assessment of the risk posed by trawl fishing across the entire ECOTF. An updated ERA based on a PSA (with a supporting Residual Risk Analysis) will also provide insight into the sensitivity of the two previous

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				qualitative assessments (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). For these reasons, *G. australis* was included in the ECOTF ERA update.
Family Hypnidae				
Coffin ray	*Hypnos monopterygius*	37 028001	**N**	**Not included**—The distribution of the coffin ray (*Hypnos monopterygius*) is confined to southern Queensland waters and it is more likely to be encountered in the eastern king prawn fishery and in New South Wales fisheries. *Hypnos monopterygius* interactions are less likely in central Queensland and highly unlikely in northern Queensland. Proportionately, *H. monopterygius* interactions will be at the lower end of the spectrum in terms of number and frequency. This is of relevance in the GBRMP where interactions with this species would be rarer. Similarly, interaction rates for *H. monopterygius* will be lower when compared to other species being considered for inclusion in an updated ECOTF ERA, namely shovelnose rays, stingarees and maskrays (*Neotrygon spp*.). *Hypnos monopterygius* was included in the two qualitative ERAs. The inclusion of the species in the GBRMP trawl ERA was due to the study employing a less-selective species rationalisation *i.e.* "*those sharks and rays that occur within the Great Barrier Reef Region in habitats that at least partially overlap with area trawled by the ECOTF and are considered to have some interaction with the fishery*" (p92; Pears *et al.*, 2012b). As the ECOTF has the potential to interact with this species in the southern reaches of the GBRMP, *H. monopterygius* was included in this assessment as a precautionary measure. The high-risk rating for this species though is considered a false-positive result and is not reflective of the risk posed to this species in central and northern Queensland (*pers. comm.* I. Jacobsen).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				When the complementary assessment was compiled for trawl fishing activities in southern Queensland (Jacobsen *et al.*, 2015), *H. monopterygius* was retained. The species is more likely to be encountered in this region (albeit at low levels) and its inclusion in the Southern Queensland ECOTF ERA allowed for further assessment and the inclusion of additional information. These additions resulted in the species receiving an intermediate-risk rating *versus* a high-risk rating in the GBRMP ERA (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). These results also support the notion that the risk rating assigned to *H. monopterygius* in the GBRMP ERA was a false-positive result. Information published since the release of the two ERAs provide further support that the qualitative ERAs are precautionary. *Hypnos monopterygius* has now been assessed using the quantitative SAFE and was determined to be at low risk from trawl fishing activities in southern Queensland (Campbell *et al.,* 2017). The SAFE method provides an absolute measure of risk and it arguably provides a better representation of the risk posed to regional *H. monopterygius* populations. This inference is supported by the *Action Plan for Australian Sharks and Rays* which lists the species as *Least Concern* with no inferred, suspected or continuing population declines (Kyne *et al.,* 2021). Assessments conducted after the qualitative ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015) indicate that *H. monopterygius* is a hardy species, has good post-interaction survival rates (Kyne *et al.,* 2021) and is at low risk from the ECOTF (Campbell *et al.,* 2017). Given this, *H. monopterygius* is considered a low reassessment priority and was not progressed as part of the ECOTF ERA update.
Family Torpedinidae				

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Short-tail torpedo ray	*Tetronarce nobiliana* (synonym: *Torpedo macneilli*)	37 028003	**N**	**Not included**—While the distribution of the short-tail torpedo ray (*Tetronarce nobiliana*) covers a large expanse of the Queensland coastline (Last *et al*., 2016b; Kyne *et al*., 2021), there is little evidence that it is caught as bycatch in the ECOTF (Jacobsen, 2007; Kyne *et al*., 2007a; Pears *et al*., 2012b; Courtney *et al*., 2014; Jacobsen *et al*., 2015). It is recognised that this absence of reports may reflect the fact that the fishery operates without an effective mechanism to monitor catch rates in real or near-real time. However, the species also inhabits environments that are less conducive to trawl fishing and/or are not accessed with great regularity by the current fleet. For example, *T. nobiliana* is found in waters down to 925 m (Kyne *et al.,* 2021) and is often associated with stony, sandy or muddy areas on the continental shelf and slope, often near reefs (Bray, 2022c). *Tetronarce nobiliana* was included in the qualitative ERA examining the risk posed by trawl fishing activities to key species in southern Queensland (Jacobsen *et al*., 2015). This study determined that trawl fishing activities (beam and otter trawl) posed a low to intermediate risk to this species (Jacobsen *et al*., 2015). The species was not assessed in the preceding GBRMP trawl ERA (Pears *et al*., 2012b) or a subsequent SAFE ERA; reflecting its status as a low assessment priority. For reference, a regional assessment of the extinction risk classified *T. nobiliana* as a species of *Least Concern* with no discernible (inferred, suspected or ongoing) population declines (Kyne *et al.,* 2021). This assessment used criteria applied in IUCN Red List assessments and did not detect a discernible (inferred, suspected or ongoing) decline in regional populations. Their capture as bycatch in commercial fisheries was classified as a moderate threat, namely within the *Southern and Eastern Scalefish and Shark Fishery* (Kyne *et al.,* 2021). These fisheries operate outside of Queensland-managed waters.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Given the low interaction potential and lack of evidence that *T. nobiliana* interacts with the ECOTF, the species was not progressed as part of the ECOTF ERA update.
Family Rhinopteridae				
Australian cownose ray	*Rhinoptera neglecta*	37 040001	**N**	**Not included**—The Australian cownose ray (*Rhinoptera neglecta*) is a medium to large sized batoid. *Rhinoptera neglecta* is born at around 31 cm DW and estimates place the *maximum size* at ~130–140 cm DW (Last *et al.*, 2016b; Kyne *et al.*, 2021). While maturity data is still required, the onset of sexual maturity is expected to occur at sizes <100 cm DW (Chan *et al.*, 2022). *Rhinoptera neglecta* was considered for inclusion in an updated ERA as it has a distribution and depth profile (0–50 m) that overlaps with the ECOTF (Kyne *et al.*, 2021). Within these areas, the species will likely encounter trawl fishing activities and may be caught as bycatch; particularly in shallow waters (*pers. obs.* I. Jacobsen; Courtney *et al.*, 2007b). A review of the available data indicates that *R. neglecta* is a lower assessment priority for the ECOTF. While the species may interact with trawl operations, these interactions will be low in number and have an increased probability of ending in a contact without capture event (Brewer *et al.*, 2006; Campbell *et al.*, 2020). As cownose rays (*Family Rhinopteridae*) are benthopelagic (Last *et al.*, 2016b), they will be encountered with less frequency in the trawl fishery; particularly when compared to benthic batoid and shark species.
Family Aetobatidae				

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Spotted eagle ray	*Aetobatus ocellatus*	37 039003	**N**	**Not included**—The spotted eagle ray (*Aetobatus ocellatus*) has historically been considered and assessed as a member of the *Family Myliobatidae*. This situation has changed with a taxonomic review subdividing this complex into eagle rays (*Family Myliobatidae*) and pelagic eagle rays (*Family Aetobatidae*); *A. ocellatus* being a member of the latter (Last *et al.*, 2016b). *Aetobatus ocellatus* is a larger batoid and attains at least 300 cm DW. While further information is required on the age and growth of *A. ocellatus*, males mature at around 100–130 cm DW and females around 150–160 cm DW (Last *et al.*, 2016b; Kyne *et al.*, 2021). *Aetobatus ocellatus* inhabits relatively shallow environments (0–40 m) and previous bycatch reports for *Aetobatus narinari* are likely to be this species (*pers. comm.* I. Jacobsen). A review of the available data indicates that *A. ocellatus* will interact with the ECOTF. These interactions though will be (comparatively) infrequent and low in number. Most, if not all, mature animals will be able to escape from the net (Brewer *et al.*, 2006; Campbell *et al.*, 2020) and there is limited evidence that their capture as bycatch poses a significant threat in Australian waters (Kyne *et al.*, 2021). *Aetobatus ocellatus* was viewed as a low priority for reassessment and was not progressed as part of the ECOTF ERA update.
Family Myliobatidae				
Southern eagle ray	*Myliobatis tenuicaudatus*	37 039001	**N**	**Not included**—In Queensland, interactions with the southern eagle ray (*Myliobatis tenuicaudatus*) will be limited to a small section of the south-east coast. This small level of overlap limits the extent of the interactions with the ECOTF and the probability that the species will be caught across the entire fishery. When compared, interactions with

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
	(synonym: *M. australis*)			*M. tenuicaudatus* are more likely to occur in adjacent jurisdictions, namely New South Wales (Kyne *et al.,* 2021). Of significance, *M. tenuicaudatus* was not included in the three previous ECOTF ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017) and has not been reported as bycatch in the ECOTF (Courtney *et al.*, 2007a; Kyne *et al.*, 2007a). While this species has a broad depth profile and can be found between 0–420 m (Kyne *et al.*, 2021), it is more commonly found in shallow environments within 50 m of the surface (Bray, 2022b). Therefore, while interactions with this species are possible, the extent of these interactions are not expected to pose a long-term or significant conservation risk. This inference is supported by the *Action Plan for Australian Sharks and Rays* which classified *M. tenuicaudatus* as a species of *Least Concern* (Kyne *et al.*, 2021). This action plan assessed the regional extinction risks for sharks and rays inhabiting Australian waters. Due to the above considerations, *M. tenuicaudatus* was classified as a low priority for reassessment and was not progressed as part of the ECOTF ERA update.
Banded eagle ray	*Aetomylaeus caeruleofasciatus*	37 039002	**N**	**Not included**—Three members of the *Family Myliobatidae* (eagle rays) were considered for inclusion in an updated ECOTF ERA. The distribution and depth profiles of the listed species overlaps with the ECOTF and they are likely to encounter trawl fishing activities on the Queensland east coast. Of the three, the ornate eagle ray (*Aetomylaeus vespertilio*) has the smallest overlap with the ECOTF and lowest interaction potential. Similarly, the depth profile of the purple eagle ray (*Myliobatis hamlyni*) would afford regional populations with a degree of protection from trawl fishing activities (Kyne *et al.*, 2021; Bray, 2022a).
Ornate eagle ray	*Aetomylaeus vespertilio*	37 039005	**N**	
Purple eagle ray	*Myliobatis hamlyni*	37 039004	**N**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				The *Myliobatidae* family displays considerable interspecific variability in terms of their growth and development. The group, as a whole, will derive some benefit from the use of a TED with contact without capture events considered the most likely outcome for most subadult and mature rays (Brewer *et al.*, 2006; Campbell *et al.*, 2020). However, the available data suggests that smaller cohorts may still be caught in the codend of a prawn trawl net (*pers. obs*. I. Jacobsen; Courtney *et al.*, 2007b). The following provides an overview of the key dynamics for the three listed species. - The banded eagle ray (*A. caeruleofasciatus*): *maximum size* = 59 cm DW, size at birth = 19–22 cm DW, *size at maturity* = >40 cm DW (Last *et al.*, 2016b). Inhabits regions with soft substrates, found in inshore and continental shelf waters down to 117 m depth (Bray, 2020a; Kyne *et al.*, 2021). - *A. vespertilio*: *maximum size* = 300 cm DW, size at birth = unknown, *size at maturity* (males) = >170 cm DW (Last *et al.*, 2016b). Inhabits bays, sandy areas and coral reef to depth of 100 m. Species is rarely observed and may be naturally uncommon (Bray, 2020b). - *Myliobatis hamlyni*: *maximum size* = at least 114 cm DW, size at birth = <27 cm DW, *size at maturity* (males) = ~65 cm DW (Last *et al.*, 2016b). Inhabits the outer continental shelf and upper continental depths from 117–350 m (Kyne *et al.*, 2021; Bray, 2022a). While smaller myliobatoids may be caught in the ECOTF, they will be encountered with less frequency when compared to other benthic batoids. The *Family Myliobatidae* are classified as demersal and semi-pelagic species and the complex are less likely to be caught in the sweep of a trawl net. This reduces the encounterability potential and, by extension, interaction rates.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				When the above factors are taken into consideration, *A. caeruleofasciatus*, *A. vespertilio* and *M. hamlyni* were viewed as lower assessment priorities for the ECOTF. When and where appropriate, these species will be considered for inclusion in subsequent ERAs *e.g.* if data indicates that interaction rates are higher than anticipated. The decision to omit *A. caeruleofasciatus*, *A. vespertilio* and *M. hamlyni* from the assessment, aligns with previous assessments. Only one of these assessments included an eagle ray, which was assigned a low-intermediate risk rating (Jacobsen *et al.*, 2015). ***Additional consultation***—Additional consultation on the scope and extent of the ECOTF SOCC ERA indicated that species *M. hamlyni* should be considered for inclusion. After further consideration, the decision was made to omit this species from the current ECOTF update. When and where appropriate, the species will be considered for inclusion in subsequent risk assessments involving this fishery.
Family Rhinidae				
Bottlenose wedgefish	*Rhynchobatus australiae*	37 026005	**Y**	**Included**—Risk profiles for the bottlenose wedgefish (*Rhynchobatus australiae*) and the eyebrow wedgefish (*R. palpebratus*), display a degree of complexity not observed in smaller batoids. The distribution of both species overlaps with extensive areas of the ECOTF and they are found at water depths fished by trawl operations (0–10 m; Kyne *et al.*, 2021). *Rhynchobatus australiae* occurs along the entire Queensland coastline and will be exposed to a broader expanse of trawl fishing activities. *Rhynchobatus palpebratus* is primarily found in waters off of central and northern Queensland (Last *et al.*, 2016b; Kyne *et al.*, 2021). Historically, *R. australiae* and *R. palpebratus* were considered conspecific with the giant guitarfish (*R. djiddensis*). *Rhynchobatus djiddensis* is now
Eyebrow wedgefish	*Rhynchobatus palpebratus*	37 026004	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				considered a Western Indian Ocean species (Kyne *et al.*, 2019b) and any historic records of this species will be *R. palpebratus* or *R. australiae*. Evidence suggests that at least one of the species, *R. australiae*, will interact with the ECOTF and be caught as bycatch. These reports cover a number of the ECOTF sub fisheries including operations targeting banana prawns, scallops and tiger and endeavour prawns (Courtney *et al.*, 2007b). While it has yet to be recorded from the ECOTF, it is reasonable to assume that some of the historic *Rhynchobatus* records will include *R. palpebratus*. When *R. australiae* and *R. palpebratus* interact with a trawl net, the outcome of the interaction will be dependent on the size of the animal. Both species are comparatively large, with *R. australiae* reaching ~300 cm TL and maturing at or around 120 cm TL (Last *et al.*, 2016b; Bray, 2017b; Kyne *et al.*, 2021). *Rhynchobatus palpebratus* is marginally smaller, with adults reaching at least 262 cm TL and maturing at or around 103 cm TL (Last *et al.*, 2016b; Bray, 2017c; Kyne *et al.*, 2021). For large, mature rays, the TED will be highly effective in terms of excluding them from the catch / preventing the ray from entering the codend of the net (Brewer *et al.*, 2006; Campbell *et al.*, 2020). The effectiveness of the TED will be more variable for subadults and smaller, immature rays. In smaller shovelnose ray species like *A. rostrata*, their flattened morphology may still allow larger rays to pass through the TED and into the codend of the net (*e.g.* subadults, mature *A. rostrata*). While this may still occur for *R. australiae* and *R. palpebratus*, the frequency of these events may be more limited due to their general morphology. Members of the *Family Rhinidae* have shark-like bodies and a broader, more robust head, trunk and dorsal fin region. While difficult to quantify, this type of morphology

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				would assist in terms of preventing larger juveniles and subadults from entering the codend of the net. For reference, *R. australiae* and *R. palpebratus* are born at around 40–50 cm TL (White *et al.*, 2014; Kyne & Rigby, 2019; Kyne *et al.*, 2019e) and TED bar spacings are currently set at 12 cm (State of Queensland, 2019). On review of the available data, it was determined that both *R. australiae* and *R. palpebratus* should be included in the updated ECOTF ERA. The two were previously assessed as a complex in the qualitative ERA (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015) and *R. australiae* was included in the quantitative ERA (Courtney *et al.*, 2014). These assessments classified trawl fishing as a low to low-intermediate risk. In the updated ECOTF ERA, separate risk profiles will be compiled for *R. australiae* and *R. palpebratus*. This will provide further insight into the risk posed by trawl fishing across the entire ECOTF and the extent of any inter-specific variability. The inclusion of these species in an updated ECOTF ERA is viewed as precautionary.
Shark ray	*Rhina ancylostoma*	37 026002	**N**	**Not included**—The shark ray (*Rhina ancylostoma*) is the third *Rhinidae* species that was considered for inclusion in an updated ECOTF ERA. The distribution of *R. ancylostoma* overlaps with a considerable portion of the ECOTF and it may encounter trawl fishing activities in shallow water (0–70 m) environments. The species though is not frequently recorded as bycatch in the ECOTF, and it was not assessed as part of the three previous ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). This absence of reports was attributed to *R. ancylostoma* being a rarely encountered species (Kyne *et al.*, 2021) and their morphology which increases the probability of an interaction ending in a contact without capture event. For instance, *R. ancylostoma* is a robust batoid with a shark-like body and has a prominent head/trunk region with distinct bony ridges (Last *et al.*, 2016b; Bray, 2020i). These traits would help to minimise the

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				number of rays that passed through the bars of the TED and into the codend of the net (Brewer *et al.*, 2006; Campbell *et al.*, 2020). The available information indicates that *R. ancylostoma* is a lower assessment priority when compared to *R. australiae* and *R. palpebratus*. This species was not progressed to the ECOTF ERA update.
Family Glaucostegidae				
Giant guitarfish (synonym: Giant shovelnose ray)	*Glaucostegus typus* (synonym: *Rhinobatos typus*)	37 027010	**Y**	**Included**—The Queensland distribution of the giant guitarfish (*Glaucostegus typus*) overlaps with the ECOTF and it inhabits areas where it would be exposed to trawl fishing activities *e.g.* feeds on sandy substrates and inshore waters down to 100 m (Kyne *et al.*, 2019d; Kyne *et al.*, 2021; Bray, 2022c). However, *G. typus* is a larger shovelnose ray reaching at least 270 cm TL and maturing at >150 cm TL (Last *et al.*, 2016b; Kyne *et al.*, 2019d). At this size, the TED would be highly effective in terms of excluding the majority of sub-adult and mature *G. typus* from the catch (Brewer *et al.*, 2006; Campbell *et al.*, 2020). As the species is born at around 40 cm TL (Last *et al.*, 2016b), there is an increased probability that smaller *G. typus* will be retained in the codend of a trawl net. This inference is supported by data showing that small shovelnose rays pass through a TED bar spacing with increased regularity (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a; Courtney *et al.*, 2014; Campbell *et al.*, 2017). Of significance, *G. typus* was included in two previous assessments examining trawl-related risks in Southern Queensland (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In these assessments *G. typus* was classified as a low-intermediate risk in the qualitative ERA within Southern Queensland (Jacobsen *et al.*, 2015) and as a low risk under SAFE (Campbell *et al.,* 2017). In a more recent evaluation of the regional extinction risk, *G.*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				typus was classified as a species of *Least Concern* with no discernible (inferred, suspected or ongoing) population declines (Kyne *et al.,* 2021). This assessment considered the capture of *G. typus* as commercial bycatch to be a low-risk element (Kyne *et al.,* 2021). It is likely that *G. typus* interacts with and is caught as bycatch in the ECOTF. The extent of these capture events will (likely) be confined to small, immature rays with larger rays excluded through the TED opening. While noting these factors, *G. typus* was included in the updated ECOTF ERA. The updated assessment will examine trawl-related risks across the entire ECOTF including areas not covered by the two southern Queensland trawl ERAs*. Glaucostegus typus* was included in the ECOTF ERA update as a precautionary measure.
Family Trygonorrhinidae				
Eastern shovelnose ray	*Aptychotrema rostrata*	37 027009	**Y**	**Included**—Habitats and water depths (0–220 m) preferred by the eastern shovelnose ray (*Aptychotrema rostrata*) overlap with trawl fishing activities on the Queensland east coast. *Aptychotrema rostrata* is a known component of the ECOTF bycatch and available research suggests that its incidental capture poses a higher threat to regional populations (Courtney *et al.*, 2007b; Kyne *et al.*, 2007a; Kyne *et al.*, 2021). In Queensland, the species was assigned a high-risk rating in the two qualitative ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). However, the species received a low-risk rating when assessed using the quantitative SAFE method (Campbell *et al.,* 2017). Further, *A. rostrata* was classified as a species of *Least Concern* in the *Australian Action Plan of Sharks and Rays* with no discernible (inferred, suspected or ongoing) population

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				declines (Kyne *et al.,* 2021). This action plan, examined the regional extinction risk and was based on criteria used for IUCN Red List assessments (Kyne *et al.,* 2021). As *A. rostrata* remains a key component of the ECOTF elasmobranch bycatch, there are inherent benefits in updating the risk profile of this species. As the updated ERA will consider fishing activities across the entire ECOTF, there should be further scope to examine the risk posed at a whole-of-fishery level. This assessment will need to take into consideration the (relative) effectiveness of BRDs (Courtney *et al.,* 2007b) and new information on post-interaction survival rates (Campbell *et al.,* 2018).
Eastern fiddler ray	*Trygonorrhina fasciata*	37 027006	**N**	**Not included**—In Queensland, interactions with the eastern fiddler ray (*Trygonorrhina fasciata*) will be limited to a small section of the south-east coast. This small level of overlap limits the extent of interactions with the ECOTF and the probability that the species will be caught across the entire fishery. When compared, interactions with *T. fasciata* are more likely to occur in adjacent jurisdictions, namely New South Wales (Kyne *et al.,* 2021). Of significance, *T. fasciata* was included in a SAFE assessment examining the risk posed by trawl fishing activities to key species in southern Queensland (Campbell *et al.,* 2017). This study considered fishing activities across the known Queensland distribution of *T. fasciata* and determined that it was at low risk (Campbell *et al.,* 2017). Subsequent assessments of the regional extinction risk also classified *T. fasciata* as a species of *Least Concern* with no discernible (inferred, suspected or ongoing) population declines (Kyne *et al.,* 2021). While this assessment considered the capture of *T. fasciata* to be a high-risk element, this primarily related to commonwealth-managed fisheries *i.e.* the *Southern and Eastern Scalefish and Shark Fishery* (Kyne *et al.,* 2021).

<table>
<tr><th colspan="5">ECOTF—T1, T2, M1 and M2 Fishery symbols</th></tr>
<tr><th>Common name</th><th>Species name</th><th>CAAB</th><th>Include</th><th>Justifications and Considerations</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Due to the above considerations, T. fasciata was classified as a low priority for reassessment and was not progressed as part of the ECOTF ERA update. For further information on the risk posed by trawl fishing in Queensland-managed waters refer to Campbell et al. (2017).</td></tr>
<tr><td colspan="5">Family Dasyatidae</td></tr>
<tr><td>Bluespotted maskray</td><td>Neotrygon australiae</td><td>37 035004</td><td>N</td><td rowspan="3">Not included—The bluespotted maskray (Neotrygon australiae).

Included—The coral sea maskray (N. trigonoides) and speckled maskray (N. picta).

Historic maskray records for Queensland include three or four different species Neotrygon leylandi, N. annotata, N. picta and N. kuhlii. However, the broader maskray complex (Neotrygon spp.) has been reviewed and these historic records will not reflect the current classifications (Last et al., 2016a).

While the review was more complicated, the implications for Queensland are as follows:

- Historical records of N. leylandi in the Gulf of Carpentaria and on the Queensland east coast should be classified as N. picta. The N. leylandi distribution is now restricted to Western Australia.

- Historical records of N. kuhlii in the Gulf of Carpentaria and the northern-most waters of far north Queensland should be classified as N. australiae.

- Historical records of N. kuhlii on the Queensland east coast (exc. northern-most waters) should be classified as N. trigonoides.</td></tr>
<tr><td>Coral sea maskray</td><td>Neotrygon trigonoides</td><td>37 035031</td><td>Y</td></tr>
<tr><td>Speckled maskray</td><td>Neotrygon picta</td><td>37 035029</td><td>Y</td></tr>
</table>

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				- The known distribution of *N. kuhlii* is now confined to a small region of the South Pacific. This species is not believed to be found in Australian waters. In the ECOTF, the majority of maskray bycatch records will be *N. picta* or *N. trigonoides* (Courtney *et al.*, 2007b; Jacobsen, 2007; Kyne *et al.*, 2007a). Current estimates indicate that *N. australiae* only inhabits a small section of the Queensland east coast where there are limited reports of trawl effort *i.e.* the northern most waters (Last *et al.,* 2016b). Interactions with *N. australiae* are less likely in the ECOTF. *Neotrygon picta* and *N. trigonoides* are small benthic batoids that will interact with the ECOTF in larger numbers / increased frequency. As smaller benthic batoids, they would derive limited use of a TED and BRD (Brewer *et al.*, 2006; Campbell *et al.*, 2020). While these species (or their synonyms) have been assessed previously, there is a sufficient case to include *N. trigonoides* and *N. picta* in an updated ECOTF ERA. *Neotrygon australiae* was not progressed as part of the ECOTF ERA update as it has a more restricted distribution on the Queensland east coast (Last *et al.*, 2016b; Kyne *et al.*, 2021). The remaining *Neotrygon species* (*e.g. N. annotata, N. kuhlii, N. ningalooensis* and *N. leylandi*) do not occur in waters fished by operators in the ECOTF.
Brown stingray	*Bathytoshia lata* (synonym: *Dasyatis thetidis*)	37 035002	**N**	**Not included**—The brown stingray (*Bathytoshia lata*) has a broad vertical distribution, inhabiting water depths from 0–800 m (Kyne *et al.*, 2021). While habitats and water depths preferred by *B. lata* overlaps with a wide cross section of the ECOTF, interactions with this species are more likely to occur in shallower depths. If and when *B. lata* encounters a trawl operation, a high percentage will end in a contact without capture event. *Bathytoshia lata* is a large stingray, attaining at least 400 cm TL, 260 cm DW and 200 kg (Last *et al.*, 2016b; Bray, 2018c; Kyne *et al.*, 2021). While further information is required on the biology of this species, *B. lata* pups are born at

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				around 35 cm DW and *size at maturity* is estimated to be at or around 100 and 110 cm DW for males and females respectively (Last *et al.*, 2016b). At this size, the use of a TED will be highly effective at excluding most subadult and mature specimens (Brewer *et al.*, 2006; Campbell *et al.*, 2020). While very large animals may still be caught in the net (*i.e.* are too large to be excluded from the opening), the frequency of these events are expected to be low. *Bathytoshia lata* was included in two previous ERAs examining the risk posed by trawl fishing activities in southern Queensland (Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). In the qualitative analysis (identified by the junior synonym *Dasyatis thetidis* (Jacobsen *et al.*, 2015; Bray, 2018c), the species was assigned a low-intermediate risk rating. Factors that contributed to this rating included the size of mature rays, high TED effectiveness and an increased probability that the animal will experience a contact without capture event. In the quantitative SAFE ERA, *B. lata* was assigned a marginally higher rating of medium, increasing to precautionary high under a more conservative assessment scenario (Campbell *et al.*, 2017). This study notes though that data deficiencies, namely on escapement and post-trawl survival rates, exerted some influence on the final risk rating (Campbell *et al.*, 2017). Obtaining data on these two parameters is inherently difficult as it requires assessment of contact without capture events and monitoring of the health of the animal after the event has taken place. A weight-of-evidence approach indicates that *B. lata* is a lower assessment priority for the ECOTF. While the species may interact with the trawl fishery, research indicates that the use of a TED reduces the capture of large rays (>1 m) by over 90 per cent (Brewer *et al.*, 2006). As noted in Campbell *et al.* (2017), the species would benefit from

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				additional data on how it interacts with the trawl fishery, the frequency of these interactions and the outcome of the interaction. Some of the deficiencies are now being addressed through the *Data Validation Plan* and the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017a; 2018a). Depending on the outputs of these programs, *B. lata* will be considered for inclusion in subsequent ERAs involving the ECOTF. For further information on the risk posed by trawl fishing in Queensland-managed waters refer to Campbell *et al.* (2017) and Jacobsen *et al.* (2015). ***Additional consultation***—Additional consultation on the scope and extent of the SOCC ERA indicated that species *B. lata* should be considered for inclusion. After further consideration, the decision was made to omit this species from the current ECOTF update. When and where appropriate, the species will be considered for inclusion in subsequent risk assessments involving this fishery.
Smooth stingray	*Bathytoshia brevicaudata* (synonym: *Dasyatis brevicaudata*)	37 035001	**N**	**Not included**—While the Queensland distribution of the smooth stingray (*Bathytoshia brevicaudata*) overlaps with the ECOTF, several factors reduce the interaction potential for this species. In Queensland, interactions with *B. brevicaudata* will be limited to trawl fishers operating between the New South Wales border and the southern reaches of the GBRMP (Kyne *et al.,* 2021). The species is commonly found in silty or sandy areas of harbours, in shallow coastal bays, estuaries, large inlets, coastal reefs and offshore islands (Bray, 2021a). While not universal, these areas are (typically) less conducive to trawl fishing activities. *Bathytoshia brevicaudata* is an extremely large batoid with size at birth estimated at >30cm DW and *maximum size* reaching ~210 cm DW (Last *et al.*, 2016b; Bray, 2021a; Kyne *et al.*, 2021; Rigby *et al.*, 2021). At this size, the TED would be highly effective in

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				terms of excluding immature and mature *B. brevicaudata* from the trawl catch (Brewer *et al.*, 2006; Campbell *et al.*, 2020). *Bathytoshia brevicaudata* was assessed as a low-intermediate risk in the qualitative Southern Queensland ECOTF ERA (Jacobsen *et al.*, 2015). The species was also included in a quantitative SAFE assessment examining the risk posed by trawl fishing activities in southern Queensland (Campbell *et al.,* 2017). This study considered fishing activities across southern Queensland and determined that *B. brevicaudata* was at low risk from trawl fishing activities within this area (Campbell *et al.,* 2017). A subsequent assessment of the regional extinction risk classified *B. brevicaudata* as a species of *Least Concern* with no discernible (inferred, suspected or ongoing) population declines (Kyne *et al.,* 2021). This assessment was compiled using the IUCN Red List criteria and indicated that the capture of *B. brevicaudata* as commercial bycatch was a moderate threat. Fisheries driving this risk/threat though are based outside of Queensland-managed waters *e.g.* the commonwealth-managed *Southern and Eastern Scalefish and Shark Fishery* (Kyne *et al.,* 2021). A weight-of-evidence approach indicates that *B. brevicaudata* is a lower assessment priority for the ECOTF. When and where appropriate, the species will be considered for inclusion in subsequent risk assessments involving this fishery. The need to reassess the capture of *B. brevicaudata* will be dependent on a range of factors including the acquisition of catch composition data through the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a). For further information on the risk posed by trawl fishing in Queensland-managed waters refer to Campbell *et al.* (2017) and Jacobsen *et al.* (2015).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Additional consultation—Additional consultation on the scope and extent of the ECOTF SOCC ERA indicated that species *B. brevicaudata* should be considered for inclusion. After further consideration, the decision was made to omit this species from the current ECOTF update. When and where appropriate, the species will be considered for inclusion in subsequent risk assessments involving this fishery. The need to reassess the capture of *B. brevicaudata* will be dependent on a range of factors including the acquisition of catch composition data through the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a).
Jenkins' whipray	*Pateobatis jenkinsii*	37 035025	**N**	**Not included**—The Jenkins' whipray (*Pateobatis jenkinsii*) was considered for inclusion in an updated ECOTF ERA as a precautionary measure. The species has limited overlap with the prescribed area of the ECOTF and any interactions would be confined to far north Queensland (Last *et al.*, 2016b; Kyne *et al.*, 2021). A review of the available data indicates that *P. jenkinsii* does not interact with the ECOTF or (if applicable) infrequently and in low numbers. This inference is supported by the *Action Plan for Australian Sharks and Rays* which classified commercial bycatch a low threat for the species (Kyne *et al.,* 2021). *Pateobatis jenkinsii* was not progressed as part of the ECOTF ERA update.
Australian whipray (synonym: Reticulate ray)	*Himantura australis* (synonym / historic identifications: *Himantura uarnak*)	37 035003	**Y**	**Included**—The Australian whipray (*Himantura australis*) was considered for inclusion in an updated ERA as it has a distribution and depth profile (0–45 m) that overlaps with sectors of the ECOTF (Kyne *et al.*, 2021). The catch history of *H. australis* is complicated as it was previously identified as *H. uarnak* on the Queensland east coast. Taxonomic revisions have since classified *H. australis* and *H. uarnak* as two separate species. *Himantura australis* is endemic to

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Australia and *H. uarnak* is found across the broader Indo-Pacific region (excluding Australia) (Last *et al.*, 2016b; Bray, 2020d). The above situation is complicated further by taxonomic complexities surrounding *H. leoparda* and *H. uarnak*. Historic records report both *H. undulata* and *H. leoparda* from the Queensland east coast. A review of *Himantura* taxonomy though revealed that *H. undulata* was not found in Australian waters with the *H. leoparda* distribution only encroaching on the northern margins of the Queensland east coast (Last *et al.*, 2016b; Bray, 2020e). While the taxonomic status of the *Himantura* complex is complicated, it is reasonable to assume that historic records of *H. uarnak, H. leoparda* and *H. undulata* on the Queensland east coast are *H. australis*. These catch records show that *H. australis* (at the very least) has been recorded in small numbers across the banana prawn and scallop fisheries (Courtney *et al.*, 2007a; Kyne *et al.*, 2007a). If and when *H. australis* interacts with the ECOTF, it will derive some benefit from the use of a TED. *Himantura australis* is a larger batoid species reaching at least 183 cm DW and maturing at or around ~112 cm DW (Bray, 2020d; Kyne *et al.*, 2021). As research has shown that the use of a TED is highly effective for rays >1 m DW (Brewer *et al.*, 2006; Campbell *et al.*, 2020), it is reasonable to assume that most subadult and mature *H. australis* will escape through the TED opening. While difficult to quantify without further monitoring, most rays that experience this type of trawl interaction (*i.e.* contact without capture) will survive the fishing event. Considering the configuration of TED bar spacings (12 cm; State of Queensland, 2019), smaller individuals may still be caught in the codend of the trawl net (Last *et al.*, 2016b).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				While *H. australis* was considered a lower priority for assessment, it was included in the ECOTF ERA update as a precautionary measure. As a result of additional consultation, it was recommended that *H. australis* be included due to the confusion and uncertainty surrounding its taxonomic history. It should be noted though that interaction rates for this species are expected to be low, with contact without capture events considered the most likely outcome.
Leopard whipray	*Himantura leoparda* (synonym / historic identifications: *Himantura undulata*)	37 035026	**N**	**Not included**—The leopard whipray (*Himantura leoparda*) was considered for inclusion in an updated ECOTF ERA as a precautionary measure. The species has limited overlap with the prescribed area of the ECOTF and any interactions would be confined to far north Queensland (Last *et al.*, 2016b; Kyne *et al.*, 2021). A review of the available data indicates that *H. leoparda* is a low assessment priority for this fishery. There is limited evidence that *H. leoparda* interacts with the ECOTF with great frequency, and commercial bycatch was classified as a low threat for this species in the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021). Of significance, *H. leoparda* was included in a comprehensive ERA examining the risk posed by otter trawl fishing in the GBRMP (Pears *et al.*, 2012b). This study considered fishing activities across a range of trawl sectors and classified *H. leoparda* as a low to intermediate risk (Pears *et al.*, 2012b). This assessment was based on the historical understanding of *Himantura spp*. distributions and taxonomy. Subsequent reviews suggest that this species has a more northern distribution with previous records more likely to be *H. australis* (Courtney *et al.*, 2007b; Jacobsen, 2007; Last *et al.*, 2016b; Bray, 2020d; Kyne *et al.*, 2021).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Note—*Himantura leoparda was previously identified as H. undulata in Australian waters. Taxonomic revisions have since classified H. leoparda and H. undulata as two distinct species. Himantura undulata is not known to inhabit Australian waters.*
Blackspotted whipray	*Maculabatis astra* (synonym: *Himantura astra*)	37 035020	Y	**Included**—The blackspotted whipray (*Maculabatis astra*) and the brown stingray (*M. toshi*) are two morphologically similar species (*pers. comm.* I. Jacobsen) that inhabit waters of north-eastern, northern and north-west Australia (Last *et al.*, 2016b; Kyne *et al.*, 2021). Both species are caught as bycatch in the ECOTF and they will interact with a range of inshore operations. The depth profile *M. astra* and *M. toshi* extends to 140 m and evidence suggests that both are caught as bycatch in the banana prawn, scallop, tiger and endeavour prawn sectors (Courtney *et al.*, 2007b; Jacobsen, 2007; Kyne *et al.*, 2007a; Kyne *et al.*, 2021). In the most recent assessment examining the regional extinction risk, the capture of *H. astra* as bycatch was classified as a high-level threat (Kyne *et al.*, 2021). The threat level for *M. toshi* was lower due, in part, to the species general preference for shallow-water environments (Bray, 2020f; Kyne *et al.*, 2021). *Maculabatis astra* and *M. toshi* registered maximum DWs of 92 and 82 cm respectively. Both species are born at or around 15 cm DW and males mature at approximately ~50 cm (Last *et al.*, 2016b; Kyne *et al.*, 2021). Based on these values, a percentage of the mature *M. astra* and *M. toshi* will be excluded from the net via the TED. The benefit of using a TED for these rays will be smaller when compared to larger rays like (*e.g.*) *Bathytoshia brevicaudata* and *B. lata*. Similarly, there is an increased probability that immature, subadult and mature *M. astra* an *M. toshi* will be caught as bycatch in the ECOTF (Jacobsen, 2007; Jacobsen & Bennett, 2011; Kyne *et al.*, 2021).
Brown whipray	*Maculabatis toshi* (synonym: *Himantura toshi*)	37 035022	Y	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Maculabatis astra and *M. toshi* were included in all three previous ECOTF ERAs (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). The results of previous ERAs varied and reflect conservative elements applied through the assessment methodology. In the two qualitative ERAs, *M. toshi* and *M. astra* were assigned respective ratings of intermediate and high (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). In the quantitative SAFE assessment, both species were assessed as being at a low risk from trawl fishing activities in southern Queensland (Campbell *et al.*, 2017). The rating for *M. astra* increased to precautionary extreme-high risk when assessed using a more conservative (precautionary) scenario that accounted for parameter estimate uncertainty. *Maculabatis astra* and *M. toshi* were viewed as higher assessment priorities and were progressed to the ECOTF ERA update. The species will benefit from additional assessment of the risk posed by trawl fishing across the entire ECOTF.
Mangrove whipray	*Urogymnus granulatus* (synonym: *Himantura granulata)*	37 035019	**N**	**Not included**—While the Queensland distribution of the mangrove whipray (*Urogymnus granulatus)* overlaps with the ECOTF, several factors reduce the interaction potential for this species. Research indicates that juvenile *U. granulatus* prefer estuaries and shallow-water mangrove-based ecosystems. Adults are also found with more regularity within reef systems (Last *et al.*, 2016b). The life history, habitat preferences and depth profile (0–85 m; Kyne *et al.*, 2021) indicates that interactions with *U. granulatus* will be confined to shallower waters and a smaller subset of ECOTF operations. With a *maximum size* of 141 cm DW and a *size at maturity* of 55–65 cm DW, it is also anticipated that a high proportion of subadults and mature rays will be excluded from the net via the TED (Brewer *et al.*, 2006; Campbell *et*

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				al., 2020). These interactions are considered contact without capture events, and it's expected that most, if not all, of these rays will survive their interaction with the trawl net. Overall, *U. granulatus* is viewed as a lower assessment priority for the ECOTF. While immature *U. granulatus* might be caught as bycatch in shallow-water operations, the extent and frequency of these interactions are not expected to pose a long-term threat to regional populations. This inference is supported by the *Action Plan for Australian Sharks and Rays* which classified commercial bycatch as a low-level threat and assessed *U. granulatus* as a species of *Least Concern* in terms of the regional extinction risk (Kyne *et al.*, 2021). The need to include *U. granulatus* in subsequent trawl ERAs will be dependent on the outputs of ancillary programs including initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a). *Urogymnus granulatus* was included in one of the previous ECOTF ERAs. The species was assessed under the synonym *Himantura granulatus* and assigned a low-intermediate risk rating (Pears *et al.*, 2012b).
Porcupine ray	*Urogymnus asperrimus*	37 035027	**N**	**Not included**—The porcupine ray (*Urogymnus asperrimus*) was considered for inclusion in an updated ERA as it has a distribution and depth profile that overlaps with trawl operations in central and northern Queensland (Last *et al.*, 2016b; Kyne *et al.*, 2021). However, a review of the available data indicates that the species is a lower priority for reassessment. *Urogymnus asperrimus* has not been reported as bycatch in the ECOTF and interactions will be low due to the species preference for coral reefs and sandy, coral rubble and seagrass substrates (Bray, 2017d).

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Urogymnus asperrimus was not included in any of the three previous ECOTF ERAs and it was assessed as a species of *Least Concern* in the *Action Plan for Australian Sharks and Rays*. As part of this assessment, commercial bycatch was viewed as a low-level threat for *U. asperrimus* (Kyne *et al.*, 2021).
Broad cowtail whipray	*Pastinachus ater*	37 035011	**N**	**Not included**—While the Queensland distribution of the broad cowtail whipray (*Pastinachus ater*) overlaps with the ECOFT, several factors reduce the interaction potential for this species. *Pastinachus ater* inhabits water depths from 0–60 m (Kyne *et al.*, 2021) and will be found in areas fished by trawl operators. If and when *P. ater* interacts with the ECOTF, its morphological features provide it with a high degree of protection. *Pastinachus ater* is a comparatively large batoid that has a size at birth of around 18 cm DW and a *maximum size* of ~200 cm (Last *et al.*, 2016b; Kyne *et al.*, 2021). While not specific to this species, research shows that the use of a TED can reduce the catch of large rays by up to 94 per cent (Brewer *et al.*, 2006; Campbell *et al.*, 2020). Considering this, smaller rays may still be caught as bycatch in the ECOTF. The frequency of these events will be low and interaction rates will not pose a significant or long-term sustainability risk to regional *P. ater* populations.
Pink whipray	*Pateobatis fai* (synonym: *Himantura fai*)	37 035024	**N**	**Not included**—The risk profile for the pink whipray (*Pateobatis fai)* is similar to *U. granulatus*. The distribution of *P. fai* overlaps with the ECOTF and the species is more likely to be encountered in shallower water environments (0–70 m). There is limited evidence to suggest that *P. fai* has frequent or numerous interactions with the ECOTF and it will derive some benefit from the use of a TED (*maximum size* = 146 cm DW, *size at maturity* >100 cm DW). While difficult to quantify, rays that escape through the TED opening are expected to have comparatively higher post-interaction survival rates.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				Pateobatis fai is considered a low assessment priority and the species was not progressed as part of the ECOTF ERA update. The commercial bycatch threat for this species is low and it has been classified as a species of *Least Concern* in the *Action Plan for Australian Sharks and Rays* (Kyne *et al.*, 2021). The need to include *P. fai* in future trawl ERAs will be dependent on the outputs of ancillary programs including initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a). *Pateobatis fai* was included in one of the previous ECOTF ERAs. The species was assessed under the synonym *Himantura fai* and assigned a low-intermediate risk rating (Pears *et al.*, 2012b).
Bluespotted fantail Ray	*Taeniura lymma*	37 035009	**N**	**Not included**—The bluespotted fantail ray (*Taeniura lymma*) was considered for inclusion in an updated ERA as it has a distribution and depth profile (0–20 m) that may expose it to shallow-water trawl fishing activities (Last *et al.*, 2016b)**.** A review of the available data indicates that *T. lymma* is a low assessment priority. It has not been reported as bycatch in the ECOTF nor in trawl fisheries operating in adjacent jurisdictions. It has a natural affinity for coral reef systems and is typically found in environments that are not conducive to trawl fishing activities (Kyne *et al.*, 2021).
Blotched fantail ray	*Taeniurops meyeni*	37 035017	**N**	**Not included**—The blotched fantail ray (*Taeniurops meyeni*) is larger than *T. lymma* and inhabits a more diversified range of habitats. The species is found in waters down to 400 m and it will be exposed to trawl fishing activities in central and northern Queensland (Kyne *et al.*, 2021). If a *T. meyeni* interacts with the ECOTF, its morphological features reduce the risk of it being caught as bycatch. *Taeniurops meyeni* is a larger species and it has a registered *maximum size* of 180 cm DW (Kyne *et al.*, 2021). While additional information is required on the age and growth of *T. meyeni*, estimates place the size at birth at 30–35

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				cm DW and the *size at maturity* at or around 100 cm DW (Last *et al.*, 2016b). With research showing that TEDs are highly effective at excluding rays >1 m from the trawl catch (Brewer *et al.*, 2006; Campbell *et al.*, 2020), it can be reasonably assumed that mature *T. meyeni* (if caught) will experience a contact without capture event. While *T. meyeni* may interact with the ECOTF, there is little evidence that the species is caught as bycatch in east coast prawn trawl operations. It has, however been reported from the *Northern Prawn Fishery*; suggesting it has the potential to be caught as bycatch. Even so, *T. meyeni* is viewed as a low assessment priority for the Queensland east coast. This inference is supported by the findings of the *Action Plan for Australian Sharks and Rays* which classified *T. meyeni* as a species of *Least Concern*. This assessment also considered commercial bycatch to be a low-level threat for *T. meyeni* (Kyne *et al.*, 2021).
Smalleye stingray	*Megatrygon microps*	37 035028	**N**	**Not included**—When compared to other batoids, the preliminary encounterability assessment for the smalleye stingray (*Megatrygon microps*) was more complicated. *Megatrygon microps* is a rare and poorly known ray that has a wide but fragmented distribution. On the Queensland east coast, the species has only been reported from a small section of the central/northern coastline. Little is known about the biology of this species, although *maximum size* estimates suggest that *M. microps* grows to >200 cm DW (Last *et al.*, 2016b; Kyne *et al.*, 2021). *Megatrygon microps* has been confirmed as bycatch in the *Northern Prawn Fishery* but has yet to be reported from the ECOTF. If a *M. microps* were to interact with a trawl net, size-estimates suggest that a proportion of subadult and mature rays would be excluded from the net. However, this inference cannot be tested due to an absence of information on the age, growth and development of *M. microps*. Such were the deficiencies

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				surrounding this species, *M. microps* was one of a small number of rays (*n* = 7 or 5.3 per cent) that were assigned a *Data Deficient* rating in the *Action Plan for Australian Sharks and Rays* (Kyne *et al.*, 2021). If *M. microps* were to be assessed as part of an updated ECOTF ERA, there is a high probability that the species will be assigned a high-risk rating. As the PSA treats data deficiencies more conservatively (Hobday *et al.*, 2007; Hobday *et al.*, 2011), it will be difficult to determine if the outputs reflect the current fishing environment or are a false-positive result (Zhou *et al.*, 2016; Australian Fisheries Management Authority, 2017; Department of Agriculture and Fisheries, 2018b). Due to the above considerations, *M. microps* was not included in the ECOTF ERA update. While the species would likely benefit from additional assessment, there is a low probability of the PSA producing an accurate account of the risk posed to this species. *Megatrygon microps* will continue to be reviewed for inclusion in subsequent ERAs involving the trawl fishery. The ability to include this species in future assessments will depend on the available data and (potentially) outcomes of initiatives instigated under the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a).
Estuary stingray	*Hemitrygon fluviorum*	37 035008	**Y**	**Included**—The estuary stingray (*Hemitrygon fluviorum*) was included in the preliminary species list due to its classification as *Near Threatened* under the Queensland *Nature Conservation Act 1992* which prohibits its retention for commercial sale in key areas. However, *H. fluviorum* is not afforded additional protections under fisheries legislation and is not listed as a threatened or migratory species under the *Environment Protection and Biodiversity Conservation Act 1999*.

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				The known distribution of *H. fluviorum* extends along the Queensland east coast and west through the Gulf of Carpentaria and Northern Territory. The species preference for intertidal, riverine, and estuarine waters reduces the likelihood that it will interact with a wide range of prawn trawl operations. The extent of these interactions are largely unknown as *H. fluviorum* was only included in the *Threatened, Protected and Endangered Animals Logbook* in September 2021 (Queensland Government, 2022a). Of note, *H. fluviorum* was included in all three previous ECOTF ERAs. Results from these assessments were consistent with the species assigned either a low or a medium (intermediate) risk rating. The regional extinction risk for *H. fluviorum* was also assessed as part of the *Action Plan for Australian Sharks and Rays*. This assessment classified *H. fluviorum* as *Vulnerable* due to a suspected population decline of >30 per cent over the last three generations (Kyne *et al.*, 2021). The capture of *H. fluviorum* as bycatch in commercial fisheries was identified as a moderate threat (Kyne *et al.*, 2021). At a whole-of-fishery level, reassessing *H. fluviorum* using the PSA will be of some benefit. It will provide the species with a more complete risk profile and help identify the extent of the risk across trawl sub-fisheries. The risk posed to this species is unlikely to be uniform and future assessments will need to consider how best to address any (potential) false-positive results.
Family Pristidae				
Dwarf sawfish	*Pristis clavata*	37 025004	**N**	**Not included**—The dwarf sawfish (*Pristis clavata*) and the largetooth sawfish (*P. pristis*).
Green sawfish	*Pristis zijsron*	37 025001	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
Largetooth sawfish	*Pristis pristis* (synonym: *Pristis microdon*)	37 025003	**N**	**Included**—The green sawfish (*P. zijsron*) and the narrow sawfish (*Anoxypristis cuspidata*). *Pristis clavata*, *P. zijsron*, *P. pristis* and *A. cuspidata* are protected in Queensland waters under the *Fisheries Act 1994* and subordinate legislation (Department of Agriculture and Fisheries, 2021c). Three of the species, *P. clavata*, *P. zijsron* and *P. pristis*, are also listed as threatened species under the *Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2019b; c; 2020). These listings were the catalyst for their inclusion in the preliminary list of species being considered for inclusion in the ECOTF ERA update. This subgroup has experienced notable population declines and their distribution has experienced a significant contraction (Last *et al.*, 2016b). This includes in Queensland where there is a degree of uncertainty surrounding the extent of their east coast distribution (D'Anastasi *et al.*, 2013; Kyne *et al.*, 2013a; Simpfendorfer, 2013). While the distribution of all four species extends through to the Queensland east coast, evidence suggests that *A. cuspidata* and *P. zijsron* are more likely to be encountered. The distributions of the two remaining species are less certain, and at least one species, *P. clavata*, may be extirpated from most, if not all of the Queensland east coast (Jacobsen *et al.*, 2021a). Catch data from the *Northern Prawn Fishery* shows that sawfish can and will be caught as bycatch in trawl fisheries. When compared to the *Northern Prawn Fishery*, sawfish interactions are less likely in the ECOTF as the *encounterability* potential will be lower for some species. A summary of these considerations has been provided below. - *P. pristis*: Juveniles demonstrate a preference for river habitats and can be found 400 km upstream (Last *et al.*, 2016b). This habitat preference provides
Narrow sawfish	*Anoxypristis cuspidata*	37 025002	**Y**	

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				refuge for individuals during vulnerable early life stages. Evidence also suggests that if this species does occur on the east coast, it will be confined to northern Queensland where effort levels are lower. - *P. clavata*: Has a limited vertical distribution, inhabiting water depths from 0–20 m (Kyne *et al.*, 2021). Shallow water-environments are fished with less frequency in the ECOTF and/or are inaccessible due to operational (gear) constraints. Evidence also suggests that if this species occurs on the east coast, it will be confined to northern Queensland where effort levels are lower. When compared, *P. zijsron* has a more expansive distribution on the Queensland east coast and overlaps with a larger portion of the ECOTF. This species has experienced considerable population declines and interactions with *P. zijsron* are more likely in the *East Coast Inshore Fishery*. *Anoxypristis cuspidata* is the most biologically productive sawfish species and is regularly caught as bycatch in Australian jurisdictions. In the ECOTF, there is an increased probability that any sawfish that interacts with a trawl net in central or northern Queensland is *A. cuspidata.* Both *P. zijsron* and *A. cuspidata* were included in the two qualitative ERAs and assigned intermediate-risk ratings (Pears *et al.*, 2012b; Jacobsen *et al.*, 2015). The inclusion of these species in previous ERAs was precautionary and largely based on their conservation status (pers. comm. I. Jacobsen; D'Anastasi *et al.*, 2013; Simpfendorfer, 2013; Department of the Environment, 2019c; Department of Agriculture and Fisheries, 2021c; Kyne *et al.*, 2021; Department of the Environment, 2022a). All four species were excluded from the SAFE assessment (Campbell *et al.,* 2017). As the fishing environment has not changed significantly, it is unlikely that the risk posed to *P. zijsron* and *A. cuspidata* has changed since the last assessment. Similarly, fishing-related risks are arguably more acute in the *East Coast Inshore Fishery* and in the Gulf

ECOTF—T1, T2, M1 and M2 Fishery symbols				
Common name	**Species name**	**CAAB**	**Include**	**Justifications and Considerations**
				of Carpentaria. With that said, *P. zijsron* and *A. cuspidata* may benefit from having their risk profiles updated using a PSA. As with previous assessments, the decision to include *P. zijsron* and *A. cuspidata* in an updated ECOTF ERA is precautionary. Removing the species from the assessment list will require further information on bycatch compositions. This data is being collected through initiatives instigated as part of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2017a; 2018a).

Appendix C—Availability Overlap Percentages.

Where available, overlap percentages were based on species distribution maps sourced from the *Atlas of Living Australia*, the *IUCN Red List of Threatened Species* and the *Commonwealth Scientific and Industrial Research Organisation* (CSIRO), and where possible, were refined using bathymetry and topographical data (Whiteway, 2009). The sources utilised were determined based on the best available species-specific distribution data. '*' Represents where global maps (*availability* option 2) were used due to discrepancies / inconsistencies among the distribution sources, or in instances where distribution sources did not align with the most updated information on a species range.

Common name	Species	CAAB	2017	2018	2019	2020	2021	Highest %	Source	Final availability score
			% Overlap	% Overlap	% Overlap	% Overlap	% Overlap			
Marine Turtles										
Loggerhead turtle	*Caretta caretta*	39 020001	13.9	13.7	14.5	12.2	11.2	14.5	ALA	2
Green turtle	*Chelonia mydas*	39 020003	13.9	13.7	14.5	12.2	11.2	14.5	ALA	2
Leatherback turtle	*Dermochelys coriacea*	39 021001	13.9	13.7	14.5	12.2	11.2	14.5	ALA	2
Hawksbill turtle	*Eretmochelys imbricata*	39 020003	13.9	13.7	14.5	12.2	11.2	14.5	ALA	2
Olive ridley turtle	*Lepidochelys olivacea*	39 020004	13.9	13.7	14.5	12.2	11.3	14.5	ALA	2
Flatback turtle	*Natator depressus*	39 020005	13.9	13.7	14.5	12.2	11.2	14.5	ALA	2
Syngnathids										
Tiger pipefish	*Filicampus tigris*	37 282064	N/A	N/A	N/A	N/A	N/A	N/A	-	3*
Spiny seahorse	*Hippocampus spinosissimus*	37 282110	25.1	25.1	26.3	22.0	19.9	25.1	CSIRO	2
Great seahorse	*Hippocampus kelloggi*	37 282117	20.6	20.3	21.6	18.2	16.7	21.6	IUCN	2
White's seahorse	*Hippocampus whitei*	37 282027	36.9	35.3	37.3	32.8	30.7	37.3	IUCN	3
Duncker's pipehorse	*Solegnathus dunckeri*	37 282098	N/A	N/A	N/A	N/A	N/A	N/A	-	3*
Pallid pipehorse	*Solegnathus hardwickii*	-	N/A	N/A	N/A	N/A	N/A	N/A	-	1*

Common name	Species	CAAB	2017	2018	2019	2020	2021	Highest %	Source	Final availability score
			% Overlap	% Overlap	% Overlap	% Overlap	% Overlap			
Bentstick pipefish	*Trachyrhamphus bicoarctatus*	37 282006	25.1	25.2	26.2	21.9	19.9	26.2	CSIRO	2
Straightstick pipefish	*Trachyrhamphus longirostris*	37 282101	N/A	N/A	N/A	N/A	N/A	N/A	-	1*
Ribboned pipefish	*Haliichthys taeniophorus*	37 282007	2.7	2.7	8.8	1.7	0.0	8.8	CSIRO	1
Sea snakes										
Reef shallows sea snake	*Aipysurus duboisii*	39 125003	32.0	31.3	31.9	28.0	25.2	32.0	IUCN	3
Mosaic sea snake	*Aipysurus mosaicus*	39 125004	N/A	N/A	N/A	N/A	N/A	N/A	-	2*
Olive sea snake	*Aipysurus laevis*	39 125007	28.4	28.0	28.7	24.9	22.2	28.7	IUCN	2
Spine-bellied sea snake	*Hydrophis curtus*	39 125031	22.9	21.3	22.2	18.9	17.7	22.9	IUCN	2
Elegant sea snake	*Hydrophis elegans*	39 125021	31.6	30.9	31.5	27.6	24.9	31.6	IUCN	3
Spectacled sea snake	*Hydrophis kingii*	39 125010	29.0	28.5	29.2	25.3	22.8	29.2	IUCN	2
Turtle-headed sea snake	*Emydocephalus annulatus*	39 125012	26.2	25.8	26.1	22.6	20.2	26.2	IUCN	2
Olive-headed sea snake	*Hydrophis major*	39 125011	28.9	28.4	29.1	25.2	22.7	29.1	IUCN	2
Small-headed sea snake	*Hydrophis macdowelli*	39 125025	28.3	27.9	28.5	24.8	22.1	28.5	IUCN	2
Spotted sea snake	*Hydrophis ocellatus*	39 125028	N/A	N/A	N/A	N/A	N/A	N/A	-	2*
Horned sea snake	*Hydrophis peronii*	39 125001	28.4	28.0	28.6	24.9	22.2	28.6	IUCN	2
Beaked sea snake	*Hydrophis zweifeli*	39 125013	N/A	N/A	N/A	N/A	N/A	N/A	-	2*
Stoke's sea snake	*Hydrophis stokesii*	39 125009	31.6	30.9	31.6	27.6	24.9	31.6	IUCN	3
Sharks										
Collar carpetshark	*Parascyllium collare*	37 013002	47.0	44.3	44.9	41.1	38.3	47.0	IUCN	3

Common name	Species	CAAB	2017 % Overlap	2018 % Overlap	2019 % Overlap	2020 % Overlap	2021 % Overlap	Highest %	Source	Final availability score
Brownbanded bambooshark	*Chiloscyllium punctatum*	37 013008	20.5	20.2	21.4	18.1	16.6	21.4	IUCN	2
Colclough's shark	*Brachaelurus colcloughi*	37 013013	28.4	29.9	30.9	26.6	24.2	30.9	IUCN	3
Crested hornshark	*Heterodontus galeatus*	37 007003	41.9	39.8	39.1	37.2	35.8	41.9	IUCN	3
Eastern angelshark	*Squatina albipunctata*	37 024004	18.5	17.8	19.7	16.6	15.7	19.7	CSIRO	2
Eastern banded catshark	*Atelomycterus marnkalha*	37 015037	17.4	17.3	18.6	15.4	13.9	18.6	IUCN	2
Zebra shark	*Stegostoma tigrinum*	37 013006	20.7	20.4	21.6	18.2	16.7	21.6	IUCN	2
Piked spurdog	*Squalus megalops*	37 020006	16.1	15.6	17.3	14.6	13.8	17.3	CSIRO	2
Australian weasel shark	*Hemigaleus australiensis*	37 018020	20.7	20.4	21.6	18.2	16.7	21.6	IUCN	2
Pale spotted catshark	*Asymbolus pallidus*	37 015025	4.1	4.1	4.7	4.0	3.9	4.7	IUCN	1
Grey spotted catshark	*Asymbolus analis*	37 015027	42.5	40.4	39.5	37.7	36.2	42.5	IUCN	3
Orange spotted catshark	*Asymbolus rubiginosus*	37 015024	37.1	35.2	35.1	33.3	30.6	37.1	IUCN	3
Batoids										
Australian butterfly ray	*Gymnura australis*	37 037001	25.5	25.2	26.6	22.3	20.0	26.6	IUCN	2
Yellowback stingaree	*Urolophus sufflavus*	37 038005	N/A	N/A	N/A	N/A	N/A	N/A	-	3*
Patchwork stingaree	*Urolophus flavomosaicus*	37 038010	24.2	24.2	26.3	21.3	19.9	26.3	IUCN	2
Sandyback stingaree	*Urolophus bucculentus*	37 038001	63.2	56.3	58.8	57.5	57.3	63.2	CSIRO	3
Kapala stingaree	*Urolophus kapalensis*	37 038018	N/A	N/A	N/A	N/A	N/A	N/A	-	3*
Greenback stingaree	*Urolophus viridis*	37 038007	N/A	N/A	N/A	N/A	N/A	N/A	-	3*
Common stingaree	*Trygonoptera testacea*	37 038006	84.6	83.4	80.2	75.1	71.0	84.6	IUCN	3

Common name	Species	CAAB	2017	2018	2019	2020	2021	Highest %	Source	Final availability score
			% Overlap	% Overlap	% Overlap	% Overlap	% Overlap			
Australian whipray	*Himantura australis*	37 035003	22.6	22.6	23.7	19.8	17.6	23.7	IUCN	2
Blackspotted whipray	*Maculabatis astra*	37 035020	20.5	20.2	21.4	18.1	16.6	21.4	IUCN	2
Brown whipray	*Maculabatis toshi*	37 035022	22.3	21.8	22.9	19.4	17.7	22.9	IUCN	2
Estuary stingray	*Hemitrygon fluviorum*	37 035008	22.8	22.7	23.8	19.9	17.8	23.8	IUCN	2
Coral sea maskray	*Neotrygon trigonoides*	37 035031	25.7	26.0	26.6	23.0	20.9	26.6	IUCN	2
Speckled maskray	*Neotrygon picta*	37 035029	19.0	18.9	19.9	16.4	14.7	19.9	IUCN	2
Bottlenose wedgefish	*Rhynchobatus australiae*	37 026005	23.4	23.2	24.4	20.5	18.4	24.4	IUCN	2
Eyebrow wedgefish	*Rhynchobatus palpebratus*	37 026004	N/A	N/A	N/A	N/A	N/A	N/A	-	1*
Eastern shovelnose ray	*Aptychotrema rostrata*	37 027009	25.3	25.3	26.7	23.1	21.0	26.7	IUCN	2
Giant guitarfish	*Glaucostegus typus*	37 027010	23.9	23.7	25.1	21.0	19.1	25.1	IUCN	2
Sydney skate	*Dentiraja australis*	37 031041	69.5	66.2	66.6	63.6	58.1	69.5	CSIRO	3
Endeavour skate	*Dentiraja endeavouri*	37 031043	N/A	N/A	N/A	N/A	N/A	N/A	-	3*
Argus skate	*Dentiraja polyommata*	37 031042	N/A	N/A	N/A	N/A	N/A	N/A	-	3*
Narrow sawfish	*Anoxypristis cuspidata*	37 025002	N/A	N/A	N/A	N/A	N/A	N/A	-	1*
Green sawfish	*Pristis zijsron*	37 025001	23.9	23.6	24.9	20.9	19.0	24.9	IUCN	2

Appendix D—Residual Risk Analysis

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
<u>Syngnathids</u> *Tiger pipefish (F. tigris)* *Spiny seahorse (H. spinosissimus)* *Great seahorse (H. kelloggi)* *Duncker's pipehorse (S. dunckeri)* *Pallid pipehorse (S. hardwickii)* *Bentstick pipefish (T. bicoarctatus)* *Straightstick pipefish (T. longirostris)* *Ribboned pipefish (H. taeniophorus)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	1	The listed species were assigned a high (3) risk score for *age at sexual maturity* due to data deficiencies (Table 4). Further consultation on *Syngnathidae* biology indicates that *age at sexual maturity* for these species would be less than five years (*pers. comm.* D. Harasti). ***Key changes to the PSA scores*** Based on the advice provided, preliminary scores assigned to this attribute were decreased from high (3) to low (1). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Syngnathids *Tiger pipefish (F. tigris)* *Spiny seahorse (H. spinosissimus)* *Great seahorse (H. kelloggi)* *Duncker's pipehorse (S. dunckeri)* *Pallid pipehorse (S. hardwickii)* *Bentstick pipefish (T. bicoarctatus)* *Straightstick pipefish (T. longirostris)* *Ribboned pipefish (H. taeniophorus)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	1	The listed species were assigned a high (3) risk score in the PSA for *maximum age* due to data deficiencies (Table 4). Further consultation on *Syngnathidae* biology indicates that the *maximum age* for these species would be less than 10 years (*pers. comm.* D. Harasti). ***Key changes to the PSA scores*** Based on the advice provided, preliminary scores assigned to this attribute were decreased from high (3) to low (1). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Syngnathids	*Fecundity (Productivity)*	ECOTF	3	2	The majority of the listed species were assigned a high (3) risk score in the PSA for *fecundity* due to data deficiencies (Table 4). Further consultation on

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Spiny seahorse (H. spinosissimus) *Great seahorse (H. kelloggi)* *Duncker's pipehorse (S. dunckeri)* *Pallid pipehorse (S. hardwickii)* *Bentstick pipefish (T. bicoarctatus)* *Straightstick pipefish (T. longirostris)* *Ribboned pipefish (H. taeniophorus)*		(T1, T2, M1, M2)			*Syngnathidae* biology estimated *fecundity* to be greater than 100 young per year, though less than 20,000 young per year (*pers. comm.* D. Harasti). ***Key changes to the PSA scores*** Based on the advice provided, the preliminary scores assigned to this attribute was decreased from high (3) to medium (2). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Syngnathids *White's seahorse (H. whitei)*	*Availability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	Criteria used to assess *availability* is effective for species whose distributions have moderate to high overlap with the fishery and species whose distribution occurs solely within the prescribed fishing area. This criterion though has the potential to overestimate the *availability* risk for species that have distributions that have more marginal overlaps with the ECOTF effort footprint. For example, the Queensland distribution of the White's seahorse (*Hippocampus whitei*) is confined to a small section of southern Queensland.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					The distribution of the species though extends into New South Wales where it has considerable refuge from trawling operations within the ECOTF. In the PSA, *H. whitei* received a high-risk rating (3) as a notable proportion of its Queensland distribution was impacted by trawl fishing activity. Subsequent analysis indicated that *H. whitei* occurs in less than 30 per cent of the area accessed/fished by ECOTF operations. This suggests that, while *H. whitei* occurs in areas where there is higher effort, the PSA over-estimated the *availability* risk for this species. ***Key changes to the PSA scores*** The preliminary score assigned to this attribute in the PSA was decreased from high (3) to medium (2). This change was done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions.* Given the size of the overlap, a medium (2) score may still represent a risk overestimate. However, a further score reduction could not be supported given the lack of information on spatially explicit syngnathid species compositions and interaction rates. As the assessment method is precautionary, reducing the *availability* score for this species will not contribute to the production of a false-positive result. The adoption of a more flexible approach for species with marginal overlaps also aligns with strategies applied in other ERAs including comparable assessments completed as part of the national *Ecological Risk Assessment for the Effects of Fishing* (ERAEF) process (Hobday *et al.*, 2011; Australian Fisheries Management Authority, 2023a).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Syngnathids *Spiny seahorse (H. spinosissimus)* *Great seahorse (H. kelloggi)* *White's seahorse (H. whitei)* *Bentstick pipefish (T. bicoarctatus)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	All nine syngnathids have the potential to interact with the ECOTF based on their habitat preference and/or depth profile. In Australia, syngnathids occupy a wide range of environments, with many utilising both soft and hard substrates (Lourie, 2016). This broad habitat profile resulted in the complex being assigned higher risk scores for the *encounterability* attribute (Table 4). While the complex will display some interspecific variance, many environments preferred by *Syngnathidae* are either less conducive to trawl fishing or not accessed by the ECOTF (*i.e.* to protect the gear, for safety reasons or operational constraints). For example, these species are unlikely to be encountered in significant quantities in offshore operations *e.g.* the deepwater eastern king prawn sector. In inshore areas, there is an increased probability of a trawl operation interacting with the syngnathid complex; particularly in areas adjacent to coral reefs and seagrass bed assemblages. Even then, the encounterability potential for some species will be reduced due to their preference for habitats with more complex structures. These reasons increase the probability that the PSA overestimated the *encounterability* risk for one or more of these species. As part of the RRA, additional consideration was given to a) the type of operations that are more likely to interact with this complex, b) the prevalence of syngnathid interactions across the entire fishery and c) the habitat preferences of key species. When these factors were considered in the context of the entire ECOTF, scores assigned to the *encounterability* attribute were viewed as a risk overestimate for a number of the species. ***Key changes to the PSA scores***

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Based on the available information, the preliminary score assigned to the *encounterability* attribute was reduced from high (3) to medium (2) for the listed species. This decision was largely based on the fact that these species prefer a range of habitats, including those that attract less effort from trawling operations. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* with further consideration given to *Guideline 3: at risk with spatial assumptions*. These changes are precautionary and are unlikely to contribute to a false-negative result. For some of these species a medium (2) risk rating may still overestimate risk. While further score reductions were considered, a lowering of the score to low (1) was not supported at this point in time. Data deficiencies make it difficult to quantify syngnathid interaction rates and catch compositions; particularly for species that cannot be retained for sale. Further, the distribution of these species is not exclusively confined to hard substrates and trawl fishing will still occur in areas where they are more likely to be encountered. These factors limited the extent of amendments made as part of the RRA. ***Note****—Most interactions are expected to be with Duncker's pipehorse (Solegnathus dunckeri) and the pallid pipehorse (S. hardwickii; Dodt, 2005). These are listed as permitted species and can be retained for sale in the ECOTF*.
<u>Syngnathids</u> *Ribboned pipefish (H. taeniophorus)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	1	All nine syngnathid species have the potential to interact with the ECOTF based on their habitat preference and/or depth profile. This was reflected in the PSA where the majority were assigned a high risk (3) score for *encounterability* (Table 4).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					A review of the available data for the ribboned pipefish (*Haliichthys taeniophorus*) indicates that a high (3) score overestimated the *encounterability* risk for this species. In Australia, *H. taeniophorus* demonstrates a preference for warmer, tropical waters and utilises a range of habitats including soft substrates such as weedy and muddy environments (Lourie, 2016). However, the distribution of this species is restricted to the northernmost extent of the ECOTF which provides the species with considerable refuge from trawl fishing activities. While the species may be caught in some tiger and endeavour prawn operations, there is a low probability of *H. taeniophorus* being encountered across the entire ECOTF. As part of the RRA, consideration was given to a) the type of operations that are more likely to interact with this species, and b) the prevalence of interactions across the entire fishery. When these factors were considered, the PSA attribute score was viewed as an overestimate. ***Key changes to the PSA scores*** Based on the available information, the preliminary score assigned to the *encounterability* attribute was reduced from high (3) to low (1). This decision was largely based on the fact that the *H. taeniophorus* distribution, depth profile and preferred habitats provide it with considerable protection from trawl fishing activities. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Syngnathids *Tiger pipefish (F. tigris)* *Spiny seahorse (H. spinosissimus)* *Great seahorse (H. kelloggi)* *White's seahorse (H. whitei)* *Bentstick pipefish (T. bicoarctatus)* *Straightstick pipefish (T. longirostris)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	3	There is limited published data on the post-interaction survival rates for individual syngnathid species. Data reported through the *Threatened, Endangered and Protected Animals* (TEPA) logbook and the former *Species of Conservation Interest* (SOCI) logbook indicates that most syngnathids are released alive. However, this data has poor resolution and provides limited insight into species-specific mortality rates. This deficiency is compounded by the fact that: a) There is limited capacity within the current management regime to verify or validate data collected through the logbook program; and b) A portion of the syngnathid catch will be discarded as unreported bycatch (*i.e.* due the cryptic nature of their life cycle / not being observed in a multi-species catch) or, in the case of the Duncker's pipehorse (*Solegnathus dunckeri*) and the pallid pipehorse (*S. hardwickii*), due to in-possession limits. The above considerations required the adoption of a more precautionary approach and the original high-risk (3) scores were retained (Table 6). In the RRA some consideration was given to lowering the scores assigned to this complex for *post-interaction mortality*. The premise being that a portion of the syngnathid catch will (likely) experience a contact without capture event (*e.g.* escape through a Bycatch Reduction Device) or survive the interaction. A review of the available data though did not support a reclassification of the *post-interaction mortality* scores. ***Key changes to the PSA scores***

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					No change to the score, although this is an area where future ERAs could be refined and improved with additional information. While difficult to quantify, the provision of this data will likely result in a risk-score reduction for one or more of the species included in this assessment.
<u>Syngnathids</u> *Ribboned pipefish (H. taeniophorus)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	3	While the ribboned pipefish (*Haliichthys taeniophorus*) has not previously been assessed in an ECOTF ERA, logbook data indicates that this species is caught in the fishery. However, there is limited capacity within the current management regime to verify or validate post-release survival for this species. While the *Threatened, Endangered and Protected Animals* (TEPA) logbook and the former *Species of Conservation Interest* (SOCI) logbook reports release fates, this information has poor species resolution. This introduces a level of assessment uncertainty and required the adoption of a more precautionary approach. In the RRA, a review of the scores assigned to *post-interaction mortality* was undertaken for all syngnathids. Unlike other species from this complex, there is some evidence that post-interaction mortalities are high for trawl caught *H. taeniophorus*. The suitability of a high risk (3) rating for *post-interaction mortality* though requires further investigation and refinement. This can only occur with additional information. ***Key changes to the PSA scores*** No change to the score, although this is an area where future ERAs could be refined and improved with additional information.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Sea snakes *Spectacled sea snake (H. kingii)* *Small-headed sea snake (H. macdowelli)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	Information on the age and growth of the spectacled sea snake (*Hydrophis kingii*) and the small-headed sea snake (*H. macdowelli*) is limited. As a consequence, the two species were assigned precautionary high (3) risk scores for the *age at sexual maturity* attribute (Table 4). Subsequent consultation on sea snake biology indicated that *maximum age* for these species would most likely be less than 10 years (*pers. comm.* A. Courtney*)*. This by default, means that the *age at sexual maturity* must also be less than 10 years. ***Key changes to the PSA scores*** Based on the advice provided, the score assigned to *age at sexual maturity* was reduced from high (3) to medium (2). This amendment was done in accordance with *Guideline 2: additional scientific assessment & consultation*. While the amended scores may still represent a risk overestimate, the available data did not support any further reductions.
Sea snakes *Mosaic sea snake (A. mosaicus)* *Spectacled sea snake (H. kingii)* *Olive-headed sea snake (H. major)* *Small-headed sea snake (H. macdowelli)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	2–3	1	The listed sea snakes were initially assigned medium (2) and high (3) risk scores for *maximum age* (Table 4). Subsequent consultation on sea snake natural mortality rates (*i.e.* when the population reaches 95 per cent natural mortality) indicates that the *maximum age* of these species will be less than 10 years (*pers. comm.* A. Courtney). This consultation was specifically targeted at sea snakes inhabiting Queensland waters and supports the hypothesis that the PSA overestimated the risk for this attribute. ***Key changes to the PSA scores*** Based on the advice provided and further consultation on the suitability of mortality-based age estimates (*pers. comm.* V. Udyawer), scores assigned to this attribute were decreased from high (3) to low (1) for *Hydrophis kingii*, *H.*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Spotted sea snake (H. ocellatus) *Beaked sea snake (H. zweifeli)*					*macdowelli* and *H. zweifeli* and from medium (2) to low (1) for *H. major*, *H. ocellatus* and *Aipysurus mosaicus*. This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.* It is recognised that age and growth datasets for sea snakes are limited and requires further investigation. However, information provided during the consultation process was considered sufficient to downgrade the scores assigned to this attribute. The decision to amend this score also aligns with the semi-quantitative nature of this report.
Sea snakes *Reef shallows sea snake (A. duboisii)* *Mosaic sea snake (A. mosaicus)* *Olive sea snake (A. laevis)* *Spine-bellied sea snake (H. curtus)* *Elegant sea snake (H. elegans)* *Spectacled sea snake (H. kingii)*	*Trophic level (Productivity)*	ECOTF (T1, T2, M1, M2)	3	3	The listed sea snakes were assigned high (3) risk scores for the *trophic level* attribute as part of the PSA (Table 4). These scores, in part, reflect deficiencies in the diets and feeding behaviours of individual sea snake species. In the RRA, further consideration was given to the suitability and applicability of the PSA scores. A review of the available data, habitat preferences, energy flow and food sources, suggest sea snakes are tertiary consumers and occupy trophic levels at or around 4.00 (Padate *et al.*, 2009). ***Key changes to the PSA scores*** No change to the score, although this is an area where future ERAs could be refined and improved with additional information.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Turtle-headed sea snake (E. annulatus) *Olive-headed sea snake (H. major)* *Small-headed sea snake (H. macdowelli)* *Spotted sea snake (H. ocellatus)* *Horned sea snake (H. peronii)* *Beaked sea snake (H. zweifeli)* *Stoke's sea snake (H. stokesii)*					
<u>Sea snakes</u> *Turtle-headed sea snake (E. annulatus)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	1	The *encounterability* attribute was assessed on two key components: 1) the habitat preferences of the species when it is an adult and 2) its bathymetric preferences. These measures are overridden for air-breathing species which, based on the ERAEF approach, are assigned a default high-risk score (3) (Hobday *et al.,* 2007). The premise being that air-breathing animals need to access the surface and therefore have a higher potential of interacting with the gear across the entire fishing event *e.g.* during the trawl deployment, active

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					trawling and the retrieval processes. In-line with this methodology, all sea snakes were assigned a preliminary high risk (3) score for *encounterability*. As the turtle-headed sea snake (*Emydocephalus annulatus*) is an air-breathing species that is found across a wide range of environments (Great Barrier Reef Marine Park Authority, 2011; Lukoschek *et al.,* 2013), it was initially assigned a high-risk score for *encounterability*. However, the likelihood of a trawl vessel catching *E. annulatus* will vary across the ECOTF and be highly dependent on the target species. For example, *E. annulatus* is unlikely to be encountered in significant quantities in offshore operations including those targeting eastern king prawns. *Emydocephalus annulatus* is more likely to be encountered in inshore regions and by fishers targeting prawns in waters adjacent to coral reefs *e.g.* red spot king prawns. However, the species was not reported in a study of sea snake bycatch (Courtney *et al.,* 2010) and it is encountered with less frequency in the ECOTF (Lukoschek *et al.,* 2007). This can be attributed to *E. annulatus* having a strong association with reef habitats (Lukoschek *et al*., 2007; Courtney *et al.*, 2010; Great Barrier Reef Marine Park Authority, 2011; Lukoschek *et al*., 2013) and shallow water environments (Great Barrier Reef Marine Park Authority, 2011). As part of the RRA, consideration was given to a) the type of operations that are more likely to interact with this species, and b) the frequency/number of *E. annulatus* interactions across the entire ECOTF. When these factors were taken into consideration, the PSA score for this attribute was viewed as a risk overestimate. ***Key changes to the PSA scores***

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Comparisons between the ECOTF effort footprint and distributional/habitat data, suggests that the initial score assigned to this attribute was an overestimate. This inference is supported by information contained within a previous study examining sea snake interactions in the broader East Coast Trawl Fishery (Courtney *et al.,* 2010). Accordingly, the *encounterability* attribute score for *E. annulatus* was reduced from high (3) to low (1). The decision to reduce the score for this attribute is based on the fact that this species has a strong association with environments that are less conducive to trawling operations. The above changes were done in accordance with *Guideline 2: additional scientific assessment & consultation* and further consideration given to *Guideline 3: at risk with spatial assumptions*.
Sea snakes *Reef shallows sea snake (A. duboisii)* *Mosaic sea snake (A. mosaicus)* *Olive sea snake (A. laevis)* *Spine-bellied sea snake (H. curtus)* *Elegant sea snake (H. elegans)*	*Selectivity (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	When the baseline criteria for *selectivity* were applied to the sea snake complex, all 13 species were assigned precautionary high (3) risk scores. In the RRA, the suitability and applicability of these scores were reviewed. There have been several studies observing the effectiveness of TEDs and Bycatch Reduction Devices (BRDs) on sea snake catch rates (Raudzens, 2007; Milton *et al.*, 2009; Courtney *et al.*, 2010). While demonstrating varying degrees of effectiveness, this research has shown that the use of an effective BRD can reduce the number of sea snakes landed in trawl operations (Raudzens, 2007; Milton *et al.*, 2009; Courtney *et al.*, 2010). In the ECOTF, research has shown that using a fisheye BRD and/or a square mesh codend with a TED will reduce the number of sea snakes landed (by up to around 63 per cent; Courtney *et al.*, 2010). Similar studies in northern Australia demonstrated that the use of a popeye fishbox reduced sea snake bycatch by 87 per cent (Raudzens, 2007). This research also showed that variations within

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Spectacled sea snake (H. kingii) *Turtle-headed sea snake (E. annulatus)* *Olive-headed sea snake (H. major)* *Small-headed sea snake (H. macdowelli)* *Spotted sea snake (H. ocellatus)* *Horned sea snake (H. peronii)* *Beaked sea snake (H. zweifeli)* *Stoke's sea snake (H. stokesii)*					the configuration and placement of these BRDs will impact their effectiveness (Raudzens, 2007; Courtney *et al.*, 2010). In the ECOTF, operators are required to have trawl nets fitted with an approved BRD (State of Queensland, 2019). This requirement takes into consideration research on BRD effectiveness and includes regionally specific variations. For example, sea snakes are more likely to be encountered in the central management region where operators target scallops and red spot king prawns. In these areas, trawl operations can only use BRD designed that have proven to be effective at excluding sea snakes from the prawn trawl catch (State of Queensland, 2019). Regional nuances applied to BRD requirements are specifically designed to minimise sea snake landings in the ECOTF. These nuances are of considerable importance when a) considering the probability that a sea snake will be retained in the codend of a trawl net and b) assessing net selectivity as part of a trawl ERA. ***Key changes to the PSA scores*** The available information supports a downgrading of the *selectivity* scores from high (3) to medium (2). This decision was based on the fact that the ECOTF has a management regime that enforces the use of BRD designs that have a proven track record of excluding sea snakes from the trawl catch (State of Queensland, 2019). While sea snakes are still caught by trawl operations, the overall *selectivity* risk for this subgroup has been mitigated in key areas. A medium (2) risk rating may still overestimate the *selectivity* risk for some species. The extent of the risk score reduction though was limited by uncertainty surrounding sea snake catch compositions, interaction rates and release fates.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					With improved information including validated data on interaction rates, catch compositions and catch locations, a number of the listed species could (potentially) have their *selectivity* risk scores reduced. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*. The inclusion of 'spatial assumptions' reflects the fact that sea snake interactions across the ECOTF are not uniform and will be more pronounced in key areas, namely central Queensland.
Sea snakes *Reef shallows sea snake (A. duboisii)* *Mosaic sea snake (A. mosaicus)* *Olive sea snake (A. laevis)* *Elegant sea snake (H. elegans)* *Olive-headed sea snake (H. major)* *Stoke's sea snake (H. stokesii)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	2–3	1	Trawl mortality rate data for the list species varied between studies and regions (Milton, 2001; Wassenberg *et al.*, 2001; Milton *et al.*, 2009; Courtney *et al.*, 2010). In the PSA, the highest post-release mortality estimate was used to assign preliminary risk scores (Table 4). This was consistent with the conservative nature of the PSA methodology and minimised the risk of a false-negative result. As part of the RRA, a broader review of the available data was undertaken to determine if the scores assigned in the PSA were appropriate. Further consideration was also given to studies with higher sample numbers as they (arguably) provide a better indication of post-interaction survival rates. This review indicated that the PSA over-estimated the *post-interaction mortality* risk for a number of species. For example, the reef shallows sea snake (*Aipysurus duboisii*) was initially assigned a medium (2) risk for *post-interaction mortality* based on survivability estimates (62–73 per cent) from northern Australia (Milton, 2001). However, a more recent regional assessment indicated that survival rates for *A. duboisii* were higher in the ECOTF (95 per cent; Courtney *et al.*, 2010). As the Courtney *et al.* (2010) analysis had a larger

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					sample number (*n* = 465), it was adopted as the primary reference for *A. duboisii*. Survival data used in the PSA and the subsequent RRA for the remaining species were as follows: - *A. mosaicus*: PSA survival estimate = 74–87 per cent (moderate survival); RRA survival estimate = 94–94.7 per cent. - *A. laevis*: PSA survival estimate = 74–87 per cent (moderate survival); RRA survival estimate = 90.3 per cent. - *Hydrophis elegans*: PSA survival estimate = 67 per cent; RRA survival estimate = 83 per cent. - *H. major*: PSA survival estimate = 62–73 per cent (low survival); RRA survival estimate = 87 per cent. - *H. stokesii*: PSA survival estimate = 56 per cent; RRA survival estimate = 90 per cent. Key references considered as part of the RRA included: (Milton, 2001; Wassenberg *et al.*, 2001; Milton *et al.*, 2009; Courtney *et al.*, 2010). ***Key changes to the PSA scores*** As a result of RRA, risk ratings assigned to *post-interaction mortality* decreased from a high (3) to low (1) for *H. stokesii* and from medium (2) to low (1) for *A. duboisii, A. mosaicus, A. laevis, H. elegans* and *H. major*. These changes were made in accordance with *Guideline 1: rating due to missing, incorrect, or out of date information* and *Guideline 2: additional scientific assessment & consultation.*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Sea snakes *Spectacled sea snake (H. kingii)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	Estimates of *Hydrophis kingii* survival rates in trawl fisheries range from 50–100 per cent (Milton, 2001; Milton *et al.*, 2009; Courtney *et al.*, 2010). This variability contributed to the species being assigned a precautionary high (3) risk rating for *post-interaction mortality* as part of the PSA. In the RRA, a broader review of the available data was undertaken to determine if the scores assigned in the PSA were appropriate. Further consideration was also given to studies with higher sample numbers as they (arguably) provide a better indication of post-interaction survival rates. This review of the available data indicated that the PSA over-estimated the *post-interaction mortality* risk for this species. The PSA score for this species was based on survivability estimates (50 per cent) from northern Australia (Milton *et al.,* 2009). However, a more recent regional assessment indicated that survival rates for *H. kingii* were higher in the ECOTF (>70 per cent; Courtney *et al.*, 2010). As the Courtney *et al.* (2010) analysis had a larger sample number (*n* = 30 *vs.* 4), it was adopted as the primary reference for *H. kingii*. ***Key changes to the PSA scores*** The score assigned to this attribute was reduced from a high (3) to medium (2). This change was made in accordance with *Guideline 1: rating due to missing, incorrect, or out of date information* and *Guideline 2: additional scientific assessment & consultation.*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
<u>Sea snakes</u> *Turtle-headed sea snake (E. annulatus)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	1	2	Available information on post-interaction mortalities for the turtle-headed sea snake (*Emydocephalus annulatus*) suggests that the species demonstrates high post-release survival (Wassenberg *et al.,* 2001). Based on this data, the species was assigned a low (1) risk score in the PSA for *post-interaction mortality*. As part of the RRA, additional consideration was given to the suitability of this score and the dynamics of the baseline assessment. The study used to assign the PSA score had a low sample size (*n* = 2) and was based on fin-fish trawls (Wassenberg *et al.,* 2001). These factors introduced a degree of uncertainty into the assessment that may not have been adequately considered in the PSA. ***Key changes to the PSA scores*** The score assigned to this attribute was increased from a low (1) to medium (2) to better account for assessment uncertainty. While some consideration was given to increasing the score to high (3), the remaining members of this complex have been assigned risk scores of low (1) or medium (2). Therefore it is reasonable to assume that *E. annulatus*, at worst, is exposed to a moderate level of risk for this attribute. Changes made as part of the RRA were done in accordance with *Guideline 1: rating due to missing, incorrect, or out of date information* and *Guideline 2: additional scientific assessment & consultation*.
<u>Sea snakes</u>	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	2	2	Information on *post-interaction mortality* rates for the small-headed sea snake (*Hydrophis macdowelli*) is highly varied (Milton, 2001; Wassenberg *et al*., 2001; Milton *et al*., 2009; Courtney *et al*., 2010). This variability resulted in *H.*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Small-headed sea snake (H. macdowelli)					*macdowelli* being assigned a medium (2) score for the *post-interaction mortality* attribute (Table 4). Many studies have observed high post-release survival rates for *H. macdowelli i.e.* between 66.7–100 per cent (Milton, 2001; Wassenberg *et al.*, 2001; Milton *et al.*, 2009). The study by Courtney *et al.* (2010) though had the most robust sample size (*n* = 153) and was regionally specific. Accordingly, Courtney *et al.* (2010) was adopted as the baseline assessment for *post-interaction mortalities* of *H. macdowelli*. ***Key changes to the PSA scores*** No change to the score, although this is an area where future ERAs could be refined and improved with additional information on sea snake interaction rates, capture locations and release fates.
<u>Sharks</u> *Collared carpetshark (P. collare)* *Colclough's shark (B. colcloughi)* *Eastern angelshark (S. albipunctata)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	*Age at sexual maturity* is not known for the collared carpetshark (*Parascyllium collare*), Colclough's shark (*Brachaelurus colcloughi*) and the eastern angelshark (*Squatina albipunctata*). As a consequence, all three were assigned a precautionary high (3) score for *age at maturity*. Data on morphologically similar species, suggests *P. collare*, *B. colcloughi* and *S. albipunctata* all reach sexual maturity within 15 years. This information was accounted for in the RRA and *age at maturity* scores were amended using the following proxies. - The brownbanded bambooshark (*Chiloscyllium punctatum*) was used as the proxy for *P. collare*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					- The blind shark (*Brachaelurus waddi*) was used as the proxy for *B. colcloughi* (Kyne *et al.,* 2015). - The Pacific angelshark (*Squatina californica*) was uses as the proxy for *S. albipunctata*. ***Key changes to the PSA scores*** The score assigned to this attribute was reduced from high (3) to medium (2). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation*.
<u>Sharks</u> *Australian weasel shark (H. australiensis)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	1	*Age at sexual maturity* for the Australian weasel shark *(Hemigaleus australiensis)* is not known and the species was assigned a precautionary high (3) score for this attribute. However, age and growth data for morphologically similar species indicates *H. australiensis* will reach sexual maturity before five years of age. For example, the fossil shark (*Hemipristis elongata*), the milk shark (*Rhizoprionodon acutus*) and Australian sharpnose shark (*R. taylori*) all reach sexual maturity at or around three years of age (Kyne *et al.,* 2021). While species-specific data is lacking for *H. australiensis*, maturity estimates for the aforementioned species were viewed as suitable proxies. ***Key changes to the PSA scores*** The score assigned to this attribute was reduced from high (3) to low (1). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Sharks *Zebra shark (S. tigrinum)* *Crested hornshark (H. galeatus)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	There is limited information on the age and growth of the zebra shark (*Stegostoma tigrinum*) and the crested hornshark (*Heterodontus galeatus*). This absence of data was reflected in the PSA where both species were assigned a precautionary high (3) score for *age at maturity*. While noting this deficiency, information obtained from captive individuals supports the hypothesis that both *S. tigrinum* and *H. galeatus* reach sexual maturity in less than 15 years (Kyne *et al.,* 2021). ***Key changes to the PSA scores*** While species-specific data is lacking for wild *S. tigrinum* and *H. galeatus*, maturity estimates from captive individuals were viewed as reasonable proxies. In line with this approach, scores assigned to this attribute were reduced from high (3) to medium (2). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation*.
Sharks *Eastern banded catshark (A. marnkalha)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	There is limited information on the age and growth of the eastern banded catshark (*Atelomycterus marnkalha*) and the species was assigned a precautionary high (3) risk score for *age at sexual maturity* (Table 4). Subsequent consultation on the biological constraints of this species indicated that the *age at sexual maturity* would most likely be less than 15 years (*pers. comm.* I. Jacobsen). ***Key changes to the PSA scores*** Based on the advice provided, preliminary scores assigned to this attribute were decreased from high (3) to medium (2). This change was done in accordance

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation*.
<u>Sharks</u> *Pale spotted catshark (A. pallidus)* *Grey spotted catshark (A. analis)* *Orange spotted catshark (A. rubiginosus)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	The listed species were assigned a precautionary high (3) risk score in the PSA for *age at sexual maturity*. Subsequent consultation on the biology of deepwater catsharks indicated the pale spotted catshark (*Asymbolus pallidus*), the grey spotted catshark (*A. analis*) and the orange spotted catshark (*A. rubiginosus*) would all (likely) reach sexual maturity within 12 years. These ages are based on proxy age parameters from the blacktip sawtail catshark (*Galeus sauteri*) scaled to size (*pers. comm.* C. Rigby). ***Key changes to the PSA scores*** Based on the advice provided, preliminary scores assigned to this attribute were decreased from high (3) to medium (2). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation*.
<u>Sharks</u> *Collared carpetshark (P. collare)* *Colclough's shark (B. colcloughi)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	The *maximum age* for the collared carpetshark (*Parascyllium collare*) and the Colclough's shark (*Brachaelurus colcloughi*) is not known and the two species were assigned a precautionary high (3) score for this attribute. However, information on the age and growth in morphologically similar species, indicates that *P. collare* and *B. colcloughi* attain a *maximum age* of between 10–25 years. While lacking species-specific data, age estimates for the brownbanded bambooshark (*Chiloscyllium punctatum*) and blind shark (*B. waddi*) were considered acceptable proxies for *P. collare* and *B. colcloughi* respectively (Kyne *et al.,* 2015; Kyne *et al.,* 2021).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Key changes to the PSA scores Scores assigned to this attribute were reduced from high (3) to medium (2). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation*.
<u>Sharks</u> *Eastern angelshark (S. albipunctata)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	3	The *maximum age* for the eastern angelshark (*Squatina albipunctata*) is not known and the species was assigned a precautionary high (3) score for this attribute (Table 4). In the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021), the Pacific angelshark (*S. californica*) was used as a proxy in generation length estimates involving *S. albipunctata*. The RRA adopted a similar approach and used *S. californica maximum age* estimates (>25 years) as a proxy for *S. albipunctata* (Cailliet *et al.,* 1992). ***Key changes to the PSA scores*** As the proxy value exceeded the threshold for a high-risk rating, the score for this attribute was not amended as part of the RRA. Further refinements to this attribute score will require additional information.
<u>Sharks</u> *Zebra shark (S. tigrinum)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	3	Information on the age and growth of the zebra shark (*Stegostoma tigrinum*) is limited and the species was assigned a precautionary high (3) score for *maximum age*. However, information from captive *S. tigrinum* indicates the species can live for >25 years (Kyne *et al.,* 2021). In the absence of a *maximum age* estimate from wild-caught *S. tigrinum*, age estimates based on captive individuals were used as a proxy.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Key changes to the PSA scores The original high (3) score for this attribute was retained; recognising that captive animals may live longer. Further refinements to this attribute score will require additional information.
Sharks *Australian weasel shark (H. australiensis)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	As the *maximum age* for the Australian weasel shark *(Hemigaleus australiensis)* is unknown, it was assigned a precautionary high (3) score in the PSA (Table 4). However, maximum age estimates from morphologically similar species suggests that the *maximum age* will be less than 25 years. For example, maximum age estimates for the fossil shark (*Hemipristis elongata*), the milk shark (*Rhizoprionodon acutus*) and Australian sharpnose shark (*R. taylori*) are all 15 years or less (Kyne *et al.,* 2021). ***Key changes to the PSA scores*** The score assigned to this attribute was reduced from high (3) to medium (2). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation*.
Sharks *Eastern banded catshark (A. marnkalha)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	There is limited information on the age and growth of the eastern banded catshark (*Atelomycterus marnkalha*) and the species was assigned a precautionary high (3) risk score for *maximum age* (Table 4). Subsequent consultation on the biological constraints of this species indicated that the *maximum age* would most likely be less than 25 years (*pers. comm.* I. Jacobsen). ***Key changes to the PSA scores***

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Based on the advice provided, preliminary score assigned to this attribute was decreased from high (3) to medium (2) for this species. This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Sharks *Pale spotted catshark (A. pallidus)* *Grey spotted catshark (A. analis)* *Orange spotted catshark (A. rubiginosus)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2–3	The listed species were assigned a high (3) risk score in the PSA for the *maximum age* attribute (Table 4). Subsequent consultation on deepwater catshark biology indicated the *maximum age* for these species, with the exclusion of the grey spotted catshark *(Asymbolus analis),* would be less than 25 years (*pers. comm.* C. Rigby). Further consultation revealed that the *maximum age* for *A. analis* would likely be greater than 25 years (*pers. comm.* C. Rigby). These ages are based on proxy age parameters from the blacktip sawtail catshark (*Galeus sauteri*) scaled to size (*pers. comm.* C. Rigby). ***Key changes to the PSA scores*** Based on the advice provided, preliminary scores for *A. pallidus* and *A. rubiginosus* were reduced from high (3) to medium (2). The preliminary score for *A. analis* (3) was retained. Changes were done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Sharks *Collared carpetshark (P. collare)*	*Fecundity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	3	Little is known about the age, growth and development of the collared carpetshark (*Parascyllium collare*); something that was reflected in the PSA. As fecundity levels have not been quantified for this species, it was assigned a precautionary high (3) rating for *fecundity*. The species though is oviparous with females enclosing their eggs in tough cases before laying them on, or attaching them to substrate (Carrier *et al.,* 2004). Oviparity is only found in three shark

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					families (*Heterodontidae*, *Scyliorhinidae*, and *Orectolobidae*) and one family of skates (within the Order *Rajiformes*). While oviparous species are (generally) more fecund, further research is required on annual egg production. In species like the brownbanded bambooshark (*Chiloscyllium punctatum*), annual fecundity levels can exceed 100 eggs (Suksuwan & Boonyanate, 2002; Onimaru *et al.*, 2018). Egg production estimates for other species are lower *e.g.* 20–50 eggs per year (Musa *et al.*, 2018; Dodd *et al.*, 2022). In the RRA, some consideration was given to lowering the *fecundity* attribute score for *P. collare*. The premise being that fecundity levels for this species may be comparable to similar-sized egg laying species *e.g. C. punctatum*. However, a review of the available information indicated that annual egg estimates for elasmobranchs display a high degree of interspecific variability. ***Key changes to the PSA scores*** No change to the score, although this is an area where future ERAs could be refined and improved with additional information.
<u>Sharks</u> *Collared carpetshark (P. collare)* *Crested hornshark (H. galeatus)*	*Availability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	1	Criteria used to assess *availability* is effective for species whose distributions have moderate to high overlap with the fishery and species whose distribution occurs solely within the prescribed fishing area. This criterion though has the potential to overestimate the *availability* risk for species whose distributions have a marginal overlap with the ECOTF effort footprint. In the RRA, further consideration was given to the suitability of the PSA scores assigned to the listed species and their relevance to the entire ECOTF.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Grey spotted catshark (A. analis) *Orange spotted catshark (A. rubiginosus)*					Distributions of the crested hornshark (*Heterodontus galeatus*) and collared carpetshark (*Parascyllium collare*) are confined to a smaller section of southern Queensland. The situation surrounding the grey spotted catshark (*Asymbolus analis*) and the orange spotted catshark (*A. rubiginosus*) is similar in that the depth profile of both species provide them with a degree of natural protection. Subsequent analysis also revealed that *P. collare*, *H galeatus*, *A. analis* and *A. rubiginosus* occurred in less than 15 per cent of the area accessed/fished by ECOTF operations. This suggests that, while *P. collare*, *H galeatus*, *A. analis* and *A. rubiginosus* occur in areas with more concentrated fishing effort, the PSA likely over-estimated the *availability* risk. ***Key changes to the PSA scores*** The preliminary score assigned to this attribute in the PSA was decreased from high (3) to low (1). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information, Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*. As the assessment method is precautionary, reducing the *availability* score for these species will not contribute to the production of a false-positive result. The adoption of a more flexible approach for species with marginal overlaps also aligns with strategies applied in other ERAs including comparable assessments completed as part of the national *Ecological Risk Assessment for the Effects of Fishing* (ERAEF) process (Hobday *et al.*, 2011; Australian Fisheries Management Authority, 2023a).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Sharks *Collared carpetshark (P. collare)* *Grey spotted catshark (A. analis)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	Habitat descriptions for the listed species indicate that they are found in a wide range of environments (Kyne & Bennett, 2015a; Bray, 2018a; Kyne *et al.*, 2021). In the PSA, this broad habitat profile resulted in the collared carpetshark (*Parascyllium collare*) and the grey spotted catshark *(Asymbolus analis)* being assigned a high (3) risk score for *encounterability*. In the RRA, further consideration was given to the suitability of these scores and any confounding factors that may have contributed to a risk overestimate. *Parascyllium collare* and *A. analis* have a demonstrated affinity for cooler, temperate waters and interactions will be limited to these regions. This by extension limits the likelihood of these species being encountered across the entire ECOTF. For example, *A. analis* is unlikely to be encountered in significant quantities in operations targeting tiger, endeavour and red spot king prawns in the central and northern regions. A general preference for deeper water environments would further reduce the encounterability risk for this species. While *P. collare* may interact with a wider cross-section of trawl fishing activities, a number of factors reduce the encounterability potential for this species. This is reflected in the *Action Plan for Australian Sharks and Rays* which indicates that *P. collare* are caught in very low numbers in the northern part of its range (Kyne *et al.,* 2021). The habitat preferences of *P. collare* also includes hard bottom substrates (amongst a variety of other habitats) which provides the species with a degree of natural protection from trawl fishing activities (Kyne *et al.,* 2021). In the RRA, further consideration was given to a) the type of operations that are more likely to interact with these species, and b) the prevalence of *A. analis* and *P. collare* interactions across the entire fishery. When these factors were considered in the context of the entire ECOTF, it was determined that the use of

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					broader habitat and bathymetry descriptions contributed to an overestimate of the *encounterability* risk. This inference is supported by ECTF bycatch composition assessments and previous risk assessments involving *A. analis* and *P. collare* (Campbell *et al.,* 2017). ***Key changes to the PSA scores*** The *encounterability* attribute scores for *P. collare* and *A. analis* were reduced from high (3) to medium (2). The decision to reduce the scores for this attribute is based on a weight-of-evidence approach and considers habitats/bathymetries preferred by these species. Changes enacted as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and further consideration given to *Guideline 3: at risk with spatial assumptions*.
<u>Sharks</u> *Orange spotted catshark (A. rubiginosus)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	1	Habitat and bathymetric descriptions for the orange spotted catshark (*Asymbolus rubiginosus*) are broad (Kyne & Bennett, 2015b; Kyne *et al.*, 2021) and resulted in the species being assigned a high (3) risk score for *encounterability* (Table 4). In the RRA, further consideration was given to the suitability of this score and any confounding factors that may have contributed to a risk over-estimate. This review identified factors analogous to that observed for the grey spotted catshark *(A. analis)* and the collared carpetshark (*Parascyllium collare*). However, the encounterability potential for this species was considered to be lower as it has a wider depth profile *i.e.* 25–540 m *versus* 25–200 m for *A. analis* (Kyne *et al.,* 2021). This inference is supported by information contained within a previous study on elasmobranch bycatch compositions which recorded 21 *A. rubiginosus* interactions across 1,175 trawl shots (Campbell *et al.,* 2017).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Key changes to the PSA scores The *encounterability* attribute score for *A. rubiginosus* was reduced from high (3) to low (1). The decision to reduce the attribute score was based on the fact that this species has: a) a stronger association with deeper water environments which provide it with a degree of natural protection; and b) the interaction potential being limited across the entire ECOTF due to a preference for temperate water environments. Changes applied in the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and further consideration given to *Guideline 3: at risk with spatial assumptions*.
<u>Sharks</u> *Brownbanded bambooshark (C. punctatum)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	Habitat and bathymetric descriptions for the brownbanded bambooshark (*Chiloscyllium punctatum*) are broad (Last & Stevens, 2009; Ebert *et al.*, 2021; Kyne *et al.*, 2021) and resulted in the species being assigned a high (3) risk score for *encounterability* (Table 4). In the RRA, further consideration was given to the suitability of this score and any confounding factors that may have contributed to a risk over-estimate. The ECOTF operates in a diverse range of inshore and offshore environments, and depth is only limited by operational constraints. The likelihood of a trawl vessel catching *C. punctatum* will vary across the fishery and be dependent on the species being targeted. For example, *C. punctatum* is less likely to be encountered in significant quantities within operations targeting prawns in deeper water environments. This species is prevalent within the ECOTF and displays the potential to interact with multiple regions. Previous studies have recorded interactions within the eastern king prawn, scallop and the northern tiger and endeavour prawn sectors (Courtney *et al.*, 2007b; Pears *et al.*, 2012b). Despite being widespread, data

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					indicates that *C. punctatum* interactions are (comparatively) low (Courtney *et al.*, 2007b; Pears *et al.*, 2012b). As part of the RRA, consideration was given to a) the type of operations that are more likely to interact with this species and b) the prevalence of interactions across the entire fishery. When these factors were considered in the context of the entire ECOTF, the score assigned to this attribute was viewed as an overestimate. This inference is supported by the limited observation rates within previous trawl bycatch studies (Courtney *et al.*, 2007b; Pears *et al.*, 2012b). ***Key changes to the PSA scores*** In the RRA, the *encounterability* attribute score for this species was reduced from high (3) to medium (2). This decision was largely based on the habitat preferences of *C. punctatum* and how they relate to the current effort footprint. As the RRA decision applies a weight-of-evidence approach, it is more qualitative in nature. However, the amended score better reflects the *encounterability* risk for this species. The decision to reduce this score is not expected to contribute to a false-negative result (*pers. comm.* I. Jacobsen). The above changes were done in accordance with *Guideline 2: additional scientific assessment & consultation* and further consideration given to *Guideline 3: at risk with spatial assumptions*.
<u>Sharks</u> *Crested hornshark (H. galeatus)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	1	Habitat and bathymetric descriptions for the crested hornshark (*Heterodontus galeatus*) are broad (Last & Stevens, 2009; Ebert *et al.*, 2021; Kyne *et al.*, 2021) and resulted in the species being assigned a high (3) risk score for *encounterability* (Table 4). In the RRA, further consideration was given to the

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					suitability of this score and any confounding factors that may have contributed to a risk over-estimate. The *encounterability* review for *H. galeatus* shared similarities with the brownbanded bambooshark (*Chiloscyllium punctatum*). While the species is found in waters accessed by trawl fishers, a number of factors limit its interaction potential in the ECOTF. For example, *H. galeatus* is found in a comparatively small section of Queensland waters. Within this range, the species utilises a range of soft and hard substrates such as rocky reefs, seagrass beds and sandy environments (Bray, 2020c). This includes within *Moreton Bay Marine Park* where the species would be afforded considerable protection from trawl fishing activities. These factors reduce the encounterability potential for this species, noting that it has been observed in operations targeting eastern king prawns (Campbell *et al.,* 2017). As part of the RRA, consideration was given to a) the type of operations that are more likely to interact with this species, and b) the prevalence of interactions across the entire fishery. When these factors were considered in the context of the entire ECOTF, the score assigned to this attribute was viewed as an overestimate. ***Key changes to the PSA scores*** Based on the available information, the preliminary score assigned to the *encounterability* attribute was reduced from high (3) to low (1). This decision was largely due to the fact that *H. galeatus* distribution and habitat preferences would reduce the encounterability potential for this species (Kyne *et al.,* 2021). As the RRA decision applies a weight-of-evidence approach, it is more

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					qualitative in nature. However, the amended score better reflects the *encounterability* risk for this species. The decision to reduce this score is not expected to contribute to a false-negative result (*pers. comm.* I. Jacobsen). Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.
<u>Sharks</u> *Piked spurdog (S. megalops)* *Pale spotted catshark (A. pallidus)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	1	Habitat and bathymetric descriptions for the piked spurdog (*Squalus megalops*) and the pale spotted catshark (*Asymbolus pallidus*) are broad (Last & Stevens, 2009; Ebert *et al.*, 2021; Kyne *et al.*, 2021); resulting in the species being assigned a PSA score of high (3) for *encounterability* (Table 4). For example, the depth profile for *S. megalops* is listed as 0–732 m with *A. pallidus* occupying waters from 225–400 m (Kyne *et al.,* 2021). For *S. megalops*, evidence suggests that the species is most abundant on the outer continental shelf and upper slopes. This (general) preference for deeper water environments provides the species with some refuge from trawl fishing activities. For *A. pallidus*, the ECOTF would operate in environments and substrates where this species is found. However, its general depth profile would limit the extent of these interactions (and the *encounterability* risk). With that said, evidence suggests that both species will be caught in the ECOTF (Rigby *et al.*, 2016b). Across the entire ECOTF, both *S. megalops* and *A. pallidus* would be afforded considerable protection or refuge from trawl fishing activities (Campbell, 2022) and the *encounterability* risk will be lower than what is reported in the PSA. ***Key changes to the PSA scores***

Species	**Attribute**	**Sub-fishery**	**PSA Score**	**RRA Score**	**Justifications and Considerations**
					Preliminary scores assigned to this attribute overestimate the *encounterability* risk for *S. megalops* and *A. pallidus*. This inference is supported by information contained in previous studies examining elasmobranch bycatch in trawl fisheries (Rigby *et al*., 2016b; Campbell, 2022). Accordingly, the *encounterability* attribute score for both *S. megalops* and *A. pallidus* was reduced from high (3) to low (1). The decision to reduce the scores for this attribute recognises a) the level of natural protection each species is afforded from trawl fishing activities and b) the restricted nature of trawl interactions *i.e.* largely confined to deeper water environments. The above changes were done in accordance with *Guideline 2: additional scientific assessment & consultation* and further consideration given to *Guideline 3: at risk with spatial assumptions*.
Sharks *Eastern angelshark (S. albipunctata)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	The depth profile of the eastern angelshark (*Squatina albipunctata*) is considerable; extending from 35 m down to 415 m (Kyne *et al.,* 2021). While some of this range overlaps with trawl effort, populations deeper than 250 m will be protected from trawl fishing activities (Campbell, 2022). In the PSA, the species was assigned a high (3) rating for *encounterability* due, in part, to its broad distribution. However, the probability of encountering this species across the entire ECOTF will be lower than what is presented in the PSA. The *Action Plan for Australian Sharks and Rays* indicates that regional *S. albipunctata* populations have declined (Kyne *et al.,* 2021). This report notes though that fishing pressures for this species are more pronounced in southern jurisdictions; namely in the Commonwealth managed *Southern and Eastern Scalefish and Shark Fishery (Kyne et al., 2021)*. This report further noted that fishing pressures are lower in Queensland; particularly off the coast of northeast Queensland (Kyne *et al.,* 2021). One explanation for this is that a proportion of

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					the Queensland *S. albipunctata* population occurs at depths not accessed by the ECOTF. ***Key changes to the PSA scores*** A weight-of-evidence approach suggests that the PSA overestimated the *encounterability* risk for this species. In line with this assessment, the score assigned to the *encounterability* attribute was decreased from high (3) to medium (2). It is recognised that a medium (2) risk rating for *encounterability* may still be conservative. While noting this possibility, any further refinement of the *encounterability* score will require further information on *S. albipunctata* interaction rates. Changes made to the *S. albipunctata* risk profile were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*. The amended score better reflects the current situation (Kyne *et al.,* 2021) and the change is unlikely to contribute to or create a false-negative result.
<u>Sharks</u> *Eastern banded catshark (A. marnkalha)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	The eastern banded catshark (*Atelomycterus marnkalha*) is a small endemic species found along the Queensland east coast and in the Gulf of Carpentaria (*maximum length* = 49 cm TL; Jacobsen & Bennett, 2007; Kyne *et al.,* 2021). Information on this species is based on a small number of specimens and further information is required on its distribution, biology and life-history constraints (*pers. comm.* I. Jacobsen). *Atelomycterus marnkalha* is found in water depths up to 75 metres and it will be caught infrequently as bycatch in inshore trawl operations.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					At present, it is difficult to ascertain how extensively this species interacts with the ECOTF. However, *A. marnkalha* is a relatively uncommon species and it is expected to have a naturally low abundance (*pers. comm.* I. Jacobsen). The distribution of *A. marnkalha* includes a large expanse of the GBRMP (Jacobsen & Bennett, 2007; Bates & Kyne, 2019) and it will yield some benefit from the *Representative Areas Program*. Anecdotal evidence also suggests that habitat preferences for this species include (at least in part) harder substrates or environments with coarser rock/rubble sediments that are less conducive to trawl fishing (Jacobsen & Bennett, 2007; Bates & Kyne, 2019). This again will provide the species with a level of protection from trawl fishing activities. When compared to the GBRMP, *A. marnkalha* interactions are less likely in southern Queensland waters. This region makes up a small component of the *A. marnkalha* distribution and trawl fishing poses a much smaller risk in these areas (*pers. comm.* I. Jacobsen). ***Key changes to the PSA scores*** Based on the available information, the preliminary score assigned to the *encounterability* attribute was reduced from high (3) to medium (2). This decision was based on the fact that the species will be afforded a comparatively high degree of protection in the GBRMP and occupies habitats less conducive to trawl fishing activities. It is recognised that a medium rating may still overestimate the *encounterability* risk for this species. However, the extent of any further score reductions was limited by data deficiencies. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Sharks *Colclough's shark (B. colcloughi)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	The Colclough's shark (*Brachaelurus colcloughi*) sample size is comparatively small with life-history data based on fewer than 80 individuals. Limited research on this species indicates that *B. colcloughi* has a conservative life-history, low productivity and a small, dispersed east-coast population (Kyne *et al.*, 2011a; Kyne *et al.*, 2021). Anecdotal evidence also suggests that this species has a naturally low abundance (*pers. comm.* I. Jacobsen). This absence of information resulted in *B. colcloughi* being assigned a number of precautionary high (3) risk ratings as part of the PSA including *post-interaction mortality*. While limited information is available for *B. colcloughi*, other morphologically similar species provide some insight into the potential for this species to survive a trawl fishing event. The brownbanded bambooshark (*Chiloscyllium punctatum)* is morphologically similar to *B. colcloughi* and survives trawl events reasonably well. Evidence also suggests that other similar-sized benthic sharks (*e.g.* the crested hornshark, *Heterodontus galeatus*, the Port Jackson shark, *H. portusjacksoni* & wobbegongs, *Family Orectolobidae*) are relatively robust and have good post-interaction survival rates (Frick *et al.*, 2010; Braccini *et al.*, 2012; Kyne *et al.*, 2021). While difficult to quantify without additional data, the above suggests that there is sufficient evidence to move away from the precautionary high rating. ***Key changes to the PSA scores*** The score assigned to the *post-interaction mortality* for *B. colcloughi* was reduced from high (3) to medium (2) based on what is known about post-interaction mortalities for sharks with similar morphologies and life-histories. While the decision to reduce the score assigned to this attribute is (largely) qualitative, there is a low probability of it contributing to a false-positive result.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					The final attribute score assigned to *B. colcloughi* is higher than assigned to reference species *i.e. H. galeatus* and *C. punctatum*. Other data deficiencies are also adequately covered as part of the broader *B. colcloughi* risk profile. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation*.
Sharks *Crested hornshark (H. galeatus)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	1	1	Information sets for the crested hornshark (*Heterodontus galeatus*) are less developed and the preliminary score assigned to this attribute was based on a small number of samples (*n* = 5; Kyne *et al.*, 2007a). As the sample number was low, the RRA assessed the suitability of this score. While the *post-interaction mortality* assessment was based on a small sample, the Port Jackson shark (*H. portusjacksoni*) has been identified as a reasonable proxy for this species (Kyne *et al.,* 2021). Post-interaction survivorship for *H. portusjacksoni* is comparatively high and similar observations can be expected for *H. galeatus*. ***Key changes to the PSA scores*** No change to the score. While the *H. galeatus* sample was small, a weight-of-evidence approach suggests that a low (1) risk score for this attribute is reasonable.
Sharks *Eastern banded catshark (A. marnkalha)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	2	2	The eastern banded catshark (*Atelomycterus marnkalha*) is a small endemic species found along the Queensland east coast and in the Gulf of Carpentaria (maximum length = 49 cm TL; Kyne *et al.,* 2021). Information on this species is based on a small number of specimens and further information is required on its biology and life-history constraints (*pers. comm.* I. Jacobsen).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					The score assigned to the *post-interaction mortality* for *A. marnkalha* was based on small number of samples (*n* = 23) and first-hand observations (*pers. obs.* I. Jacobsen; Jacobsen, 2007; Jacobsen & Bennett, 2007). In the RRA, the suitability and applicability of this score was reviewed. Evidence suggests that while a portion of the species will survive the trawl event, this species will also (likely) experience some level of fishing mortality. *Atelomycterus marnkalha* is a smaller species and mortalities may occur due to injuries (internal and external) incurred during the fishing event and/or crushing during the net retrieval process. Preliminary assessments and observations for this species though suggest that post-release survival rates for *A. marnkalha* will be better than other species. ***Key changes to the PSA scores*** No change to the score, although this is an area where future ERAs could be refined and improved with additional information.
<u>Sharks</u> *Grey spotted catshark (A. analis)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	2	3	The grey spotted catshark (*Asymbolus analis*) is a smaller endemic species found along the southern extent of the Queensland east coast (*maximum length* = 61 cm TL; Kyne *et al.,* 2021). As it is a comparatively small species, the use of a TED will be less effective in terms of excluding it from the prawn trawl catch. The preliminary PSA score was based on a study observing Chondrichthyan bycatch within the broader *East Coast Trawl Fishery* (Kyne, 2008). Limited information from this study (*n* = 6 specimens) indicated that three-quarters of the trawl-caught *A. analis* survived the event (Kyne, 2008). Accordingly, the species was assigned a medium risk rating for this attribute. As the assessment was

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					based on a limited number of samples (*n* = 6), it may not be an accurate reflection of the current fishing environment. While noting this preliminary assessment, there are a number of confounding factors that were not given adequate consideration as part of the PSA. For example, *A. analis* inhabits a broad range of depths (25–200 m) and is caught in the ECOTF in deeper water environments. While not universal, elasmobranchs caught in deeper waters often have poorer post-release survival rates. This is partly attributed to the fact that they are more susceptible to injuries (internal and external). This injury potential combined with a) uncertainty surrounding current interaction rates / release fates and b) the absence of a suitable proxy, supports the adoption of a more conservative approach. ***Key changes to the PSA scores*** The score assigned to *post-interaction mortality* was increased from medium (2) to high (3). This change reflects the fact that *A. analis* has a high probability of being landed if caught in the sweep of the net and the extent of the available information on interaction rates and release fates. The decision to increase the score assigned to this attribute is precautionary and aligns with the broader, more conservative approach applied in the ECOTF SOCC ERA. This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Batoids</u>	*Age at sexual maturity (Productivity)*	ECOTF	3	2	*Age at sexual maturity* for the Australian butterfly ray (*Gymnura australis*) is not known and the species was assigned a precautionary high (3) score for this attribute (Table 4). Subsequent consultation regarding the biology of this

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Australian butterfly ray (G. australis)		(T1, T2, M1, M2)			species indicated that it would most likely mature within 15 years (*pers. comm.* I. Jacobsen). ***Key changes to the PSA scores*** Based on the advice provided, preliminary scores assigned to this attribute were decreased from high (3) to medium (2). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation*.
<u>Batoids</u> *Yellowback stingaree (U. sufflavus)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	1	*Age at sexual maturity* for the yellowback stingaree (*Urolophus sufflavus*) is not known and the species was assigned a precautionary high (3) score in the PSA (Table 4). In the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021), it was hypothesised that the biology of *U. sufflavus* would be similar to other stingarees. Known information on the *age at sexual maturity* for other stingarees (*e.g.* the lobed stingaree, *U. lobatus*) indicates that *U. sufflavus* will reach sexual maturity in less than five years (Kyne *et al.,* 2021). ***Key changes to the PSA scores*** The score assigned to this attribute was reduced from high (3) to low (1). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Batoids</u> *Kapala stingaree (U. kapalensis)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	1	The *age at sexual maturity* for the kapala stingaree (*Urolophus kapalensis*), greenback stingaree (*U. viridis*) and the common stingaree (*Trygonoptera testacea*) is not known and these species were assigned precautionary high (3) scores in the PSA (Table 4). The masked stingaree (*T. personata*) was used as

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Greenback stingaree (U. viridis) *Common stingaree (T. testacea)*					a proxy to estimate the generation length of these species in the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021); therefore was considered an acceptable proxy. Known information on the *age at sexual maturity* for *T. personata* indicates that the listed species are likely to reach sexual maturity in less than five years (Kyne *et al.,* 2021). ***Key changes to the PSA scores*** Scores assigned to this attribute were reduced from high (3) to low (1) for all three species. This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Batoids *Patchwork stingaree (U. flavomosaicus)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	1	*Age at sexual maturity* for the patchwork stingaree (*Urolophus flavomosaicus*) is not known and the species was assigned a precautionary high (3) score in the PSA (Table 4). This absence of data makes it difficult to assess attributes involving the age and growth of *U. flavomosaicus*. However, studies on the growth of closely related species including from within the *Family Urolophidae* suggest that the *age at maturity* is most likely to be below five years of age (White *et al.*, 2001). ***Key changes to the PSA scores*** The score assigned to this attribute was reduced from high (3) to low (1). Amendments made as part of the RRA better reflect what is known about stingaree age and growth development. While this decision is more qualitative, a weight-of-evidence approach supports a downgrading of the score assigned to this attribute. This change was done in accordance with *Guideline 1: rating due*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					to missing, incorrect or out of date information and *Guideline 2: additional scientific assessment & consultation.*
Batoids *Australian whipray (H. australis)* *Brown whipray (M. toshi)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	While information on batoid life histories is improving, data deficiencies still remain. For species like the Australian whipray (*Himantura australis*) and the brown whipray (*Maculabatis toshi*), these deficiencies can be partly attributed to taxonomic changes and the splitting of closely related species (Manjaji-Matsumoto & Pogonoski, 2008; Last *et al.*, 2016b). As no species-specific data was available for *H. australis* and *M. toshi*, both were assigned a precautionary high (3) score for *age at maturity* (Table 4). A review of the available data indicates that the PSA scores for *age at sexual maturity* are likely overestimates. This inference is supported by studies on similar species (and potential conspecifics; *pers. comm.* I. Jacobsen) which show that the age at maturity is likely to be less than 15 years *e.g.* 8–10 years for the blackspotted whipray (*M. astra*; Jacobsen & Bennett, 2011). ***Key changes to the PSA scores*** The scores assigned to *age at maturity* for both *H. australis* and *M. toshi* were reduced from precautionary high (3) to medium (2). This change was done in accordance with *Guideline 2: additional scientific assessment & consultation* and will not contribute to the production of a false-positive result.
Batoids *Sydney skate (D. australis)*	*Age at sexual maturity (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	*Age at sexual maturity* for the Sydney skate (*Dentiraja australis*) and endeavour skate (*D. endeavouri*) is not known and the two species were assigned precautionary high (3) scores for this attribute. In the RRA, a broader

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Endeavour skate (D. endeavouri)					examination of skate biology was undertaken to determine if a suitable proxy could be found for one or both species. In the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021), the argus skate (*D. polyommata*) and whitespotted skate (*D. cerva*) were used as proxies to estimate generation length. Information on the *age at sexual maturity* for *D. polyommata* and *D. cerva* indicates that the species reach sexual maturity within five years (Kyne *et al.,* 2021). While species-specific data is lacking for *D. australis* and *D. endeavouri*, maturity estimates for *D. polyommata* and *D. cerva* were considered to be suitable proxies. ***Key changes to the PSA scores*** Scores assigned to this attribute were reduced from high (3) to medium (2). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Batoids</u> *Yellowback stingaree (U. sufflavus)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	The *maximum age* of the yellowback stingaree (*Urolophus sufflavus*) is not known and the species was assigned a precautionary high (3) score for this attribute. In the RRA, a broader examination of stingaree biology was undertaken to determine if a suitable proxy could be found. In the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021), the lobed stingaree (*U. lobatus*) was used as a proxy to estimate generation length of *U. sufflavus*. Given its previous use as a proxy, biological data for *U. lobatus* was applied to the *U. sufflavus* assessment. Data indicates that *U. lobatus* reaches a maximum age of between 10–25 years (Kyne *et al.,* 2021).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Key changes to the PSA scores The score assigned to this attribute was reduced from high (3) to medium (2). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Batoids</u> *Patchwork stingaree (U. flavomosaicus)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	The *maximum age* of the patchwork stingaree (*Urolophus flavomosaicus*) is not known and the species was assigned a precautionary high (3) score for this attribute. This absence of data makes it difficult to assess attributes involving the age and growth of *U. flavomosaicus*. However, studies on the growth of closely related species including from within the *Family Urolophidae* (White *et al.*, 2001) indicates that 10–25 years is an appropriate maximum age estimate for this species. ***Key changes to the PSA scores*** The score assigned to this attribute was reduced from high (3) to medium (2). Amendments made as part of the RRA better reflect what is known about stingaree age and growth development. While this decision is more qualitative, a weight-of-evidence approach supports a downgrading of the score assigned to this attribute. This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation*.
<u>Batoids</u> *Kapala stingaree (U. kapalensis)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	The *maximum age* for the kapala stingaree (*Urolophus kapalensis*), greenback stingaree (*U. viridis*) and the common stingaree (*Trygonoptera testacea*) is not

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Greenback stingaree (U. viridis) *Common stingaree (T. testacea)*					known. As a consequence, they were all were assigned a precautionary high (3) score for this attribute as part of the PSA. In the *Action Plan for Australian Sharks and Rays* (Kyne *et al.,* 2021), the masked stingaree (*T. personata*) was used as a proxy to estimate generation length for all three species. The available information indicates that the maximum age of *T. personata* falls within the 10–25 years age bracket (White *et al.*, 2001; Kyne *et al.*, 2021). As *T. personata* has previously been used as a biological proxy for *U. kapalensis, U. viridis* and *T. testacea*, it is reasonable to apply to same approach in the ECOTF SOCC ERA. ***Key changes to the PSA scores*** Scores assigned to this attribute were reduced from high (3) to medium (2) for all three species. This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Batoids *Sydney skate (D. australis)* *Endeavour skate (D. endeavouri)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	2	The *maximum age* for the Sydney skate (*Dentiraja australis*) and endeavour skate (*D. endeavouri*) is not known and the species were assigned precautionary high (3) scores for this attribute. In the RRA, a broader examination of skate biology was undertaken to determine if a suitable proxy could be found for one or both species. In the *Action Plan for Australian Sharks and Rays* (Treloar, 2008; Rigby *et al.*, 2016a; Kyne *et al.*, 2021), the argus skate (*D. polyommata*) and whitespotted skate (*D. cerva*) were used as proxies to estimate generation length for *D. endeavouri* and *D. australis* respectively. Information on the age, growth and development of these species indicate that both reach maximum ages of

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					between 10 and 25 years (Kyne *et al.,* 2021). While species-specific data is lacking for *D. australis* and *D. endeavouri*, age estimates for *D. polyommata* and *D. cerva* were considered to be acceptable proxies. ***Key changes to the PSA scores*** Scores assigned to this attribute were reduced from high (3) to medium (2) for both species. This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Batoids *Australian whipray (H. australis)* *Brown whipray (M. toshi)*	*Maximum age (Productivity)*	ECOTF (T1, T2, M1, M2)	3	3	There are a number of gaps in the biological datasets for the Australian whipray (*Himantura australis*) and the brown whipray (*Maculabatis toshi*). These limitations were reflected in key aspects of the PSA including the *maximum age* attribute (Table 4). In the RRA, precautionary high (3) risk scores assigned to these species were reviewed. As part of this review, comparisons were made with the morphologically and taxonomically similar blackspotted whipray (*M. astra*). Age estimates for *M. astra* indicate that this species can reach and exceed 25 years (Jacobsen & Bennett, 2011). While this estimate cannot be applied directly to *H. australis* and *M. toshi*, it demonstrates that a high-risk rating is not out of the realm of possibility for these two species. ***Key changes to the PSA scores*** No change to the score, though it is recognised that a high (3) risk rating could be conservative. A reduction in the precautionary scores though was not supported (directly or indirectly) by the available data.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Batoids *Sandyback stingaree (U. bucculentus)* *Common stingaree (T. testacea)* *Sydney skate (D. australis)*	*Availability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	1	Criteria used to assess *availability* is effective for species whose distributions have moderate to high overlap with the fishery and species whose distribution occurs solely within the prescribed fishing area. This criterion though has the potential to overestimate the *availability* risk for species that have distributions that have marginal overlap with the ECOTF effort footprint. For example, the sandyback stingaree (*Urolophus bucculentus*), the common stingaree (*Trygonoptera testacea*) and the Sydney skate (*Dentiraja australis*) distributions are all confined to a smaller section of southern Queensland. The restricted distribution of these species in Queensland will limit the extent of ECOTF interactions and suggests that a high (3) risk rating is too conservative (Last *et al.*, 2016b; Kyne *et al.*, 2021). In the RRA, further consideration was given to *availability* attribute scores assigned to all three species. As part of this process, an *ad-hoc* assessment was undertaken to determine the extent of the overlap between the Queensland distribution of each species and the entire ECOTF effort footprint. In this assessment all listed species demonstrated the potential to interact with less than 15 per cent of the entire ECOTF. ***Key changes to the PSA scores*** The preliminary scores assigned to this attribute in the PSA was decreased from high (3) to low (1). This change was done in accordance with *Guideline 1: rating due to missing, incorrect or out of date information, Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					As the assessment method is precautionary, reducing the *availability* score for these species will not contribute to the production of a false-positive result. The adoption of a more flexible approach for species with marginal overlaps also aligns with strategies applied in other ERAs including comparable assessments completed as part of the National *Ecological Risk Assessment for the Effects of Fishing* (ERAEF) process (Hobday *et al.*, 2011; Australian Fisheries Management Authority, 2023a).
Batoids *Sandyback stingaree (U. bucculentus)* *Kapala stingaree (U. kapalensis)* *Common stingaree (T. testacea)* *Yellowback stingaree (U. sufflavus)* *Greenback stingaree (U. viridis)* *Sydney skate (D. australis)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	All included batoids have the potential to interact with the ECOTF based on their habitat preference and/or depth profile. The listed species are found in a wide range of environments (Bray, 2018g; 2021f; Kyne *et al.*, 2021; Fishes of Australia, Undated) and they were all assigned a higher risk rating for *encounterability*. However, the ECOTF operates across a diverse range of temperate and tropical waters and the encounterability potential will not be uniform. In inshore regions, the listed species are more likely to be caught by fishers targeting key species at the southern extent of the fishery *e.g.* operations targeting eastern king prawns. Within this region the interaction potential for the common stingaree (*Trygonoptera Testacea*) and the kapala stingaree (*Urolophus kapalensis)* will be more significant; an inference that is supported by previous studies examining the risk posed by trawl fishing in southern Queensland (Campbell *et al.,* 2017). Conversely, interactions with the sandyback stingaree (*U. bucculentus*) are more likely to occur in the deepwater eastern king prawn (EKP) fishery (Jacobsen *et al.,* 2015). At a whole-of-fishery level, operators are more likely to encounter species that utilise inter-reefal habitats and environments with softer substrates. While the

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
Endeavour skate (D. endeavouri)					bathymetric ranges and habitat preferences of the listed species overlap with trawl effort, interactions across the entire fishery will be limited. In the RRA, these factors were given further consideration in conjunction with a) the type of operations that are more likely to interact with these species, and b) the prevalence of interactions across the entire fishery. When these factors were considered in the context of the entire ECOTF, scores assigned in the PSA were viewed as overestimates. ***Key changes to the PSA scores*** Closer examination of the ECOTF effort footprint in relation to the preferred habitats/temperature profiles (*versus* the described habitats), indicated that the preliminary score assigned to this attribute was too precautionary. Accordingly, *encounterability* scores for these species were reduced from high (3) to medium (2). For some of these species a medium (2) risk rating may still represent an overestimate. However, the current information did not support a further reduction. With additional information on catch compositions and locations these scores could be refined further. The above changes were done in accordance with *Guideline 2: additional scientific assessment & consultation* and further consideration given to *Guideline 3: at risk with spatial assumptions*. While the decision to reduce the *encounterability* score is more qualitative, it is considered to be a better representation of the *attribute* risk.
<u>Batoids</u> *Australian whipray (H. australis)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	Habitat descriptions for the Australian whipray (*Himantura australis*) are relatively broad and resulted in it being assigned the highest PSA rating for *encounterability* (Table 4).

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					The depth profile for this species is smaller (0–45 m) and it is more commonly found in inshore environments that are exposed to lower levels of otter trawl effort *e.g.* rivers, estuaries and brackish environments (Kyne *et al.,* 2021). These habitats will still overlap with sectors of the ECOTF and *H. australis* will still interact with otter trawl operations. However, the *encounterability* potential for this species will likely be lower than what is presented in the PSA. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute was reduced from high (3) to medium (2). A rating of medium (2) better reflects the *encounterability* potential for this species (*pers. comm.* **I**. Jacobsen) and is unlikely to contribute to a false-negative result. Evidently, a medium rating may still represent a risk overestimate for this species. However, the available information did not support a further reduction of the *encounterability* attribute score. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.
<u>Batoids</u> *Eyebrow wedgefish (R. palpebratus)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	Two species of wedgefish will interact with the ECOTF: the eyebrow wedgefish (*Rhynchobatus palpebratus*) and the bottlenose wedgefish (*R. australiae*). These two species have overlapping distributions, although the distribution of *R. palpebratus* only extends to central and northern Queensland (Kyne *et al.,* 2021). This geographical nuance does not negate the risk of *R. palpebratus* interacting with a trawl operation and the species will still be caught in the ECOTF. These interactions though would be confined to more northern sections

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					of the ECOTF. Of the two species, interactions with *R. australiae* are more likely to occur throughout the ECOTF. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute was reduced from high (3) to medium (2). A rating of medium (2) better reflects the *encounterability* potential for this species on the Queensland east coast (*pers. comm.* I. Jacobsen). No change was made to the risk profile of *R. australiae* as it is likely to be encountered across a broader expanse of the ECOTF. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.
Batoids *Patchwork stingaree (U. flavomosaicus)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	All included batoid species have the potential to interact with the ECOTF based on their habitat preference and/or depth profile. Information demonstrates that the patchwork stingaree (*Urolophus flavomosaicus)* inhabits a wide range of environments and has a relatively broad depth profile (Bray, 2018h; Kyne *et al.*, 2019c; Kyne *et al.*, 2021), This resulted in this species being assigned a high (3) score for *encounterability* in the PSA. *Urolophus flavomosaicus* generally occurs at depths beyond inshore trawl fisheries and the species will more likely be encountered in deeper water operations *e.g.* operations targeting eastern king prawns. Outside of the EKP, the species will have low or negligible interactions with the remainder of the fishery. This by extension suggests that the *encounterability* potential, at a whole-of-fishery level, will be lower than what is presented in the PSA.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					In the RRA, further consideration was given to a) the type of operations that are more likely to interact with this species, and b) the prevalence of interactions across the entire fishery. When these factors were considered in the context of the entire ECOTF, it was determined that the preliminary score assigned to this attribute was an overestimate. ***Key changes to the PSA scores*** Closer examination of the ECOTF effort footprint in relation to the habitats/depths preferred by *U. flavomosaicus*, support the inference that the PSA score was too precautionary. Accordingly, the *encounterability* attribute score for *U. flavomosaicus* was reduced from high (3) to medium (2). The decision to reduce the score for this attribute was partly based on the fact that the depth profile for this species exceeds the maximum constraints of most ECOTF operations. These changes were done in accordance with *Guideline 2: additional scientific assessment & consultation* and further consideration given to *Guideline 3: at risk with spatial assumptions*.
<u>Batoids</u> *Argus skate (D. polyommata)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	The argus skate (*Dentiraja polyommata)* inhabits a wide range of environments (Kyne *et al.,* 2021) and the species was assigned a higher risk rating for *encounterability*. While noting this preliminary assessment, *D. polyommata* is a deeper water species and evidence suggests that it is more commonly found on the continental shelf / upper slope (depths of 135–400 m; Last *et al*., 2016b; Kyne *et al*., 2021). At these depths, the probability of *D. polyommata* being encountered in the ECOTF is greatly reduced. For example, *D*. *polyommata* is unlikely to be encountered in inshore environments or in significant quantities across the entire ECOTF.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					As part of the RRA, consideration was given to a) the type of operations that are more likely to interact with this species, and b) the prevalence of interactions across the entire fishery. When these factors were taken into consideration, the preliminary score assigned to this attribute was viewed as an overestimate. ***Key changes to the PSA scores*** Closer examination of the ECOTF effort footprint in relation to the habitats/depths preferred by *D. polyommata* support the inference that the PSA score was too precautionary. Accordingly, the *encounterability* attribute score for this species was reduced from high (3) to medium (2). With a depth profile ranging from 135–400 m, there is an increased probability that a medium (2) rating still overestimates the *encounterability* risk for this species. The ability to reduce this score further was limited by data deficiencies; namely on interaction rates and locations. The above changes were done in accordance with *Guideline 2: additional scientific assessment & consultation* and further consideration given to *Guideline 3: at risk with spatial assumptions*.
<u>Batoids</u> *Estuary stingray (H. fluviorum)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	1	Habitat descriptions for the estuary stingray (*Hemitrygon fluviorum*) are relatively broad and resulted in it being assigned the highest rating for the *encounterability* (Table 4). The depth profile for this species though is relatively small (0–28 m) and it is commonly found in inshore environments that attract smaller amounts of otter trawl effort *e.g.* mangroves, seagrass beds, estuaries and brackish environments (Last *et al.*, 2016b; Bray, 2018f; Kyne *et al.*, 2021). Habitats preferred by *H. fluviorum* will have more overlap with the *River and Inshore Beam Trawl Fishery*. This fishery operates more frequently in areas

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					where *H. fluviorum* are found including in south-east Queensland. When compared, the potential of *H. fluviorum* being encountered by ECOTF operations is low. This potential will be much lower when compared to other batoids included in this assessment. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute was reduced from high (3) to low (1). A rating of low (1) better reflects the *encounterability* potential and reducing the score is not expected to contribute to a false-negative result. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.
Batoids *Giant guitarfish (G. typus)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	Habitat descriptions for the giant guitarfish (*Glaucostegus typus*) are relatively broad and it was assigned the highest rating for *encounterability* in the PSA (Table 4). However, the situation surrounding *G. typus* habitat preferences is more complex. For instance, juvenile *G. typus* prefer inter-tidal environments which tend to attract lower levels of otter trawl effort *e.g.* mangroves, seagrass beds, estuaries and brackish environments (Bray, 2017a). The reliance on inter-tidal nursery grounds will provide juvenile *G. typus* with a degree of natural protection from trawl fishing activities. As adults, individuals are found in a range of habitats including offshore, continental shelf waters down to a depth of 100 m (Last *et al.*, 2016b; Bray, 2017a; Kyne *et al.*, 2021). The probability of an ECOTF operation encountering a *G. typus* will be higher in these areas. The notable caveat being that some of these interactions will be contact without capture events as larger animals will

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					be excluded from the net via the TED (addressed as part of the *selectivity* attribute assessment). The probability of *G. typus* interacting with a trawl net on the Queensland east coast will not be uniform and be dependent on their life-history. This variability is linked with life cycle habitat/bathymetric preferences and it will have a bearing on the *encounterability* risk. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute was reduced from high (3) to medium (2) as part of the RRA. While the decision to reduce the score is more qualitative, a medium (2) risk rating better reflects the *encounterability* risk for this species across its age and growth development. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.
<u>Batoids</u> *Narrow sawfish (A. cuspidata)*	*Encounterability (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	The narrow sawfish (*Anoxypristis cuspidata*) inhabits shallower water environments with the species having a depth profile of 0–40 m (Kyne *et al.,* 2021). While *A. cuspidata* was assigned a high (3) risk rating in the PSA, the *encounterability* potential for this species will be lower. This species is commonly associated with shallow embayments, estuaries and inshore waters which, proportionately, attract lower levels of otter trawl effort (D'Anastasi *et al.*, 2013; Last *et al.*, 2016b; Kyne *et al.*, 2021). Outside of these areas, the probability of *A. cuspidata* encountering a trawl operation will be higher. This risk though will not apply to all management regions *e.g.* deepwater eastern king prawns and southern Queensland. Noting

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					that the distribution of *A. cuspidata* on the Queensland east coast is largely confined to the northern region (Peverell, 2005; D'Anastasi *et al.*, 2013; Field *et al.*, 2013; Department of the Environment, 2022a). As part of the RRA, consideration was given to a) the type of operations that are more likely to interact with *A. cuspidata*, and b) the prevalence of *A. cuspidata* interactions across the entire fishery. When these factors were considered in the context of the entire ECOTF, the score assigned to this attribute was viewed as an overestimate. ***Key changes to the PSA scores*** The preliminary score assigned to the *encounterability* attribute was reduced from high (3) to medium (2) as part of the RRA. While the decision to reduce the score is more qualitative, a rating of medium (2) better reflects the encounterability potential for this species on the Queensland east coast. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and *Guideline 3: at risk with spatial assumptions*.
<u>Batoids</u> *Australian butterfly ray (G. australis)*	*Selectivity (Susceptibility)*	ECOTF (T1, T2, M1, M2)	2	3	Criteria used to assign scores for the *selectivity* attribute were based on the disc width at sexual maturity. Based on the criterion, the Australian butterfly ray (*Gymnura australis*) was assigned a medium (2) score for *selectivity*. While *G. australis* is a medium sized batoid, the species has a very shallow body depth which increases the selectivity of the net. This is because there is little to prevent the entire animal being drawn into the codend net once a pectoral fin passes through the bars of the TED (*pers. comm.* I. Jacobsen). In similar sized batoids (*e.g.* <100 cm disc width) such as the blackspotted whipray

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					(*Maculabatis astra*) and the brown whipray (*M. toshi*), the size and morphology of the cranium helps limit the capture of larger rays (Last *et al.*, 2016b; Kyne *et al.*, 2021). This is less likely to occur for *G. australis*. ***Key changes to the PSA scores*** The score assigned to the *selectivity* attribute for *G. australis* was increased from medium (2) to high (3). This change reflects the fact that the use of a TED will be less effective for this species; an inference supported by research showing that rays up to 92.8 cm disc width can be caught in the codend of a trawl net (Jacobsen & Bennett, 2009; Jacobsen *et al.*, 2009; Jacobsen & White, 2015). Changes applied as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation* and was based on direct observations of the size classes caught in prawn trawl fisheries (*pers. obs.* I. Jacobsen).
<u>Batoids</u> Blackspotted whipray (*M. astra*) Brown whipray (*M. toshi*)	*Selectivity (Susceptibility)*	ECOTF (T1, T2, M1, M2)	2	2	The blackspotted whipray (*Maculabatis astra*) and the brown whipray (*M. toshi*) have registered maximum disc widths of 92 cm and 82 cm respectively (Jacobsen & Bennett, 2011; Last *et al.*, 2016b; Kyne *et al.*, 2021). At this size, both were assigned a medium (2) score for *selectivity* (Table 4). As *M. astra* and *M. toshi* increase in size, the probability of the species experiencing a contact without capture event will increase. This is due to the fact that larger rays have body depths and cranium depths that align more closely with the TED bar spacings (Brewer *et al.*, 2006; Last *et al.*, 2016b; Campbell *et al.*, 2020; Kyne *et al.*, 2021). In the RRA, the age and growth of *M. astra* and *M. toshi* were further reviewed to determine if there was sufficient evidence to support a reduction of the *selectivity* risk score.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Key changes to the PSA scores A review of the available data did not support a reduction in the score assigned to this attribute. This situation may change though with further information on *M. astra* and *M. toshi* catch/size compositions. This is an area where future ERAs could be refined and improved with additional information.
Australian whipray (H. australis)	*Selectivity (Susceptibility)*	ECOTF (T1, T2, M1, M2)	2	1	The Australian whipray (*Himantura australis*) is a very large ray, attaining at least 183 cm disc width (Last *et al.*, 2016b; Kyne *et al.*, 2021). At this size, the likelihood of a mature *H. australis* being caught in the codend of a trawl net is comparatively small. Similarly, there is an increased probability that subadult and mature rays will experience a contact without capture event *versus* direct capture in the codend. While juvenile *H. australis* will still be caught in trawl nets, the probability of this species being retained in higher quantities is comparatively low. This inference is supported by the *Action Plan for Australian Sharks and Rays* which classified commercial bycatch as a low threat element (Kyne *et al.*, 2021). In the RRA, further consideration was given to the (likely) development of *H. australis* and the probability of trawl operations landing an extended range of cohorts for this species. ***Key changes to the PSA scores*** The *selectivity* risk score for *H. australis* was reduced from medium (2) to low (1). The decision to reduce this score was more qualitative in nature but provides a more accurate representation of the likelihood or probability that this species will be retained in the codend of a trawl net. While *H. australis* will interact with the ECOTF, the size of this species makes contact without capture

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					events more likely; particularly when compared to other batoids. The RRA changes were done in accordance with *Guideline 2: additional scientific assessment & consultation*.
Batoids *Narrow sawfish (A. cuspidata)* *Green sawfish (P. zijsron)*	*Selectivity (Susceptibility)*	ECOTF (T1, T2, M1, M2)	1	2	Criteria used to assign scores for the selectivity attribute are based on the size of the individual at sexual maturity relative to the TED bar spacings. Based on the criterion, the PSA assigned the narrow sawfish (*Anoxypristis cuspidata*) and the green sawfish (*Pristis zijsron*) with a low (1) score for *selectivity*. As sawfish possess a large, toothed rostrum, criteria used to assess the *selectivity* attribute are less suited to this complex. The toothed rostrum increases the likelihood of an interaction ending in entanglement and this risk will apply across a wide range of size classes. Historically, it has been considered that this morphological feature renders TEDs ineffective at excluding sawfish species from entering the codend (Pears *et al.*, 2012b). However, a study in 2006 demonstrated that trawl nets fitted with a TED resulted in 73.3 per cent fewer catches of *A. cuspidata* (Brewer *et al.,* 2006). As these species are physically similar, it can be implied that the capture of *P. zijsron* in trawling operations would also decrease when fitted with a TED. ***Key changes to the PSA scores*** Risk scores for *A. cuspidata* and *P. zijsron* were increased from low (1) to medium (2). It is recognised that a medium rating may still overestimate the *selectivity* risk for these species. The decision to increase this score though, better reflects the increased entanglement risk including anterior to the TED. These changes were done in accordance with *Guideline 1: rating due to*

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					missing, incorrect or out of date information and *Guideline 2: additional scientific assessment & consultation*.
<u>*Batoids*</u> *Australian butterfly ray (G. australis)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	The Australian butterfly ray (*Gymnura australis*) was assigned a precautionary high (3) risk for the *post-interaction mortality* attribute. While noting this assessment, anecdotal evidence suggests that the PSA overestimated the *post-interaction mortality* risk for this species (*pers. obs.* I. Jacobsen). Research from the *Northern Prawn Fishery* (NPF) indicates that within-net mortality rates for *G. australis* are comparatively high (Stobutzki *et al.*, 2001; Stobutzki *et al.*, 2002). On the Queensland east coast, datasets are less developed and provide more limited insight into the extent of trawl-related mortalities. However, Kyne *et al.* (2007a) reported that all trawl-caught *G. australis* were landed 'alive' and *personal observations* from research surveys indicate that a portion survive the initial event (*pers. obs.* I. Jacobsen; Jacobsen, 2007). ***Key changes to the PSA scores*** The preliminary score assigned to the *post-interaction mortality* attribute was reduced from high (3) to medium (2) as part of the RRA. This decision considers direct reports from the ECOTF and better reflects the potential for this species to incur post-interaction mortalities. It is recognised that a) the available data only provides insight into the fate of the animal once landed and b) mortality rates are likely to be higher when release fates are taken into consideration. However, the probability of *G. australis* surviving the trawl event is likely to be higher than what was presented in the PSA.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment.*
Batoids *Yellowback stingaree (U. sufflavus)* *Kapala stingaree (U. kapalensis)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	1	3	Where possible, the PSA utilises data to assign preliminary scores to each of the respective attributes. This is done irrespective of the sample size and provides each attribute with a preliminary risk assessment. In the case of *U. sufflavus* and *U. kapalensis*, the available data provides a more positive assessment of *post-interaction mortality*. These assessments though were based on a very small sample size: *n* = 1 for *U. sufflavus* and *n* = 3 for *U. kapalensis* (Kyne, 2008). In the RRA, a broader review of the available data was undertaken to determine if a low-risk rating was appropriate for the two listed species. As datasets for the two species were limited, the RRA considered information from morphologically similar species that could be used as proxies. Research involving the common stingaree (*Trygonoptera testacea*) provides some insight into the potential mortality rates for these two species. *Trygonoptera testacea* is a similar sized species and has a range that is comparable to *U. sufflavus* and *U. kapalensis*. For the purpose of this ERA, *T. testacea* is considered a reasonable proxy for this attribute. Campbell *et al.* (2018) provided a detailed examination of post-release survival in two elasmobranchs caught as bycatch in the ECOTF: *T. testacea* and the eastern shovelnose ray (*Aptychotrema rostrata*). While more nuanced, this study reported post-trawl survival rates of 33.5 per cent and 17.5 per cent for female and male *T. testacea* respectively. These results suggest that post-interaction mortality rates for *U. sufflavus* and *U. kapalensis* are higher than what was represented in the PSA (Table 4). The study also supports the

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					hypothesis that smaller batoids are more likely to incur injuries and mortalities during a trawl fishing event (Stobutzki *et al.*, 1996; Griffiths *et al.*, 2006). ***Key changes to the PSA scores*** The preliminary score assigned to the *post-interaction mortality* was increased from low (1) to high (3) for *U. sufflavus* and *U. kapalensis*. The decision to increase the scores assigned to this attribute was precautionary and recognises a) deficiencies in the current data set and b) research indicating that post-interaction mortalities may be higher for this subgroup (Campbell *et al.,* 2018). Changes made as part of the RRA were done in accordance with *Guideline 1: risk rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>***Batoids***</u> *Australian whipray (H. australis)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	Information on the Australian whipray (*Himantura australis*) is somewhat limited, particularly with respect to post-interaction mortalities. In the RRA, a broader review of the available data was undertaken to determine if a high-risk rating was appropriate for *H. australis*. *Himantura australis* is a larger species and there is a high probability that most subadult and mature rays will experience a contact without capture event if caught in a trawl net. As a larger ray, there is also an increased probability of *H. australis* surviving a trawl event when compared to smaller stingrays, skates and stingarees. These factors suggest that the *post-interaction mortality* risk for *H. australis,* at the very least, is the same as the blackspotted whipray (*Maculabatis astra*) and the brown whipray (*M. toshi*). *Maculabatis astra* and *M. toshi* attain a smaller maximum disc width (80–95 cm) and have a moderate *post-interaction risk*.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Key changes to the PSA scores The preliminary score assigned to the *post-interaction mortality* was reduced from high (3) to medium (2). The decision to reduce this score was more qualitative in nature but better reflects the current fishing environment. Given that this species has a higher (likely) level of TED effectiveness, a medium (2) rating may still represent a risk overestimate. However, the current level of information did not support a further reduction of the risk score assigned to this attribute. With improved information, even on landing fates, the rating assigned to this attribute could be refined further. Changes made as part of the RRA were done in accordance with *Guideline 1: risk rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Batoids</u> *Blackspotted whipray (M. astra)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	1	2	Where possible, the PSA utilises data to assign preliminary scores to each of the respective attributes. This is done irrespective of the sample size and provides each attribute with a preliminary risk assessment. In the case of *M. astra* (Kyne, 2008), the available data suggested the species had a reasonable probability of surviving a trawl event. This assessment though assessed *M. astra* as a complex with *M. toshi* and results were based on a small sample size (*n* = 23; Kyne, 2008). In the RRA, a broader review of the available data was undertaken to determine if a low-risk rating was appropriate for the listed species. Overall, there is limited information on post-release survival rates for trawl-caught batoids. However, it is also important to note that as this species increases in size, so too does the likelihood that it will experience contact without capture events.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					For *M. astra*, there is an increased probability that mature rays will be excluded from the net via the TED. While noting this potential, a mixture of juvenile, subadult and mature *H. astra* (Jacobsen & Bennett, 2011) will likely pass through the TED and be retained in the codend of the trawl net. Once in the net, there is an increased probability that the ray (particularly smaller individuals) will incur some level of internal and/or external injuries (Stobutzki *et al.*, 1996; Griffiths *et al.*, 2006). ***Key changes to the PSA scores*** The preliminary score assigned to the *post-interaction mortality* attribute was increased from low (1) to medium (2). The decision to increase this score was precautionary and it may overestimate the attribute risk for this species. However, data deficiencies make it difficult to quantify post-release survival and increase the level of assessment uncertainty. With improved information, even on landing fates, the score assigned to this attribute could be further refined. Changes made as part of the RRA were done in accordance with *Guideline 1: risk rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Batoids</u> *Giant guitarfish (G. typus)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	No information is currently available for post-interaction mortalities or survival rates for the giant guitarfish (*Glaucostegus typus*). Consequently, the species was assigned a precautionary high (3) score for the *post-interaction mortality* attribute (Table 4). While noting the reasons behind this decision, there are a number of confounding factors that were not considered by the PSA criteria. *Glaucostegus typus* is a large batoid registering a size-at-birth of around 40 cm TL and a maximum length of at least 240 cm TL (Timm *et al.*, 2014; Last *et al.*,

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					2016b; Kyne *et al.*, 2021). At these sizes, the use of a TED would be highly effective in terms of excluding both sub-adult and mature *G. typus* from the codend of the net. The general morphology of *G. typus* would also assist in terms of preventing the ray from passing through the TED bar spacings. These factors make contact without capture events more likely for this species with sub-adults and mature rays being excluded from the net. While difficult to quantify, species with more frequent contact without capture events are more likely to have fewer post-interaction mortalities. ***Key changes to the PSA scores*** The preliminary score assigned to the *post-interaction mortality* was reduced from high (3) to medium (2) in recognition of the fact that sub-adult and mature *G. typus* are more likely to be excluded from the net via the TED. When compared to their direct capture within the codend, contact without capture events are less likely to end in significant injuries or mortalities. Changes made as part of the RRA were done in accordance with *Guideline 1: risk rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
<u>Batoids</u> *Estuary stingray (H. fluviorum)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	1	2	There is limited published data on the post-interaction survival rates for the estuary stingray (*Hemitrygon fluviorum*). Data reported through the *Threatened, Endangered and Protected Animals* (TEPA) logbook and the former *Species of Conservation Interest* (SOCI) logbook indicates high historical survival within the ECOTF. The veracity of this data though cannot be verified as the fishery does not have an effective mechanism in place to monitor catch rates or release fates in real or near-real time.

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					Outside of the TEPA/SOCI logbook data, the *Action Plan of Australian Sharks and Rays* indicates that post-release survival rates for *H. fluviorum* are low (Kyne *et al.,* 2021). Without the ability to validate catch compositions and interaction rates, there are limited avenues to assess the relevance of this statement to the ECOTF. ***Key changes to the PSA scores*** The preliminary score assigned to the *post-interaction mortality* attribute was increased from low (1) to medium (2) as a precautionary measure. With additional information on catch rates and interaction rates, the assessment of this attribute could be further refined. The evidence at present though does not support the assignment of a lower risk rating. Changes made as part of the RRA were done in accordance with *Guideline 1: risk rating due to missing, incorrect or out of date information* and *Guideline 2: additional scientific assessment & consultation.*
Batoids *Narrow sawfish (A. cuspidata)* *Green sawfish (P. zijsron)*	*Post-interaction mortality (Susceptibility)*	ECOTF (T1, T2, M1, M2)	3	2	Where possible, the PSA utilises data to assign preliminary scores to each of the respective attributes. This is done irrespective of the sample size and provides each attribute with a preliminary risk assessment. In the case of the narrow sawfish (*Anoxypristis cuspidata*) and the green sawfish (*Pristis zijsron*), evidence suggested that the two species have a low probability of surviving a trawl event (Stobutzki *et al.,* 2002). Accordingly, both were assigned a high (3) risk rating in the PSA. In the RRA, a broader review of the available data was undertaken to determine if a high-risk rating was appropriate for this species. Data reported through the *Threatened, Endangered and Protected Animals* (TEPA) logbook and the former *Species of Conservation Interest* (SOCI)

Species	Attribute	Sub-fishery	PSA Score	RRA Score	Justifications and Considerations
					logbook indicate that trawl-caught sawfish (generally) survive the fishing event. However, this data has poor resolution and comes with inherent problems such as misidentifications within the sawfish complex. This deficiency is compounded by the fact that there is limited capacity within the current management regime to verify or validate data collected through the logbook program. Of importance, a study in 2006 demonstrated that trawl nets fitted with a TED resulted in 73.3 per cent fewer catches of *A. cuspidata* (Brewer *et al.,* 2006), implying that contact without capture events may be more prevalent for this species than initially expected. As *P. zijsron* is a larger species (Last *et al.*, 2016b; Kyne *et al.*, 2021), a reasonable hypothesis would be that at least some individuals would also be excluded from the net. While difficult to quantify, species experiencing contact without capture events are likely to have fewer post-interaction mortalities. ***Key changes to the PSA scores*** The preliminary score assigned to the *post-interaction mortality* attribute was reduced from high (3) to medium (2) for *A. cuspidata* and *P. zijsron*. Both species have an increased probability of experiencing a contact without capture event which, when compared to their direct capture within the codend of the net, are less likely to result in significant injuries or mortalities. This suggests that that post-interaction mortality risk for *A. cuspidata* and *P. zijsron* is lower than what is reported for other species. Changes made as part of the RRA were done in accordance with *Guideline 2: additional scientific assessment & consultation.*

Appendix E—Whole-of-fishery: Likelihood & Consequence Analysis

1. Overview & Background

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

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

In the whole-of-fishery 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 from this supplementary assessment 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 *et al.*, 2002; Fletcher *et al.*, 2005; Fletcher, 2014) 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. These steps were fulfilled with the completion of a Scoping Study (Department of Agriculture and Fisheries, 2023) and three previous risk assessments (Pears *et al.*, 2012a; Pears *et al.*, 2012b; Jacobsen *et al.*, 2015; Campbell *et al.*, 2017). Therefore, they were not replicated in the ECOTF SOCC ERA. For a more comprehensive overview of the *National ESD Reporting Framework for Australian Fisheries* consult Fletcher *et al.* (2002) and Fletcher (2014).

Risk Analysis considers a) the potential consequences of an issue, activity or event (Table E1) and b) the likelihood of a particularly adverse consequence occurring due to these activities or events (Table

E2). Central to this is the establishment of a *Likelihood x Consequence* matrix which provides an estimate of risk based on scores assigned to each component (Table E3).

For the consequence analysis (Table E1), criteria used to assign individual scores (0–4) were based on the outputs of the semi-quantitative assessment (*e.g.* PSA/RRA results outlined in section 5, Table 6). In the likelihood assessment (Table E2), scores reflect the likelihood of the fishery causing or making a significant contribution to the occurrence of the most hazardous consequence (Fletcher *et al.* 2002). Once scores are assigned to each aspect of the LCA, they are used to calculate an overall risk value (*Risk = Consequence x Likelihood*) for each species (Table E3).

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

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

Level	Score	Definition
Negligible	0	Almost zero harvest / fishing-related mortalities with an 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 a minimal impact on stocks or populations.
Moderate	2	Assessed as a medium risk through the PSA and/or harvest levels / fishing-related mortalities have a higher potential to impact regional populations.
Severe	3	Species assessed as high risk through the PSA and/or have harvest levels / fishing-related mortalities that are impacting stocks and/or has a higher vulnerability or lower resilience to rebound from fishing-related mortalities.
Major	4	Species assessed as high risk through the PSA and/or harvest levels / fishing-related mortalities have the potential to cause serious impacts with a long recovery period required to return the stock or population to an acceptable level.

Table E2*. Criteria used to assign indicative scores of the likelihood that fishing activities in the East Coast Otter Trawl Fishery (ECOTF).*

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 or sufficient uncertainty requiring the adoption of a more conservative approach.
Rare	2	May occur in exceptional circumstances.
Remote	1	Has never occurred but is not impossible.

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

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

3. Results & Considerations

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

Marine turtles

The LCA assessed five marine turtles as a low-medium risk and one as low risk. Scores for these species were lower than the outputs of the SOCC ERA and, based on their interaction potential and current management strategies, these LCA ratings were supported. A further review of the risk posed to these species by the ECOTF suggests that results for the loggerhead turtle (*Caretta caretta*), leatherback turtle (*Dermochelys coriacea*) and olive ridley turtle (*Lepidochelys olivacea*) are more representative of a potential risk. As a result, the assignment of a *precautionary* risk rating was justified for these three species.

Syngnathids

Three of the LCA results for the syngnathids aligned with estimates obtained through the PSA/RRA (Table E4; Table 6). The remaining six species demonstrated marginally lower LCA results (Table E4; Table 6). This was likely attributed to differences between the methodologies resulting in the allocation of low-medium risk ratings, a score which is not accounted for, or reflected within the PSA/RRA. While the ECOTF SOCC ERA outputs may be more conservative, the decision was made to retain the original risk rating for all species within this group. This in part is due to the absence of a mechanism to effectively monitor catch rates in real or near-real time and uncertainty surrounding total interaction rates.

Notably, the Duncker's pipehorse (*Solegnathus dunckeri)* and the Pallid pipehorse *(S. hardwickii)* can be retained for sale in the ECOTF. These species are managed under fairly stringent trip/boat limits (*n* = 50), preventing the species being targeted in significant quantities or significant levels of effort being directed at the complex *e.g.* due to changing market demand. However, a degree of uncertainty remains for these species regarding their conservation status (*Data Deficient*), distributions and their ability to rebound from fishing pressure. As a result, the LCA outputs for these *Solegnathus* species were comparatively higher than the other assessed syngnathids (Table E4).

Sea snakes

The LCA for the sea snake complex largely reflects the interaction potential of the species being assessed. Of the species included in the ECOTF SOCC ERA, the LCA supports the assignment of a *precautionary* risk rating for the turtle-headed sea snake (*Emydocephalus annulatus*). The LCA results for four of the remaining species produced lower ratings (Table E4). While noting this differential, there remains considerable uncertainty surrounding catch compositions, regional interaction rates and release fates. These factors make it more difficult to assign *precautionary* ratings to any additional species; despite the LCA outputs.

Sharks

The shark LCA mirrored that of the marine turtle complex, in that the majority of the risk estimates were lower than the PSA/RRA (Table E4; Table 6). While these species are likely to interact with the fishery, the extent and nature of the species-specific interactions need to be considered.

When the LCA results were considered in conjunction with the key drivers of risk, six shark species were assigned *precautionary* risk ratings. The LCA results for some of the remaining species reflected the outputs of the ECOTF SOCC ERA. Ratings for these species were considered more representative of risk levels within the current fishing environment. For example, LCA results of the Colclough's shark (*Brachaelurus colcloughi)* aligns with the outputs of the PSA/RRA (high risk). The ongoing conservation concerns and limited information regarding populations and distributions were all constituents that increased the likelihood of the fishery contributing to a severe or major event. Given the small suspected population size (Kyne *et al.*, 2021), this could occur at lower levels of fishing mortality. In the case of the pale spotted catshark (*Asymbolus pallidus*), results from the LCA were marginally higher than the PSA/RRA outputs (Table E4; Table 6). Notably, this did not impact the original risk rating for this species.

For reference, the outputs of the LCA supported retaining the original risk ratings for the following species: the brownbanded bambooshark (*Chiloscyllium punctatum*), Colclough's shark (*B. colcloughi*), piked spurdog (*Squalus megalops*), crested hornshark (*Heterodontus galeatus*), the orange spotted catshark (*A. rubiginosus*) and *A. pallidus.*

Batoids

The batoid LCA indicates that the ratings assigned to 14 species were more representative of the potential risk. That is, the rating is less likely to come to fruition unless there is a notable change or divergence from the current fishing environment (Table E4). These results were intimately linked with these species having either a) sufficient management interventions which effectively manage the current risk (*e.g.* high TED effectiveness), b) low interaction rates and/or c) a lower risk of mortality due to interactions. When adopting a weight-of-evidence approach, the LCA lends support to the adoption of a *precautionary* risk rating for these 14 species.

The sawfish complex has experienced historic range contractions along the eastern coastline of Queensland and both the narrow sawfish (*A. cuspidata*) and the green sawfish (*Pristis zijsron*) are known to interact with the ECOTF (Department of Agriculture and Fisheries, 2023). The conservation status of these species, combined with their interaction potential were reflected in the LCA, with both species scores aligning with the PSA/RRA results (*A. cuspidata = medium risk; P. zijsron = high risk)* (Table E4; Table 6). As there is a degree of uncertainty surrounding total interaction rates and there is (at present) limited capacity to validate data submitted through the logbook program.

Outside of sawfish, LCA scores for three batoids were consistent with the outcomes of the PSA/RRA (Table E4; Table 6). One example, the estuary stingray (*Hemitrygon fluviorum*), has ongoing conservation concerns, uncertainty surrounding the extent of regional population declines and limited information on interaction rates in the ECOTF. At a whole-of-fishery level, the final rating for *H. fluviorum* will apply to the current fishing environment and the ECOTF may be a contributor of risk for this species. However, it is acknowledged that this species has experienced range contractions and the conservation status of this species reflects a wider range of issues *e.g.* habitat degradation and loss, cumulative fishing pressures.

Overall, original risk scores were retained (*i.e.* not assigning a *precautionary* score) for the common stingaree (*Trygonoptera testacea*), the Sydney skate (*Dentiraja australis*), the argus skate (*D. polyommata*), the Australian whipray (*Himantura australis*), the estuary stingray (*H. fluviourm*) and the Coral sea maskray (*Neotrygon trigonoides*).

***Table E4**. Results of the Likelihood & Consequence Analysis for species assessed as part of the ECOTF whole-of-fishery ERA.*

Common name	Species name	Likelihood	Consequence	Matrix score	Risk category
Marine Turtles					
Loggerhead turtle	*Caretta caretta*	3	2	6	Low-medium
Green turtle	*Chelonia mydas*	3	2	6	Low-medium
Leatherback turtle	*Dermochelys coriacea*	2	2	4	Low
Hawksbill turtle	*Eretmochelys imbricata*	3	2	6	Low-medium
Olive ridley turtle	*Lepidochelys olivacea*	3	2	6	Low-medium
Flatback turtle	*Natator depressus*	3	2	6	Low-medium
Syngnathids					
Tiger pipefish	*Filicampus tigris*	3	2	6	Low-medium
Spiny seahorse	*Hippocampus spinosissimus*	3	2	6	Low-medium
Great seahorse	*Hippocampus kelloggi*	3	2	6	Low-medium
White's seahorse	*Hippocampus whitei*	3	2	6	Low-medium
Duncker's pipehorse	*Solegnathus dunckeri*	3	3	9	Medium
Pallid pipehorse	*Solegnathus hardwickii*	3	3	9	Medium
Bentstick pipefish	*Trachyrhamphus bicoarctatus*	3	2	6	Low-medium

Common name	Species name	Likelihood	Consequence	Matrix score	Risk category
Straightstick pipefish	*Trachyrhamphus longirostris*	5	1	5	Low
Ribboned pipefish	*Haliichthys taeniophorus*	5	1	5	Low
Sea snakes					
Reef shallows sea snake	*Aipysurus duboisii*	4	2	8	Medium
Mosaic sea snake	*Aipysurus mosaicus*	2	2	4	Low
Olive sea snake	*Aipysurus laevis*	4	2	8	Medium
Spine-bellied sea snake	*Hydrophis curtus*	4	2	8	Medium
Elegant sea snake	*Hydrophis elegans*	4	2	8	Medium
Spectacled sea snake	*Hydrophis kingii*	3	2	6	Low-medium
Turtle-headed sea snake	*Emydocephalus annulatus*	5	1	5	Low
Olive-headed sea snake	*Hydrophis major*	3	2	6	Low-medium
Small-headed sea snake	*Hydrophis macdowelli*	4	2	8	Medium
Spotted sea snake	*Hydrophis ocellatus*	4	2	8	Medium
Horned sea snake	*Hydrophis peronii*	4	2	8	Medium
Beaked sea snake	*Hydrophis zweifeli*	2	2	4	Low
Stoke's sea snake	*Hydrophis stokesii*	3	2	6	Low-medium
Sharks					
Collar carpetshark	*Parascyllium collare*	3	2	6	Low-medium
Brownbanded bambooshark	*Chiloscyllium punctatum*	5	1	5	Low
Colclough's shark	*Brachaelurus colcloughi*	4	3	12	High
Crested hornshark	*Heterodontus galeatus*	3	2	6	Low-medium
Eastern angelshark	*Squatina albipunctata*	3	3	9	Medium
Eastern banded catshark	*Atelomycterus marnkalha*	2	2	4	Low
Zebra shark	*Stegostoma tigrinum*	2	2	4	Low
Piked spurdog	*Squalus megalops*	4	2	8	Medium
Australian weasel shark	*Hemigaleus australiensis*	2	2	4	Low
Pale Spotted Catshark	*Asymbolus pallidus*	3	2	6	Low-medium
Grey spotted catshark	*Asymbolus analis*	3	2	6	Low-medium
Orange spotted catshark	*Asymbolus rubiginosus*	3	2	6	Low-medium
Batoids					
Australian butterfly ray	*Gymnura australis*	3	2	6	Low-medium
Yellowback stingaree	*Urolophus sufflavus*	2	3	6	Low-medium

Common name	Species name	Likelihood	Consequence	Matrix score	Risk category
Patchwork stingaree	*Urolophus flavomosaicus*	3	2	6	Low-medium
Sandyback stingaree	*Urolophus bucculentus*	2	3	6	Low-medium
Kapala stingaree	*Urolophus kapalensis*	3	3	9	Medium
Greenback stingaree	*Urolophus viridis*	3	2	6	Low-medium
Common stingaree	*Trygonoptera testacea*	4	2	8	Medium
Australian whipray	*Himantura australis*	3	2	6	Low-medium
Blackspotted whipray	*Maculabatis astra*	3	2	6	Low-medium
Brown whipray	*Maculabatis toshi*	3	2	6	Low-medium
Estuary stingray	*Hemitrygon fluviorum*	3	3	9	Medium
Coral sea maskray	*Neotrygon trigonoides*	3	2	6	Low-medium
Speckled maskray	*Neotrygon picta*	3	2	6	Low-medium
Bottlenose wedgefish	*Rhynchobatus australiae*	3	2	6	Low-medium
Eyebrow wedgefish	*Rhynchobatus palpebratus*	3	2	6	Low-medium
Eastern shovelnose ray	*Aptychotrema rostrata*	3	2	6	Low-medium
Giant guitarfish	*Glaucostegus typus*	2	2	4	Low
Sydney skate	*Dentiraja australis*	3	2	6	Low-medium
Endeavour skate	*Dentiraja endeavouri*	3	3	9	Medium
Argus skate	*Dentiraja polyommata*	4	2	8	Medium
Narrow sawfish	*Anoxypristis cuspidata*	3	3	9	Medium
Green sawfish	*Pristis zijsron*	3	4	12	High