# East coast otter trawl fishery regional risk assessments

## Species of conservation concern technical report

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*The Department of Agriculture and Fisheries proudly acknowledges all First Nations peoples (Aboriginal peoples and Torres Strait Islanders) and the Traditional Owners and Custodians of the country on which we live and work. We acknowledge their continuing connection to land, waters and culture and commit to ongoing reconciliation. We pay our respect to their Elders past and present.*

# Note to Reader

This technical report is one of two documents compiled as part of the East Coast Otter Trawl Fishery Regional Risk Assessment process. The technical report provides a detailed overview of the risk profiles for each region and the species at higher risk within the current fishing environment. The technical report is supported by a second document, the data report, which provides an overview of the justifications used to assign risk scores to each species within each of the five trawl management regions.

These reports have been prepared between 2023 and 2024 and is based on the management regime used in the East Coast Otter Trawl Fishery during this time. Risk assessments contained in this report will not take into consideration a) more recent changes to management or reform initiatives that have been implemented in the fishery after the commencement of this assessment or b) management and reform initiatives that are anticipated to occur in the near future.

Similarly, this report does not take into account recent updates to species-specific extinction risk assessments, conservation statuses and population trends that have occurred since the development of this assessment. Where changes have occurred prior to publication the authors have made all attempts to consider these and make amendments where necessary.

# Executive Summary

In 2023, a species-specific (Level 2) Ecological Risk Assessment (ERA) was completed for the East Coast Otter Trawl Fishery (ECOTF; Dedini *et al.*, 2023). The Level 2 ERA was based at a whole-of-fishery level and its publication fulfilled a key obligation of the ECOTF Wildlife Trade Operation (WTO) accreditation (Department of Climate Change Energy the Environment and Water, 2021).

One of the key recommendations of the Level 2 ERA was to undertake a finer-scale assessment examining the extent of any regional risk variability. This recommendation recognised that species ratings assigned at a whole-of-fishery level may not apply at a regional level. The Level 2 ERA also noted that some species-specific ratings were likely risk overestimates and, therefore, would be less applicable to the current fishing environment. These findings were reflected in the final ERA report where a proportion of the species were assigned precautionary risk ratings (Dedini *et al.,* 2023).

Risk assessments have now been completed for key bycatch species within each of the five ECOTF management regions (Department of Agriculture and Fisheries, 2021b; c; d; e; f). For continuity, the scope of the regional assessments were aligned with the Level 2 ERA and focused specifically on 62 Species of Conservation Concern (Dedini *et al.,* 2023). These species included marine turtles, sea snakes, syngnathids and a select group of sharks and batoids. Cross-comparing the distribution of these species with the prescribed management boundaries produced an assessment list of 43 species for the Northern Trawl Region, 46 species for the Central Trawl Region, 46 species for the Southern Inshore Trawl Region, 49 species for the Southern Offshore Trawl Region and 30 species for the Moreton Bay Trawl Region. As expected, these lists had a high degree of overlap and the vast majority of species were included in more than one assessment.

The Level 2 ERA was constructed using a Productivity and Susceptibility Analysis or PSA. The PSA is a data-driven assessment method which uses a predefined set of criteria to assign each species with an indicative risk rating. A review of the available information determined that regional datasets were not sufficient to support this type of assessment. Accordingly, regional risk assessments were constructed using a Likelihood and Consequence Analysis (LCA). The LCA is a qualitative risk assessment method and, when compared to the PSA, has fewer data requirements. It provides a more flexible framework to assess risk at a regional level and minimises the potential for false-positive results or risk overestimates. At its core, the LCA examines the consequence of a species interacting with the ECOTF and the likelihood of it coming to fruition **within the current fishing environment**.

The collective results of the LCA indicate that current fishing activities pose a low to low-medium risk to most of the species assessed. Risk ratings for marine turtles and syngnathids displayed a high level of consistency across the five trawl management regions. Conversely, risk ratings for sea snakes, batoids and sharks showed more variability. This variability demonstrates how the target species, individual habitat preferences and trawl-depth profiles influence bycatch rates and compositions in the ECOTF. For example, risk ratings for the sea snake complex were higher in the Central Trawl Region where operators target reef-associated species like red spot king prawns (*Melicertus longistylus*). Similarly, the batoid complex had a higher average risk rating in more southern trawl regions due, in part, to operators interacting with a more diverse range of species.

Across the study, only two species were considered to be at high risk within the current fishing environment. The Colclough's shark (*Brachaelurus colcloughi*) registered a high-risk rating in the

Southern Inshore and Offshore Trawl Regions, with the green sawfish (*Pristis zijsron*) assessed as a high risk in all regions excluding the Southern Offshore Trawl Region. *Brachaelurus colcloughi* occurs at a naturally low abundance and there is limited information on the age, growth and development of this species. There are, however, concerns surrounding the conservation status of *B. colcloughi* and the impact of commercial fishing on regional populations (Kyne *et al.*, 2015; Kyne *et al.*, 2021; Kyne *et al.*, 2023l). Similarly, *P. zijsron* has experienced significant population declines and range contractions on the Queensland east coast, resulting in the species being listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2019; Harry *et al.*, 2022; Kyne *et al.*, 2021).

For *B. colcloughi* and *P. zijsron*, there is an increased risk that interactions with the ECOTF will have a negative and potentially longer-term impact on regional populations. From a risk-management perspective, improving the level of information on interaction rates and release fates should be prioritised for these two species. This information will allow further refinement of their risk profiles and provide greater clarity on the interaction potential across the five trawl regions.

While the drivers of risk varied between species and regions, uncertainty surrounding catch compositions, interaction rates, locations and release fates were all contributing factors. With improved fisheries-based data, a number of the likelihood and consequence scores could be refined. This data may also facilitate the removal of species included in this assessment as a precautionary measure. The extent of any refinements though, will depend on the quality and quantity of the available data across each of the five trawl regions. Likewise, the data may identify areas where further assessment may be required at a regional or whole-of-fishery level.

The purpose of the LCA is to establish a risk profile for each trawl region based on the current fishing environment. This report helps contextualise the immediacy of the need for management intervention and identifies species within each region that are at higher risk of experiencing an undesirable event. The outputs of this report will be sensitive to change, particularly with respect to a changing fishing environment (e.g. changing effort levels, changing effort footprint and gear modifications) and conservation status movements. These sensitivities will limit the longevity of this report and, depending on the timing and extent of any change, may result in the ratings becoming outdated.

The above contrasts with the Level 2 ERA which provides a longer-term evaluation of attributes and elements that increase a species vulnerability to trawl fishing e.g. biological constraints, data deficiencies and management limitations (Dedini *et al.,* 2023). As a forward-looking assessment, the Level 2 ERA also provides a better account of the potential risk areas in this fishery e.g. species that may be affected more acutely if there is a significant change in the fishing environment. For this reason, the Level 2 ERA may be of more value when considering the long-term risk potential of the ECOTF, when reviewing the cumulative fishing risks and/or evaluating the efficacy of strategic management reforms.

**Summary of the outputs from the regional Likelihood and Consequence Analysis for the East Coast Otter Trawl Fishery (ECOTF) Trawl Regions.**

Key: Not Assessed ( ); Low Risk ( ); Low-Medium Risk ( ); Medium Risk ( ); and High Risk ( ).

| Common name | Species name | Regional risk | | | | |
|---|---|---|---|---|---|---|
| | | Northern | Central | Southern Inshore | Southern Offshore | Moreton Bay |
| **Marine turtles** | | | | | | |
| Loggerhead turtle | *Caretta caretta* | | | | | |
| Green turtle | *Chelonia mydas* | | | | | |
| Leatherback turtle | *Dermochelys coriacea* | | | | | |
| Hawksbill turtle | *Eretmochelys imbricata* | | | | | |
| Olive ridley turtle | *Lepidochelys olivacea* | | | | | |
| Flatback turtle | *Natator depressus* | | | | | |
| **Syngnathids** | | | | | | |
| Tiger pipefish | *Filicampus tigris* | | | | | |
| Spiny seahorse | *Hippocampus spinosissimus* | | | | | |
| Great seahorse | *Hippocampus kelloggi* | | | | | |
| Bentstick pipefish | *Trachyrhamphus bicoarctatus* | | | | | |
| White's seahorse | *Hippocampus whitei* | | | | | |
| Duncker's pipehorse | *Solegnathus dunckeri* | | | | | |
| Pallid pipehorse | *Solegnathus hardwickii* | | | | | |
| Straightstick pipefish | *Trachyrhamphus longirostris* | | | | | |
| Ribboned pipefish | *Haliichthys taeniophorus* | | | | | |
| **Sea snakes** | | | | | | |
| Reef shallows sea snake | *Aipysurus duboisii* | | | | | |
| Mosaic sea snake | *Aipysurus mosaicus* | | | | | |
| Olive sea snake | *Aipysurus laevis* | | | | | |
| Spine-bellied sea snake | *Hydrophis curtus* | | | | | |
| Elegant sea snake | *Hydrophis elegans* | | | | | |
| Spectacled sea snake | *Hydrophis kingii* | | | | | |
| Turtle-headed sea snake | *Emydocephalus annulatus* | | | | | |
| Olive-headed sea snake | *Hydrophis major* | | | | | |
| Small-headed sea snake | *Hydrophis macdowelli* | | | | | |
| Spotted sea snake | *Hydrophis ocellatus* | | | | | |
| Horned sea snake | *Hydrophis peronii* | | | | | |
| Beaked sea snake | *Hydrophis zweifeli* | | | | | |
| Stoke's sea snake | *Hydrophis stokesii* | | | | | |

| Common name | Species name | Regional risk | | | | |
|---|---|---|---|---|---|---|
| | | Northern | Central | Southern Inshore | Southern Offshore | Moreton Bay |
| **Sharks** | | | | | | |
| Collared carpetshark | *Parascyllium collare* | | | | | |
| Brownbanded bambooshark | *Chiloscyllium punctatum* | | | | | |
| Colclough's shark | *Brachaelurus colcloughi* | | | | | |
| Crested hornshark | *Heterodontus galeatus* | | | | | |
| Eastern angelshark | *Squatina albipunctata* | | | | | |
| Eastern banded catshark | *Atelomycterus marnkalha* | | | | | |
| Zebra shark | *Stegostoma tigrinum* | | | | | |
| Piked spurdog | *Squalus megalops* | | | | | |
| Australian weasel shark | *Hemigaleus australiensis* | | | | | |
| Pale spotted catshark | *Asymbolus pallidus* | | | | | |
| Grey spotted catshark | *Asymbolus analis* | | | | | |
| Orange spotted catshark | *Asymbolus rubiginosus* | | | | | |
| **Batoids** | | | | | | |
| Australian butterfly ray | *Gymnura australis* | | | | | |
| Yellowback stingaree | *Urolophus sufflavus* | | | | | |
| Patchwork stingaree | *Urolophus flavomosaicus* | | | | | |
| Sandyback stingaree | *Urolophus bucculentus* | | | | | |
| Kapala stingaree | *Urolophus kapalensis* | | | | | |
| Greenback stingaree | *Urolophus viridis* | | | | | |
| Common stingaree | *Trygonoptera testacea* | | | | | |
| Australian whipray | *Himantura australis* | | | | | |
| Blackspotted whipray | *Maculabatis astra* | | | | | |
| Brown whipray | *Maculabatis toshi* | | | | | |
| Estuary stingray | *Hemitrygon fluviorum* | | | | | |
| Coral Sea maskray | *Neotrygon trigonoides* | | | | | |
| Speckled maskray | *Neotrygon picta* | | | | | |
| Bottlenose wedgefish | *Rhynchobatus australiae* | | | | | |
| Eyebrow wedgefish | *Rhynchobatus palpebratus* | | | | | |
| Eastern shovelnose ray | *Aptychotrema rostrata* | | | | | |
| Giant guitarfish | *Glaucostegus typus* | | | | | |
| Sydney skate | *Dentiraja australis* | | | | | |
| Endeavour skate | *Dentiraja endeavouri* | | | | | |
| Argus skate | *Dentiraja polyommata* | | | | | |
| Narrow sawfish | *Anoxypristis cuspidata* | | | | | |
| Green sawfish | *Pristis zijsron* | | | | | |

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# Definitions and Abbreviations

| | | |
|---|---|---|
| BRD | – | Bycatch Reduction Device. |
| ECOTF | – | East Coast Otter Trawl Fishery. |
| EPBC Act | – | *Environment Protection and Biodiversity Conservation Act 1999.* |
| ERA | – | Ecological Risk Assessment. |
| False positive | – | The situation where a species at low risk is incorrectly assigned a higher risk rating due to the method being used, data limitation etc. In the context of an ERA, false positives are preferred over false negatives. |
| 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 and Consequence Analysis. A **qualitative** assessment method that provides an indicative (low, medium, high) evaluation of fishing-related risks. |
| PSA | – | Productivity and Susceptibility Analysis. A **semi-quantitative** assessment method that provides an indicative (low, medium, high) evaluation of fishing-related risks. |
| 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. |
| 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 and Protected Animals logbook. |
| TED | – | Turtle Excluder Device. |

| | | |
|---|---|---|
| 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 Species of Conservation Interest (SOCI) logbook in 2021. |
| WTO | – | Wildlife Trade Operation. |

# 1 Background

In 2023, a whole-of-fishery (Level 2) Ecological Risk Assessment (ERA) was completed for the East Coast Otter Trawl Fishery (ECOTF), herein referred to as the Level 2 ERA (Dedini *et al.*, 2023). This assessment focused specifically on marine turtle, sea snake, syngnathid, shark and batoid species, and identified attributes (e.g. biological constraints, data deficiencies and management limitations) that increase their vulnerability to trawl fishing activities (Dedini *et al.,* 2023). The publication of this report also fulfilled a key obligation of the ECOTF Wildlife Trade Operation (WTO) accreditation (Department of Climate Change Energy the Environment and Water, 2021).

The scope of the Level 2 ERA was based at the whole-of-fishery level and it differs from the regional management framework employed in this fishery (Department of Agriculture and Fisheries, 2021b; c; d; e; f). This differential was in direct response to a WTO condition that required the assessment to consider risk at a whole-of-fishery level. This requirement, in part, recognised that fishing pressures may be higher for species whose distribution extends across multiple trawl regions. These cumulative fishing pressures, and the contributing management regions, were discussed at length in the Level 2 ERA report (Dedini *et al.,* 2023).

Within the Level 2 ERA, it was recognised that ratings assigned at a whole-of-fishery level may not apply at a regional level. It was further noted that ratings assigned to some species were (likely) overestimates and may be less applicable to the current fishing environment. These findings were reflected in the final ERA report where a proportion of the species were assigned precautionary risk ratings (Dedini *et al.,* 2023). In response to these findings, the Level 2 ERA recommended that the ECOTF be subject to a finer-scale assessment examining the extent of any regional risk variability. In line with this recommendation, risk assessments have now been completed for key non-target species across all five trawl management regions.

The following provides an in-depth account of the risk assessments compiled for each trawl management region. The outputs of this report help contextualise the risk posed by regional trawl fishing activities and establishes a series of baseline assessments that can be updated through time. They provide further insight into the immediacy of the need for management intervention and will inform ancillary programs examining ways to better understand, mitigate and manage risk within the ECOTF.

# 2 Objectives

The primary objective of the regional assessments is to establish a risk profile for each trawl management region (Department of Agriculture and Fisheries, 2021b; c; d; e; f). The main difference between the outputs of this report and the Level 2 ERA (Dedini *et al.*, 2023), is that individual species will be assigned a risk rating in each region where it interacts, or has the potential to interact with trawl fishing activities. These outputs will inform discussions surrounding the management of risk within each management region and help identify key (regional) monitoring and research priorities.

Of notable importance, regional risk assessments assess risk **within the current fishing environment**. As such, the outputs of this report will be sensitive to change, particularly with respect to a changing fishing environment (e.g. changing effort levels, changing effort footprint and gear modifications) and conservation status movements. These sensitivities, depending on the timing and

extent of any change, may result in the regional assessments becoming outdated more rapidly and/or requiring more regular updates.

In contrast, the published Level 2 ERA provides a longer-term evaluation of attributes and elements (e.g. biological constraints, data deficiencies and management limitations) that increase a species vulnerability to trawl fishing (Dedini *et al.,* 2023). As a forward-looking assessment, the Level 2 ERA provides a better account of the long-term risk areas in this fishery. For example, species that may be affected more acutely if there is a significant change in the fishing environment. For this reason, the Level 2 ERA will be of more value when considering the long-term risk potential of the ECOTF, when reviewing the cumulative fishing risks and/or evaluating the efficacy of strategic management reforms. This report also includes recommendations on how longer-term risk areas can be better understood, managed and mitigated within the ECOTF (Dedini *et al.,* 2023).

# 3 Methods

The Level 2 ERA was constructed using a Productivity and Susceptibility Analysis (PSA). The PSA forms the cornerstone of all Level 2 assessments under the *Queensland Ecological Risk Assessment Guidelines* (the Guidelines) and provides a detailed examination of the biological constraints of each species and how they interact with a fishery (Department of Agriculture and Fisheries, 2018a; 2022b). A review of the available information determined that regional datasets were not sufficient to support a PSA and, if applied at this level, would result in a high number of false positives or risk overestimates (Dedini *et al.*, 2023; Zhou *et al.*, 2016). For this reason, the regional risk assessments employed an alternate method, the Likelihood and Consequence Analysis (LCA).

## 3.1 Scope

The framework of the regional risk assessments were aligned with the ECOTF harvest strategy program, with separate assessments being completed for the Northern Trawl Region, Central Trawl Region, Southern Inshore Trawl Region, Southern Offshore Trawl Region and Moreton Bay Trawl Region (Department of Agriculture and Fisheries, 2021b; c; d; e; f).

For continuity, the species list for the Level 2 ERA also formed the basis of the regional risk assessments. This list consisted of 62 Species of Conservation Concern (SOCC) and included marine turtles ($n$ = 6), syngnathids ($n$ = 9), sea snakes ($n$ = 13), batoids ($n$ = 22) and sharks ($n$ = 12). These 62 SOCC were identified as assessment priorities as part of a broader species rationalisation process completed for the Level 2 ERA. The full details of the species rationalisation process are provided in Dedini *et al.* (2023).

To compile a species list for each region, the known distribution of each species was cross-referenced with the prescribed, legislated fishing boundaries (Department of Agriculture and Fisheries, 2021b; c; d; e; f). Species were omitted from a regional assessment if a) the known distribution did not overlap with a harvest strategy boundary (i.e. no possibility of an interaction occurring) or b) if a weight-of-evidence approach indicated that the probability of an interaction was negligible, minimal or would only occur in exceptional circumstances (Fig. 1). Where there was uncertainty surrounding a species distribution and/or their potential to interact with regional-specific trawl operations, it was retained in the assessment as a precautionary measure. This approach has been applied across the broader ERA program and ensures that potentially at-risk species are not omitted from the analysis.

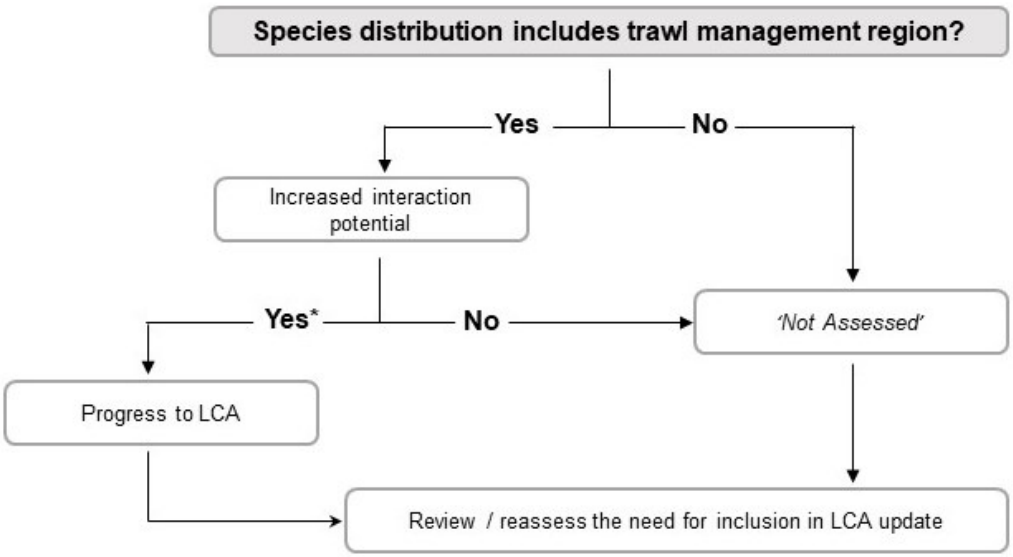



***Figure 1**. Decision tree to determine the inclusion/omittance of a species from being progressed for assessment. '*' Indicates where a precautionary approach was applied to the Likelihood and Consequence Analysis (LCA) which required a species to be included in the assessment if evidence used to justify their exclusion was unavailable or considered insufficient.*

Datasets complied for the Level 2 ERA informed the LCA and included information on the biological attributes and vulnerabilities of each species. This information was collated through a comprehensive review of peer-reviewed articles, grey literature and publicly accessible databases including 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 for each group was sourced from core references such as *Rays of the World* (Last *et al*., 2016), *Sharks and Rays of Australia* (Last & Stevens, 2009), the *Action Plan of Australian Sharks and Rays* (Kyne *et al.,* 2021), marine turtle biological reviews (Limpus, 2007a; b; 2008a; b; c; 2009), the *Queensland Marine Turtle Conservation Strategy 2021–2031* (Department of Environment and Science, 2021) and associated recovery plans (e.g. Department of the Environment, 2015b; 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 (Courtney *et al.*, 2010; Udyawer *et al.*, 2020; Udyawer *et al.*, 2016).

Fisheries data underpinning the assessment were 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) and the Statewide Recreational Fishing Survey (Department of Agriculture and Fisheries, 2021g; Teixeira *et al.*, 2021; Webley *et al.*, 2015).

## 3.2 Likelihood and Consequence Analysis (LCA)

The LCA is a qualitative risk assessment method that, when compared to the PSA, has fewer data requirements (Fletcher, 2015; Fletcher *et al.*, 2005). It provides a more flexible framework to assess risk at a regional level and minimises the potential for false-positive results or risk overestimates. At its core, the LCA examines the consequence of a species interacting with the ECOTF and the likelihood

of it coming to fruition within the current fishing environment. As a qualitative assessment method, the LCA relies more heavily on a weight-of-evidence approach and may include anecdotal evidence based on expert opinion.

Under this method, risk profiles are compiled through the assignment of scores signifying the extremity of the consequence (Negligible to Major) and the likelihood (Remote to Likely) of it coming to fruition (Fletcher, 2015; Fletcher *et al.*, 2005). Consequence and likelihood scores assigned to each species are based on the pre-defined criteria outlined in Table 1 and Table 2 respectively. A 'Likelihood x Consequence Analysis matrix' was then used to assign an indicative risk rating to each species based on the two component scores (Table 3).

In the regional trawl assessments, consequence scores considered a range of factors including fishery-dependent data, third-party assessments (e.g. IUCN Red List assessments, *Shark and Ray Report Card*), legislative protections, population trend analysis, bycatch assessments and the effectiveness of current risk mitigation strategies (e.g. Turtle Excluder Device [TED] / Bycatch Reduction Device [BRD] effectiveness, spatial closures). Consequence score criteria also included options to consider the outputs of the Level 2 ERA (Dedini *et al.,* 2023). The Level 2 ERA identified species-specific vulnerabilities and the inclusion of these factors ensured that they were given adequate consideration as part of the regional risk assessments (Table 1).

In the likelihood component (Table 2), scores reflected the likelihood of the fishery causing or making a significant contribution to the occurrence of the most hazardous consequence (Fletcher *et al.* 2002). Parameters influencing the overall score included a) a species habitat and bathymetric preferences, b) the likelihood of a species being encountered by trawling apparatus, c) refuge beyond trawled areas and d) evidence to determine the extent of any interactions (or lack thereof) occurring.

Once scores were assigned to likelihood and consequence components, they were cross-referenced with thresholds outlined in Table 3 to provide each species with a preliminary risk rating. These preliminary ratings were refined in consultation with members of the Trawl Fishery Working Group, Regional Harvest Strategy Advisory Groups and scientific experts with specific knowledge of the species most likely to interact with the ECOTF.

***Table 1.*** *Criteria used to assign indicative scores in 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 harvest levels/fishing-related mortalities 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 2.*** *Criteria used to assign indicative scores in the likelihood component of the analysis.*

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

***Table 3****. The 'Likelihood x Consequence Analysis matrix' used to assign indicative risk ratings to each species: negligible = score 0–1 (blue), low = score 2–5 (green), low-medium = score 6 (light yellow), medium = score 8–10 (orange) and high = score 12–20 (red).*

| | | 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 |

# 4 Results and Observations

## 4.1 General

A cross-comparison of the species distribution data and prescribed management boundaries produced an assessment list of 43 species for the Northern Trawl Region, 46 species for the Central Trawl Region, 46 species for the Southern Inshore Trawl Region, 49 species for the Southern Offshore Trawl Region and 30 species for the Moreton Bay Trawl Region (Fig. 2). As expected, regional lists had a high degree of overlap and the vast majority of species were included in more than one assessment. When this overlap was accounted for, this study included a combined total of 214 individual, species-specific risk assessments across the five trawl regions (Fig. 2).

The outputs from the LCA indicate that regional trawl fishing activities pose a low, low-medium or medium risk to most of the species assessed (Fig. 3). Risk ratings for marine turtles and syngnathids displayed a high level of consistency across the five trawl management regions (Table 4). Conversely,

risk ratings for sea snakes, batoids and sharks showed more variability. This variability demonstrates how the target species, individual habitat preferences and trawl-depth profiles influence bycatch rates and compositions in the ECOTF. For example, risk ratings for the sea snake complex were higher in the Central Trawl Region where operators target reef-associated species like red spot king prawns (*Melicertus longistylus*). Similarly, the batoid complex had a higher average risk rating in more southern trawl regions due, in part, to operators interacting with a more diverse range of species (Department of Agriculture and Fisheries, 2023b).

Across the study, only two species were considered to be at a high (potential) risk within the current fishing environment. The Colclough's shark (*Brachaelurus colcloughi*) registered a high-risk rating in the Southern Inshore and Offshore Trawl Regions, with the green sawfish (*Pristis zijsron*) assessed as a high risk in all regions excluding the Southern Offshore Trawl Region (Table 4). *Brachaelurus colcloughi* occurs at a naturally low abundance and there is limited information on the age, growth and development of this species. There are, however, concerns surrounding the conservation status of *B. colcloughi* and the impact of commercial fishing on regional populations (Kyne *et al.*, 2015; Kyne *et al.*, 2021; Kyne *et al.*, 2023l). Similarly, *P. zijsron* has experienced significant population declines and range contractions on the Queensland east coast, resulting in the species being listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; Department of the Environment, 2019; Harry *et al.*, 2022; Kyne *et al.*, 2021).

Within the ECOTF, *B. colcloughi* interactions are more likely to occur in the Central, Southern (Inshore and Offshore) and Moreton Bay Trawl Regions. The known distribution of *P. zijsron* indicates that this species has the potential to interact with trawl operations along the entire Queensland east coast (Kyne *et al.*, 2021; Last *et al.*, 2016). However, evidence suggests that this species is now extirpated in southern and potentially central Queensland (Harry *et al.*, 2022; Kyne *et al.*, 2023aa). This complicates the *P. zijsron* risk profile as it means interactions are (now) unlikely to occur in the Central, Southern (Inshore and Offshore) and Moreton Bay Trawl Regions. The inherent trade off being that any *P. zijsron* interactions in these regions will be with a remnant population. This heightens the risk that trawl-related mortalities will impact the long-term survivability of this species in central and southern Queensland.

For *B. colcloughi* and *P. zijsron*, there is an increased risk that regional trawl fishing activities will have a negative and potentially longer-term impact on regional populations. Data deficiencies make it difficult to determine the extent (none, low, medium or high) of these impacts and the collection of additional information should be prioritised for both species. Additional information on interaction rates, locations and release fates will enable the *B. colcloughi* and *P. zijsron* risk profiles to be further refined and provide greater clarity on their interaction potential across the five management regions. Further information on the interaction potential of both species is provided in the risk assessment analysis for each region (refer to section 4.2).

While the drivers of risk varied between species and regions, uncertainty surrounding catch compositions, interaction rates, locations and release fates were all contributing factors. With improved fisheries-based data, a number of the species-specific likelihood and consequence scores could be further refined (Table 4). This data may also facilitate the removal of species included in this assessment as a precautionary measure, for example, some of the stingaree and skate species included in the southern trawl region LCAs (Table 4). The extent of these refinements will depend on the quality and quantity of the available data across each of the five trawl regions. Likewise, this data may identify areas where further assessment may be required at a regional or whole-of-fishery level.

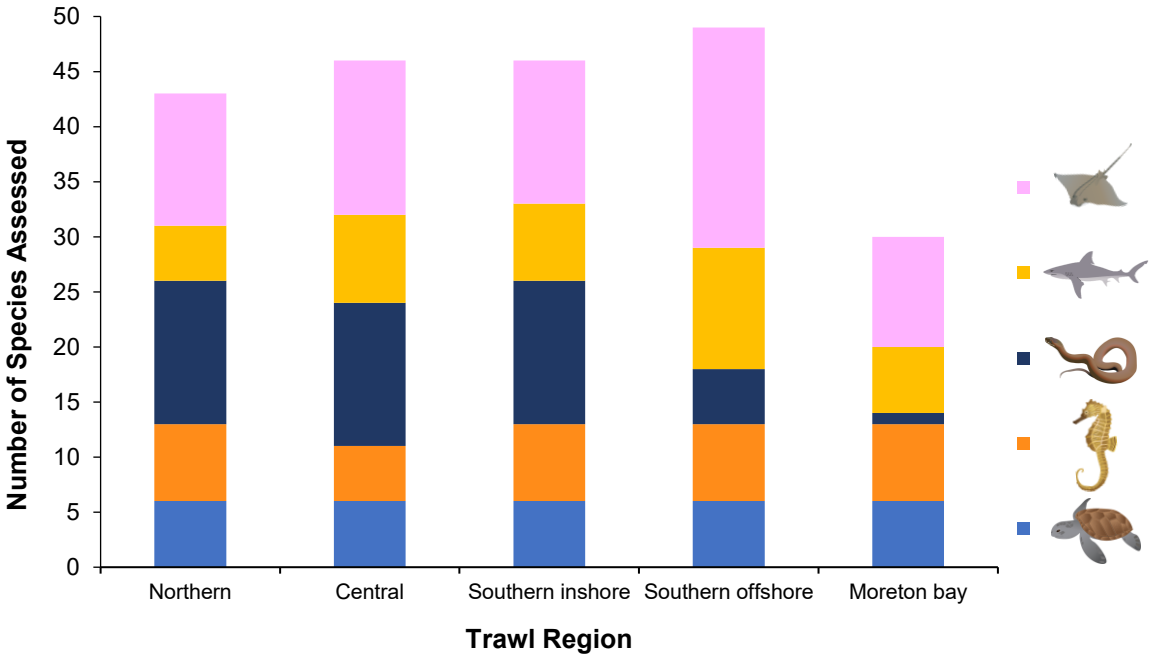



***Figure 2.*** *Overview of the composition of the species assessment list (by subgoup) for the Northern, Central, Southern Inshore, Southern Offshore and Moreton Bay Trawl Regions.*

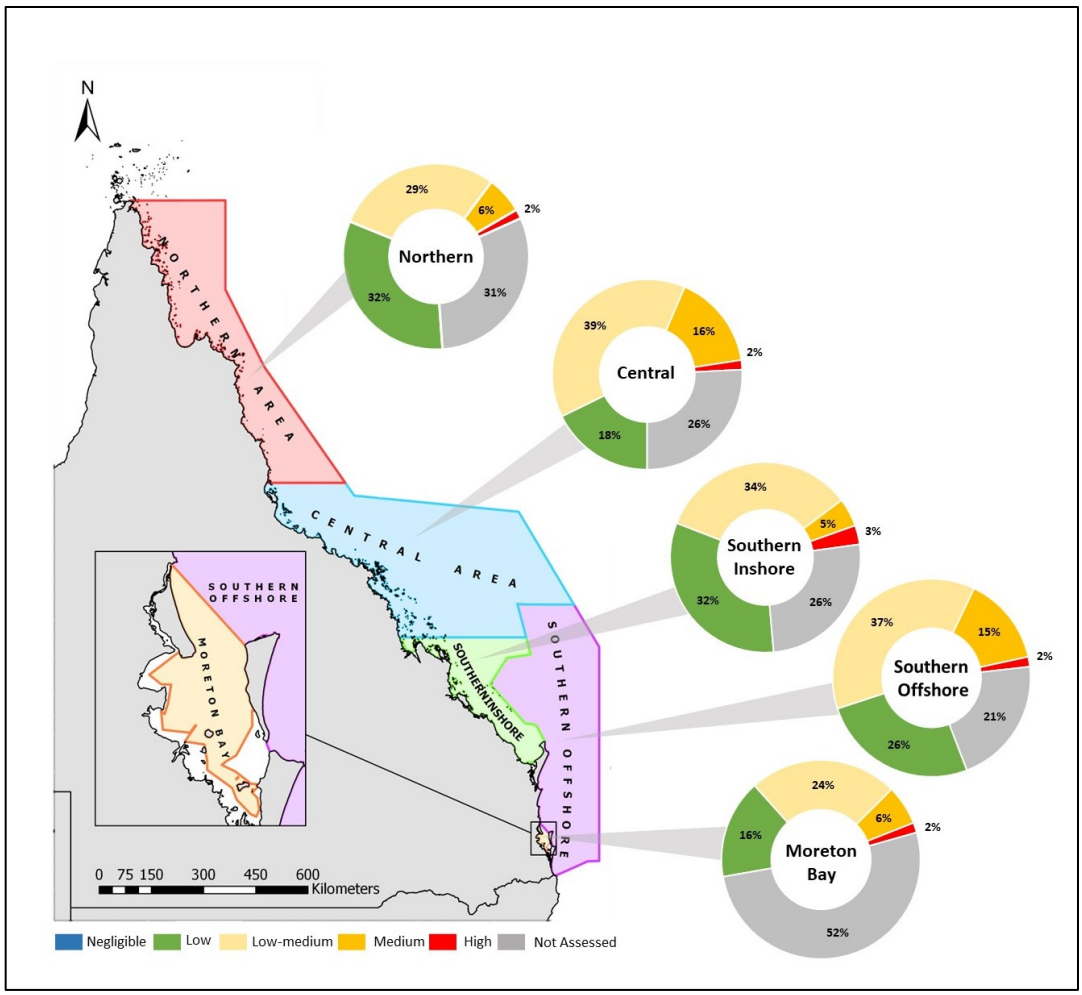



***Figure 3****. Visual representation of the risk variability within each of the five ECOTF regions.*

***Table 4**. Summary of the outputs for the regional Likelihood Consequence Analysis examining risk levels within the five ECOTF Regions (Department of Agriculture and Fisheries, 2021b; c; d; e; f). Key: Not Assessed ( ); Low Risk ( ); Low-Medium Risk ( ); Medium Risk ( ); and High Risk ( ).*

| Common name | Species name | Regional risk | | | | |
|---|---|---|---|---|---|---|
| | | Northern | Central | Southern Inshore | Southern Offshore | Moreton Bay |
| **Marine turtles** | | | | | | |
| Loggerhead turtle | *Caretta caretta* | | | | | |
| Green turtle | *Chelonia mydas* | | | | | |
| Leatherback turtle | *Dermochelys coriacea* | | | | | |
| Hawksbill turtle | *Eretmochelys imbricata* | | | | | |
| Olive ridley turtle | *Lepidochelys olivacea* | | | | | |
| Flatback turtle | *Natator depressus* | | | | | |
| **Syngnathids** | | | | | | |
| Tiger pipefish | *Filicampus tigris* | | | | | |
| Spiny seahorse | *Hippocampus spinosissimus* | | | | | |
| Great seahorse | *Hippocampus kelloggi* | | | | | |
| Bentstick pipefish | *Trachyrhamphus bicoarctatus* | | | | | |
| White's seahorse | *Hippocampus whitei* | | | | | |
| Duncker's pipehorse | *Solegnathus dunckeri* | | | | | |
| Pallid pipehorse | *Solegnathus hardwickii* | | | | | |
| Straightstick pipefish | *Trachyrhamphus longirostris* | | | | | |
| Ribboned pipefish | *Haliichthys taeniophorus* | | | | | |
| ***Sea snakes*** | | | | | | |
| Reef shallows sea snake | *Aipysurus duboisii* | | | | | |
| Mosaic sea snake | *Aipysurus mosaicus* | | | | | |
| Olive sea snake | *Aipysurus laevis* | | | | | |
| Spine-bellied sea snake | *Hydrophis curtus* | | | | | |
| Elegant sea snake | *Hydrophis elegans* | | | | | |
| Spectacled sea snake | *Hydrophis kingii* | | | | | |
| Turtle-headed sea snake | *Emydocephalus annulatus* | | | | | |
| Olive-headed sea snake | *Hydrophis major* | | | | | |
| Small-headed sea snake | *Hydrophis macdowelli* | | | | | |
| Spotted sea snake | *Hydrophis ocellatus* | | | | | |
| Horned sea snake | *Hydrophis peronii* | | | | | |
| Beaked sea snake | *Hydrophis zweifeli* | | | | | |
| Stoke's sea snake | *Hydrophis stokesii* | | | | | |
| **Sharks** | | | | | | |

| Common name | Species name | Regional risk | | | | |
|---|---|---|---|---|---|---|
| | | Northern | Central | Southern Inshore | Southern Offshore | Moreton Bay |
| Collared carpetshark | *Parascyllium collare* | | | | | |
| Brownbanded bambooshark | *Chiloscyllium punctatum* | | | | | |
| Colclough's shark | *Brachaelurus colcloughi* | | | | | |
| Crested hornshark | *Heterodontus galeatus* | | | | | |
| Eastern angelshark | *Squatina albipunctata* | | | | | |
| Eastern banded catshark | *Atelomycterus marnkalha* | | | | | |
| Zebra shark | *Stegostoma tigrinum* | | | | | |
| Piked spurdog | *Squalus megalops* | | | | | |
| Australian weasel shark | *Hemigaleus australiensis* | | | | | |
| Pale spotted catshark | *Asymbolus pallidus* | | | | | |
| Grey spotted catshark | *Asymbolus analis* | | | | | |
| Orange spotted catshark | *Asymbolus rubiginosus* | | | | | |
| **Batoids** | | | | | | |
| Australian butterfly ray | *Gymnura australis* | | | | | |
| Yellowback stingaree | *Urolophus sufflavus* | | | | | |
| Patchwork stingaree | *Urolophus flavomosaicus* | | | | | |
| Sandyback stingaree | *Urolophus bucculentus* | | | | | |
| Kapala stingaree | *Urolophus kapalensis* | | | | | |
| Greenback stingaree | *Urolophus viridis* | | | | | |
| Common stingaree | *Trygonoptera testacea* | | | | | |
| Australian whipray | *Himantura australis* | | | | | |
| Blackspotted whipray | *Maculabatis astra* | | | | | |
| Brown whipray | *Maculabatis toshi* | | | | | |
| Estuary stingray | *Hemitrygon fluviorum* | | | | | |
| Coral Sea maskray | *Neotrygon trigonoides* | | | | | |
| Speckled maskray | *Neotrygon picta* | | | | | |
| Bottlenose wedgefish | *Rhynchobatus australiae* | | | | | |
| Eyebrow wedgefish | *Rhynchobatus palpebratus* | | | | | |
| Eastern shovelnose ray | *Aptychotrema rostrata* | | | | | |
| Giant guitarfish | *Glaucostegus typus* | | | | | |
| Sydney skate | *Dentiraja australis* | | | | | |
| Endeavour skate | *Dentiraja endeavouri* | | | | | |
| Argus skate | *Dentiraja polyommata* | | | | | |
| Narrow sawfish | *Anoxypristis cuspidata* | | | | | |
| Green sawfish | *Pristis zijsron* | | | | | |

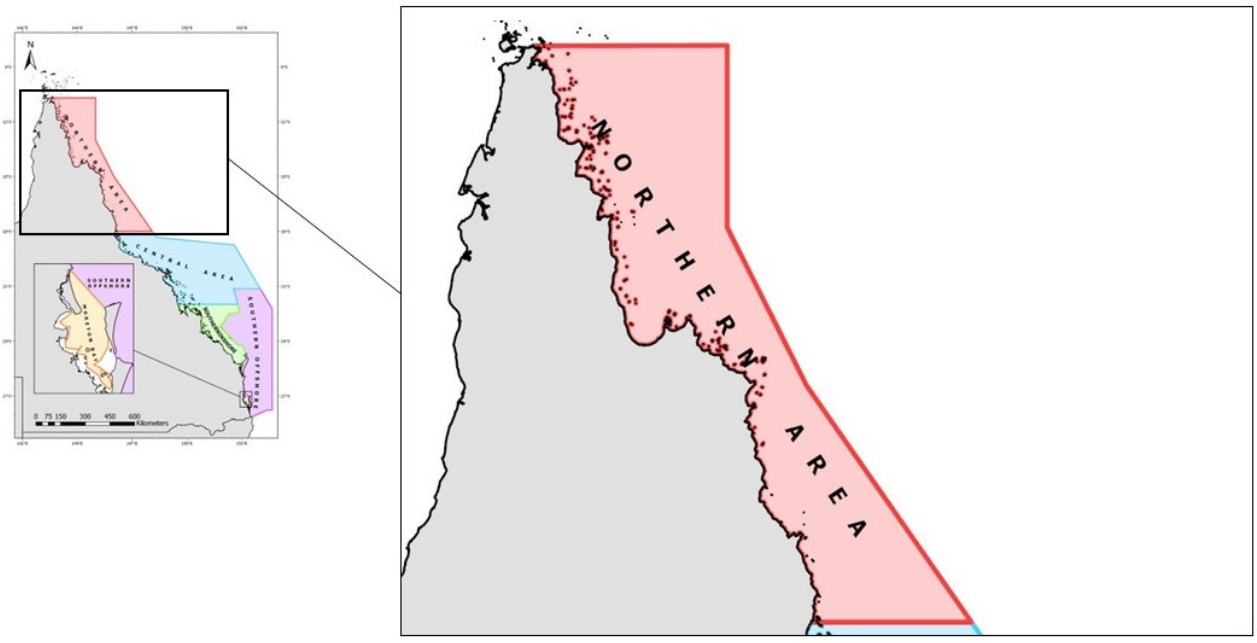
## 4.2 Regional Risk Assessments

The following provides an overview of the risk profiles for the Northern, Central, Southern Inshore, Southern Offshore and Moreton Bay Trawl Regions (Department of Agriculture and Fisheries, 2021b; c; d; e; f). To facilitate easier comparison, Table 4 provides a summary of the LCA outputs for all species across the five management regions. A more detailed account of the regional risk profiles is provided in sections 4.2.1 to 4.2.5. A comprehensive overview of the justifications underpinning the likelihood and consequence score for each species is provided in the Data Report: Appendix A to E.

The outputs of the regional LCAs will be sensitive to change, particularly with respect to a changing fishing environment (e.g. changing effort levels, changing effort footprint and gear modifications) and conservation status movements. These sensitivities will limit the longevity of this report and, depending on the timing and extent of any change, may result in the regional assessments becoming outdated more rapidly and/or requiring more regular updates. In contrast, the Level 2 ERA provides a longer-term evaluation of attributes and elements that increase a species vulnerability to trawl fishing e.g. biological constraints, data deficiencies and management limitations (Dedini *et al.,* 2023).

As a forward-looking assessment, the Level 2 ERA provides a better account of the potential risk areas in this fishery e.g. species that may be affected more acutely if there is a significant change in the fishing environment. It also provides a more detailed overview of what is being done to address longer-term risks in this fishery and identifies areas where risk can be better understood, managed or mitigated within the ECOTF. For this reason, the Level 2 ERA may be of more value when considering the long-term risk potential of the ECOTF, when reviewing the cumulative fishing risks and/or evaluating the efficacy of strategic management reforms.

### 4.2.1 Northern Trawl Region



Of the 62 species considered for assessment, 43 had distributions that overlapped with the Northern Trawl Region (Department of Agriculture and Fisheries, 2021d). The remaining 19 species had distributions and depth profiles that negated or significantly reduced their interaction potential in this region. These species were excluded from the Northern Trawl Region LCA and assigned a 'Not Assessed' classification (Fig. 3; Table 4).

All five subgroups were represented in the Northern Trawl Region LCA including all marine turtles (*n* = 6), sea snakes (*n* = 13), and the majority of the syngnathids (*n* = 7 of 9). Fewer sharks (*n* = 5 of 12) and batoids (*n* = 12 of 22) required assessment in this region due to geographical (range) constraints and depth profile considerations (Table 4). The main subgroups excluded from the analysis were stingarees (*Urolophus* spp., *Trygonoptera* spp.), skates (*Dentiraja* spp.) and deeper-water shark species (Asymbolus spp.; Department of Agriculture and Fisheries, 2021d; Kyne *et al.*, 2021; Last *et al.*, 2016; Last & Stevens, 2009).

The vast majority of species included in this assessment registered risk ratings of low (*n* = 20) or low-medium (*n* = 18). Four species were classified as a medium risk (one syngnathid, one sea snake and two batoids), with the green sawfish (*Pristis zijsron*) registering the only high-risk rating in the Northern Trawl Region LCA (Table 4). While not universal, ongoing conservation concerns, an increased interaction potential and uncertainty surrounding interaction rates and release fates were identified as the key contributors of risk.

#### 4.2.1.1 Marine Turtles

All but one of the marine turtle species were assigned a risk rating of low-medium in the Northern Trawl Region (Table 4). The exception being the leatherback turtle (*Dermochelys coriacea*) whose life-history has a stronger correlation with pelagic-water environments (Department of the Environment, 2023a; Department of the Environment and Energy, 2017; Eckert *et al.*, 2012; Limpus, 2009). These life-history traits combined with the habitat preferences of the two primary target species, brown (*Penaeus esculentus*) and grooved (*P. semisulcatus*) tiger prawns, reduce the probability of a *D. coriacea* interaction occurring in this region. These preferences though do not completely mitigate the interaction risk and a small number of *D. coriacea* have been reported as bycatch within the broader ECOTF (Department of Agriculture and Fisheries, 2023b). The interactions, combined with uncertainty surrounding the accuracy of data compiled through the Threatened, Endangered and Protected Animals (TEPA) logbook (Dedini *et al.*, 2023), supported the inclusion of *D. coriacea* in the Northern Trawl Region LCA. With improved catch data, it is conceivable that *D. coriacea* could be removed from future risk assessments involving this region.

Distributional and habitat data for the remaining species indicate that they can and will interact with trawl operations in this region. Most interactions will (likely) involve the green turtle (*Chelonia mydas*) which is found in higher abundances along the Queensland east coast (Department of the Environment, 2023b; Limpus, 2008c). However, the hawksbill turtle (*Eretmochelys imbricata*) has nesting sites in northern Queensland and migrating loggerhead turtles (*Caretta caretta*) may also be found in this area (Department of Agriculture and Fisheries, 2023b; Limpus, 2007b; 2008b). When compared to more southerly trawl grounds, operators in the Northern Trawl Region are more likely to encounter the olive ridley turtle (*Lepidochelys olivacea*) and the flatback turtle (*Natator depressus*; Limpus, 2007a; Limpus, 2008a). This is of particular relevance to *L. olivacea* which nests in northern Australia and are found with more regularly in tropical waters (Department of the Environment and Energy, 2017; Limpus, 2007a; 2008a).

Across the complex, the use of a Turtle Excluder Device (TED) contributed to the marine turtle complex receiving ratings at the lower end of the risk spectrum (Table 4; Data Report: Appendix A). The use of a TED remains a pivotal component of the broader ECOTF management regime and it is arguably the most effective risk-mitigation strategy employed for this subgroup. Research has shown that the use of a TED, combined with a Bycatch Reduction Device (BRD), can reduce landing rates for marine turtles by 97–99 per cent (Brewer *et al.*, 2006; Campbell *et al.*, 2020; Department of Agriculture and Fisheries, 2012; National Oceanic and Atmospheric Administration Fisheries, 2021). While similar turtle exclusion rates could be expected within the Northern Trawl Region, further information is required on the effectiveness of TEDs at a species, regional and whole-of-fishery level.

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 (Business Queensland, 2022; Department of Agriculture and Fisheries, 2012). 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 (e.g. internal and external injuries incurred during the net retrieval/landing process and/or being crushed by the weight of the catch). When a marine turtle is caught within the sweep of the net, the majority will experience a contact without capture event (Brewer *et al.,* 2006; Campbell *et al.,* 2020; Dedini *et al.,* 2023). These types of events are less likely to result in significant injuries and pose a lower long-term risk to the effected individual. These benefits were reflected in the outputs of this assessment and previous ERAs where the use of a TED, combined with declining effort levels, contributed to the complex receiving lower risk ratings (Table 4; Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b).

More broadly, the marine turtle complex will be afforded considerable protection through a range of legislative instruments. For example, most nesting sites situated in north Queensland occur in habitats now protected under marine parks legislation or the Queensland *Nature Conservation Act 1992* (Limpus, 2007a; b; 2008a; b; c; 2009). For a number of the species, these protections extend to their preferred coastal foraging habitats. The level of protection will vary between species and may be less effective for highly migratory species like *E. imbricata* (Limpus, 2007b). These measures though help to reduce the exposure of this complex to trawl fishing and restrict or prohibit activities in areas where marine turtles are found in higher abundances throughout the year (Great Barrier Reef Marine Park Authority, 2022; 2023; Undated). These factors were taken into consideration as part of the LCA and supported the assignment of lower risk ratings (Table 4; Data Report: Appendix A).

Data compiled through the TEPA logbook contains fewer than 100 marine turtle interactions across the entire ECOTF (2006–2021 data; Department of Agriculture and Fisheries, 2023b).[1] The veracity of this data has yet to be fully tested as the ECOTF does not currently operate with an effective mechanism to validate regional bycatch compositions, interaction rates or release fates.[2] This creates uncertainty surrounding the accuracy of marine turtle interaction-rate data and increases the risk of

[1] Includes data from the previous Species of Conservation Interest (SOCI) logbook. The TEPA logbook superseded the SOCI logbook in 2021 as part of a broader review of the logbook reporting requirements.

[2] Independent data validation is an integral component of the “Improved monitoring and research” foundational reform outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018b). A trial of independent data validation in the ECOTF is well advanced. However, data validation has yet to be fully implemented across the ECOTF. More information on the mechanisms being used to address the long-term data validation risk has been provided in the Level 2 ERA (Dedini *et al.*, 2023).

non-compliance and under-reporting. At the time of this assessment, marine turtle interaction rates could not be confirmed for the Northern Trawl Region.

The inability to validate TEPA logbook data increases the level of uncertainty surrounding the extent of marine turtle interactions in the Northern Trawl Region. However, cross comparisons with analogous fisheries lend support to the hypothesis that marine turtle interactions are under-reported across the entire ECOTF. For example, the Northern Prawn Fishery (NPF) observer program recorded 525 marine turtle interactions between 2018 and 2022 inclusive (Australian Fisheries Management Authority, 2023b).[3] Over this same period, the entire ECOTF reported 35 marine turtle interactions through the TEPA logbook (Department of Agriculture and Fisheries, 2023b). 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 (Department of Agriculture and Fisheries, 2023b; Patterson *et al.*, 2022). This uncertainty was a key consideration in the current assessment and contributed to a number of the species receiving marginally higher risk ratings (Table 4).

With the ongoing rollout of the *Data Validation Plan*, expectations are that the level of information on marine turtle interactions will improve across the ECOTF and within each of the five management regions (Department of Agriculture and Fisheries, 2018b; 2023a; Queensland Government, Undated). The outputs of this program may be the key determinant in terms of the need to update the LCA for this complex within the Northern Trawl Region.

#### 4.2.1.2 Sea Snakes

The Northern Trawl Region LCA had one of the highest sea snake representations with all 13 species included in the assessment. The vast majority registered an LCA score within the low-risk category with just three recording a regional risk rating of low-medium or medium (Table 4). A review of the available data indicates that the distributions and habitat preferences of the spine-bellied sea snake (*Hydrophis curtus*), spectacled sea snake (*H. kingii*) and elegant sea snake (*H. elegans*) increase their interaction potential within the Northern Trawl Region (Data Report: Appendix A). This was reflected in their respective risk ratings (Table 4).

Sea snake bycatch data for the ECOTF has poor species resolution and provides limited insight into regional catch compositions. At a whole-of-fishery level, sea snakes are the most reported complex in the TEPA logbook data with an average of 1,655 sea snake interactions (*range* = 336–4,753) recorded from the ECOTF each year (2003–2021 data; Department of Agriculture and Fisheries, 2023b).[4] While difficult to quantify, a high percentage of these interactions will occur further south in the Central Trawl Region. This region incorporates the red spot king prawn (*Melicertus longistylus*) sector which is the main source of ECOTF sea snake interactions and mortalities (Courtney *et al.*, 2010; Department of Agriculture and Fisheries, 2021b; d). For context, Courtney *et al.* (2010) reported that over half of the sea snake interactions (59 per cent) and 85 per cent of the sea snake mortalities occurred in trawl operations targeting *M. longistylus*. When compared to central Queensland, trawl operators in the Northern Trawl Region will pose a lower (general) risk to this complex.

[3] The NPF operates in northern Australia, has Marine Stewardship Council (MSC) certification and has a multi-faceted catch validation program that includes crew member observers and scientific observers (Australian Fisheries Management Authority, 2023a; Marine Stewardship Council, 2023).

[4] Includes data from the previous Species of Conservation Interest (SOCI) logbook. The TEPA logbook superseded the SOCI logbook in 2021 as part of broader review of the logbook reporting requirements.

Research has shown that BRD designs like the Fisheye and Square Mesh Codend are effective at excluding sea snakes from the trawl catch (Courtney *et al.*, 2010; Dedini *et al.*, 2023; Milton *et al.*, 2009; Queensland Government, 2022). In some instances, the use of these designs combined with a TED can reduce sea snake landing rates by up to 63 per cent (Courtney *et al.,* 2010). These findings have been accounted for in regional management regimes and are proven mitigators of risk for this subgroup. One of the inherent benefits of excluding sea snakes from the trawl catch is that they are more likely to experience a contact without capture event. Contact without capture events are less likely to result in the death of the animal or impede their long-term survivability. This was taken into consideration as part of the regional assessment and factored into sea snakes receiving lower risk ratings in the Northern Trawl Region.

Data compiled through the TEPA logbook indicates that between three and 30 per cent of landed sea snakes die due to drowning or injuries sustained during a trawl fishing event (Dedini *et al.*, 2023; Department of Agriculture and Fisheries, 2023b). Analysis of observer data from the NPF also places sea snake trawl mortality rates between 16 and 25 per cent (Australian Fisheries Management Authority, 2023b; Dedini *et al.*, 2023). Without a mechanism to validate regional TEPA logbook data, it is difficult to determine if mortality rate percentages for the entire ECOTF hold true for the Northern Trawl Region and/or if they have been influenced by more recent management reforms and declining effort (Table 4; Data Report: Appendix A). From an ERA perspective, this increases the level of assessment uncertainty and requires the adoption of a more precautionary approach.

The level of information on sea snake bycatch in the Northern Trawl Region will improve with the continued roll-out of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018b; Queensland Government, Undated). Research has also commenced on a project exploring avenues to reduce the impact of the fishery on threatened, endangered and protected species including sea snakes (Fisheries Research and Development Corporation, 2023a). The outputs of these data improvement initiatives may alter the risk profile of this complex and help refine the findings of the Northern Trawl Region LCA. Depending on the outputs, there may be a greater need to update the risk profiles of this complex within this region.

As this is the first regional assessment undertaken for the ECOTF, there are limited avenues to compare the results of this LCA with previous ERAs. The most tangible results being from a previous qualitative ERA examining the risk posed by trawl fishing activities within the Great Barrier Reef Marine Park (GBRMP; Pears *et al.*, 2012b). The outputs of this assessment showed broad similarities with the LCA in that the majority of sea snakes were situated at the lower end of the risk spectrum. While the outputs of the GBRMP Trawl ERA are marginally higher (Pears *et al.*, 2012b), this assessment considered trawl fishing activities across the entire GBRMP including activities now encompassed within the Central Trawl Region (Department of Agriculture and Fisheries, 2021b). As noted, fishing operations in the Central Trawl Region are more likely to interact with this subgroup and pose a higher risk to the sea snake complex. It is further recognised that a) the assessment methodology used for the GBRMP Trawl ERA is more analogous to that used in the Level 2 ERA (Dedini *et al.*, 2023; Pears *et al.*, 2012b) and b) effort levels have declined since the completion of this report (Department of Agriculture and Fisheries, 2023b).

#### 4.2.1.3 Syngnathids

Risk considerations for the Syngnathidae complex showed less variability across the five trawl management regions. Key risk factors for this group included poor TED/BRD efficiency, limited

information on regional catch compositions and an increased potential for *in-situ* mortalities (Dedini *et al.,* 2023). If caught in the sweep of the net, seahorse and pipefish are unlikely to be excluded from the catch via the TED or BRD. Once caught, there is an increased probability that the animal will be landed in a dead or moribund state due to injuries incurred during the trawl fishing event.

Syngnathid catch rates and compositions are not well understood in the Northern Trawl Region and logbook data provides limited insight into species-specific rates of fishing mortality (Department of Agriculture and Fisheries, 2023b). These limitations reflect broader deficiencies in the amount of available data on trawl-caught syngnathids. One of the challenges of monitoring syngnathid catch rates in a trawl fishery is that that they can be difficult to detect due to their size and cryptic lifestyles. As a consequence, there is an increased probability that a trawl-caught seahorse or pipefish will go undetected within a multi-species trawl catch. This has likely contributed to an underreporting of syngnathid interaction rates in the ECOTF; particularly for non-retainable species.

In the Level 2 ERA, the Duncker's pipehorse (*Solegnathus dunckeri*) and the Pallid pipehorse (*S. hardwickii*) were identified as the two Syngnathidae species exhibiting the highest long-term vulnerability to trawl fishing (Dedini *et al.,* 2023). *Solegnathus dunckeri* and *S. hardwickii* are the only syngnathids that can be retained for sale in the ECOTF and their retention is managed under a combined trip limit of 50 individuals. Of the two, only *S. hardwickii* is found in the Northern Trawl Region where it can be retained as byproduct. This consideration was reflected in the regional risk rating (medium) assigned to this species (Table 4; Data Report: Appendix A).

While not universal, fine-scale habitat preferences are a risk-limiting factor for this subgroup. Many syngnathids are predominantly associated with highly structured habitats such as coral reefs and garden bottoms which are avoided by trawl operations (Kuiter, 2000; Lourie, 2016; Pears *et al.*, 2012b). This helps limit the interaction potential and is one of the reasons why syngnathids are frequently assigned ratings in the low to medium risk categories (Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b). In the current assessment, habitat preference data were used as part of a weight-of-evidence approach to assign lower risk scores to several species (Table 4; Data Report: Appendix A). This approach considered additional protections provided to this subgroup through the *Great Barrier Reef Marine Park Zoning Plan*, third party assessments like IUCN Red List extinction risk evaluations and information contained in the Species Profile and Threats Database (Department of Climate Change Energy the Environment and Water, Undated; International Union for Conservation of Nature's Red List of Threatened Species, 2022).[5]

In the Northern Trawl Region, the influence of habitat preference was most evident in the (low) ratings assigned to the straightstick pipefish (*Trachyrhamphus longirostris*) and the ribboned pipefish (*Haliichthys taeniophorus*) (Table 4; Data Report: Appendix A).

#### 4.2.1.4 Sharks

The shark complex had a fairly low representation with just five of the 12 available species included in the Northern Trawl Region LCA (Fig. 2; Table 4).[6] The majority were excluded from the analysis as the

[5] The *Great Barrier Reef Marine Park Zoning Plan* does not contain syngnathids-specific closures or fisheries-protection measures. However, the plan will afford protection to structured habitats preferred by these species including rocky reef assemblages, seagrass beds and coral reef systems.

[6] Research has shown that trawl operations targeting tiger and endeavour prawns will interact with a wider array of shark species including, but not limited to, the Epaulette shark (*Hemiscyllium ocellatum*) and other small

northern extent of their distribution does not encroach on this management region. While the piked spurdog (*Squalus megalops*) may be encountered by northern trawl operations (Kyne *et al.,* 2021), it is more commonly found in deeper water environments (down to >700 m) located on the outer continental shelf and upper slope of southern Australia (Ebert *et al.*, 2021; Kyne *et al.*, 2023n). This reduced interaction potential was considered sufficient to exclude *S. megalops* from the analysis.

Sharks have a *k*-selected life-history that increases their long-term vulnerability to trawl fishing activities (Dedini *et al.,* 2023). While noting these vulnerabilities, the best available information indicates that these risks are being managed within the current fishing environment. The brownbanded bamboo shark (*Chiloscyllium punctatum*), eastern banded catshark (*Atelomycterus marnkalha*), zebra shark (*Stegostoma tigrinum*) and Australian weasel shark (*Hemigaleus australiensis*) are all classified as Least Concern under the IUCN Red List criteria. Complementary assessments have also classified their fishing status as Negligible (catch limited) or Sustainable across their known distributions (Fisheries Research and Development Corporation, 2023b; Kyne *et al.*, 2021; Kyne *et al.*, 2023a; e; f).[7] These findings indicate that the probability of these species experiencing an undesirable event in the Northern Trawl Region is currently low (Table 4; Data Report: Appendix A). This situation may change if there is a notable shift in the fishing environment or a decline in the conservation status or extinction risk classification for one or more of these species.

The situation surrounding the eastern angelshark (*Squatina albipunctata*) is more complicated as the species is currently listed as Vulnerable under the IUCN Red List criteria (Kyne *et al.,* 2021). Further, a complementary assessment determined that *S. albipunctata* stocks on the Australian east coast are in decline (Kyne *et al.*, 2023d). A closer inspection of the stock status assessment indicates that the main threats for this species are located in New South Wales and in the Commonwealth-managed Southern and Eastern Scalefish and Shark Fishery (Kyne *et al.*, 2023d). When compared, *S. albipunctata* will experience lower fishing pressures in northern Queensland where its depth profile (35–415 m) affords the species with a degree of natural protection from trawl fishing activities (Kyne *et al.*, 2021; Kyne *et al.*, 2023d). These factors were given significant weighting when determining the risk rating for *S. albipunctata* in the Northern Trawl Region (Table 4; Data Report: Appendix A).

Overall, the Northern Trawl Region will be a contributing risk factor *versus* the main driver of risk for *S. albipunctata* and the remaining shark species (Table 4). While the regional risk levels are comparatively low, the contribution this region makes to the cumulative fishing pressure will need to be taken into consideration (Dedini *et al.,* 2023). Similarly, the regional risk rating for one or more of the assessed species will likely decline if, for example, there is a further reduction in their extinction risk level or fisheries status. At present though, these species will be exposed to higher risks in more southern trawl regions and in adjacent jurisdictions.

#### 4.2.1.5 Batoids

Fishers targeting tiger (*P. esculentus, P. semisulcatus*), endeavour (*Metapenaeus endeavouri*) and banana (*P. indicus* and *P. merguiensis*) prawns interact with a diverse array of benthic batoids

whalers (e.g. blacktip reef sharks, *Carcharhinus melanopterus*; Australian blacktip shark, *C. tilstoni*) (Courtney *et al*., 2007; Kyne, 2008). The risk posed by trawl fishing to these species was considered low to negligible and they were excluded from the analysis as part of an extensive species rationalisation process connected to the Level 2 ERA (Dedini *et al.*, 2023).

[7] Status assessments compiled as part of the *Shark and Ray Report Card* consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

(Courtney *et al.*, 2007; Jacobsen, 2007; Kyne, 2008; Kyne *et al.*, 2021; Salini *et al.*, 2007; Stobutzki *et al.*, 2001; White *et al.*, 2019). While noting this diversity, only 22 batoids were considered for inclusion in the regional risk assessments (Table 4). The remaining species were excluded from the analysis through a detailed species rationalisation process conducted as part of the Level 2 ERA (Dedini *et al.*, 2023). The Level 2 ERA provides a full account of this process including the justifications used to include or omit a species from the analysis (Appendix A and B of Dedini *et al.*, 2023).

Of the 22 batoids considered, 12 were assessed as part of the Northern Trawl Region LCA (Fig. 2; Table 4). The remaining 10 species had distributions and depth profiles that did not encroach on this management region and/or reduced their interaction potential (Table 4; Data Report: Appendix A). Key species groups excluded from the Northern Trawl Region LCA included stingarees and skates which are more commonly encountered in the Southern Offshore Trawl Region (Kyne *et al.*, 2021; Last *et al.*, 2016).

All but two of the batoids included in the Northern Trawl Region LCA were assigned risk ratings above low (Table 4; Data Report: Appendix A). The Australian whipray (*Himantura australis*; 183 cm disc width) and the giant guitarfish (*Glaucostegus typus*, 284 cm total length) grow to a considerable size and they will quickly exceed the TED bar spacings (Kyne *et al.*, 2021; Last *et al.*, 2016). Sub-adult and adults of these two species are more likely to be excluded from the catch with individuals experiencing a contact without capture event (Dedini *et al.*, 2023; Kyne *et al.*, 2021; Last *et al.*, 2016). Contact without capture events are difficult to quantify as they will often go unobserved. Expectations are though that the vast majority of animals will survive this type of interaction and have fewer long-term injuries.

The majority of the remaining batoids ($n$ = 7) were classified as being at a low-medium risk within the Northern Trawl Region. These seven species have higher biological vulnerabilities and there is a marginally higher risk of trawl fishing activities impacting regional populations (Table 4). While noting these vulnerabilities, all species at low-medium risk have fewer sustainability concerns within Australian waters and are expected to be in high abundance within their preferred habitats (Kyne *et al.*, 2021; Last *et al.*, 2016). Similarly, all seven have extinction risk classifications of Least Concern or Near Threatened (Kyne *et al.,* 2021) and have been assessed as Sustainable across their known distributions (Fisheries Research and Development Corporation, 2023b; Kyne *et al.*, 2023o; p; s; v; w; x; z).[8] These findings support a wider hypothesis that fishing-related risks for these species are being managed within the current fishing environment.

The three remaining species, the estuary stingray (*Hemitrygon fluviorum*), the narrow sawfish (*Anoxypristis cuspidata*) and the green sawfish (*Pristis zijsron*) all registered higher risk ratings (Table 4; Data Report: Appendix A). Biological vulnerabilities for these three species will be similar to other batoids in that they are all long-lived, have a delayed onset of sexual maturity and lower levels of fecundity. However, *H. fluviorum*, *A. cuspidata* and *P. zijsron* have also experienced historic range contractions and population declines across the Queensland east coast. These declines/contractions are most significant for *P. zijsron* and the species may now be regionally extirpated south of the Whitsundays (Department of the Environment, 2019). In each instance, commercial fishing activities

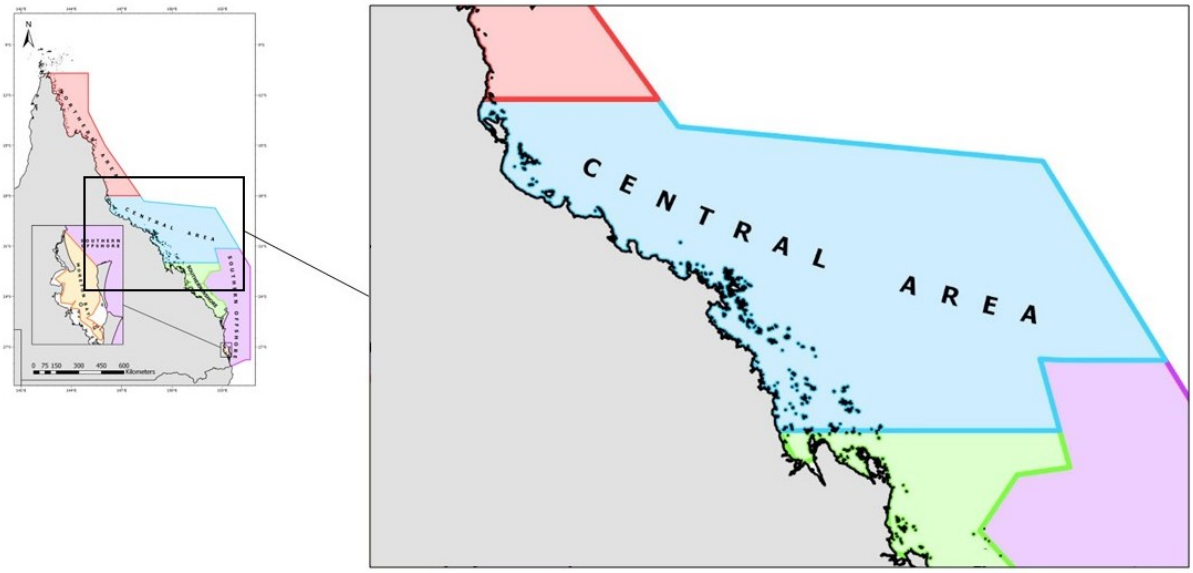
[8] Status assessments compiled as part of the *Shark and Ray Report Card* consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

have been identified as a contributing factor in terms of the observed declines (Department of the Environment, 2015a; Kyne *et al.*, 2023u; y; 2023aa; Last *et al.*, 2016).

Population declines and range contractions for *H. fluviorum*, *A. cuspidata* and *P. zijsron* resulted in all three being assigned higher extinction risk classifications (Kyne *et al.*, 2023u; y; 2023aa). *Hemitrygon fluviorum* is also listed as Near Threatened under the Queensland *Nature Conservation Act 1992* and *P. zijsron* is listed as Vulnerable under the EPBC Act. However, the *Action Plan for Australian Sharks and Rays* has recommended that a) *A. cuspidata* be considered for listing under the EPBC Act and b) the *P. zijsron* classification be elevated to Critically Endangered (Kyne *et al.,* 2021). While the action plan does not recommend further listings for *H. fluviorum*, the species has been identified as a priority for data collection (Kyne *et al.,* 2021).

For species at medium (*H. fluviorum*, *A. cuspidata*) and high risk (*P. zijsron*), fishing activities in the Northern Trawl Region have a greater potential to impact regional populations and contribute to ongoing declines (Kyne *et al.*, 2023u; y; 2023aa). These impacts could occur at low levels of fishing mortality with the consequences including further range contractions, reduced genetic diversity and the fragmentation of remnant populations. The outputs of this report highlights the need to improve the level of information on batoid interaction rates within and across the Northern Trawl Region. This is of particular relevance to sawfish as evidence suggests that northern Australia is one of the few remaining strongholds for Indo-West Pacific species (Kyne *et al.,* 2021).

### 4.2.2 Central Trawl Region




Of the 62 species considered for assessment, 46 had distributions that overlapped with the Central Trawl Region (Department of Agriculture and Fisheries, 2021b). All five subgroups were represented in the study including all marine turtle (*n* = 6) and sea snake (*n* = 13) species (Fig. 2; Table 4). Proportionately, fewer numbers of syngnathids (*n* = 5 of 9), sharks (*n* = 8 of 12) and batoids (*n* = 14 of 22) required assessment in the Central Trawl Region LCA. Of the species considered, sixteen had distributions and depth profiles that negated or significantly reduced their interaction potential in this

region. These species were excluded from the Central Trawl Region LCA and assigned a 'Not Assessed' classification (Fig. 3; Table 4).

The vast majority of species included in this assessment registered risk ratings of low (*n* = 11) or low-medium (*n* = 24). Ten species were classified as a medium risk (one syngnathid, seven sea snakes, one shark and one batoid), with the green sawfish (*Pristis zijsron*) registering the only high-risk rating in the Central Trawl Region LCA (Table 4). While not universal, ongoing conservation concerns, an increased interaction potential and uncertainty surrounding interaction rates and release fates were identified as the key contributors of risk.

Operators in this region have historically targeted saucer scallops (*Ylistrum balloti*) which are classified as a Tier 2 species under the *Trawl Fishery (Central Region) Harvest Strategy: 2021–2026* (Department of Agriculture and Fisheries, 2021e). Research into the health of regional *Y. balloti* stocks indicated that a) the Queensland east coast saucer scallop stock has been the subject of an extended period of overfishing and b) biomass levels have failed to rebound to a level that would support larger-scale fishing activities (Wortmann, 2022; Wortmann *et al.*, 2020). In response to these findings, the management regime for saucer scallops was significantly reformed and the species classified as no-take in the Central and Southern Inshore Trawl Region to assist with stock recovery (Department of Agriculture and Fisheries, 2021a).

Prohibiting the take of this Tier 2 species will affect the risk profile of the Central Trawl Region. In the LCA, one of the biggest challenges was determining how the prohibition on the take of *Y. balloti* will alter fishing behaviour in this region and any potential flow-on effects for bycatch species. Across this region, the impact of this management reform initiative will be smaller than in the Southern Inshore Trawl Region where *Y. balloti* is classified as a Tier 1 species (Department of Agriculture and Fisheries, 2021e).

#### 4.2.2.1 Marine Turtles

All but one of the marine turtle species were assigned a risk rating of low-medium in the Central Trawl Region. The exception being the leatherback turtle (*Dermochelys coriacea*) whose life-history has a stronger correlation with pelagic-water environments (Department of the Environment, 2023a; Department of the Environment and Energy, 2017; Eckert *et al.*, 2012; Limpus, 2009). These life-history traits combined with habitat preferences of the primary (brown tiger prawn, *Penaeus esculentus*; grooved tiger prawn, *P. semisulcatus*) and secondary target species (e.g. endeavour prawns, *Metapenaeus endeavouri*; red spot king prawns, *Melicertus longistylus*; Moreton Bay bugs, *Thenus* spp.), reduce the probability of a *D. coriacea* interaction occurring in this region. These preferences though do not completely mitigate the interaction risk and a small number of *D. coriacea* have been reported as bycatch within the broader ECOTF (Department of Agriculture and Fisheries, 2023b). These interactions, combined with uncertainty surrounding the accuracy of data compiled through the Threatened, Endangered and Protected Animals (TEPA) logbook (Dedini *et al.*, 2023), supported the inclusion of *D. coriacea* in the Central Trawl Region LCA.

The situation surrounding the olive ridley turtle (*Lepidochelys olivacea*) mirrors parts of the *D. coriacea* risk profile. Available data including stock dispersal records indicates that *L. olivacea* prefers tropical waters and key nesting sites for this species are all located in northern Australia (Department of the Environment and Energy, 2017; Limpus, 2008a). These life-history preferences reduce the likelihood of *L. olivacea* interacting with trawl operations in the Central Trawl Region; an inference that is

supported by the TEPA logbook data (Department of Agriculture and Fisheries, 2023b). The species though has a broader range and it has been reported from waters as far south as Moreton Bay in south-east Queensland (Department of Environment Science and Innovation, 2021; Department of the Environment and Energy, 2017). Given these factors, the decision was made to include *L. olivacea* in the Central Trawl Region LCA as a precautionary measure. With improved data validation, it is conceivable that the *L. olivacea* risk profile could be refined and/or the species removed from future regional assessments as a low-risk element.

Distributional and habitat data for the remaining species indicate that they have an increased potential to interact with trawl operations in the Central Trawl Region. Most interactions will involve the green turtle (*Chelonia mydas*) which is found in higher abundances along the Queensland east coast (Department of the Environment, 2023b; Limpus, 2008c). However, the flatback turtle (*Natator depressus*) also has substantial nesting records / nesting sites in this region (Department of the Environment and Energy, 2017; Limpus, 2007a; b). These two species make up the majority of the marine turtle TEPA logbook reports and a portion of these will originate from the Central Trawl Region (Department of Agriculture and Fisheries, 2023b).

The situation surrounding the loggerhead (*Caretta caretta*) and the hawksbill turtle (*Eretmochelys imbricata*) is more complex. While *C. caretta* and *E. imbricata* have distributions / stock dispersal records that overlap with the Central Trawl Region; key nesting sites are located to the south and north respectively (Department of the Environment and Energy, 2017; Limpus, 2007b; 2008b). The absence of nesting sites within this region may assist in terms of limiting the exposure of these species to regional trawl fishing activities (Data Report: Appendix B).[9] This inference though can only be confirmed with additional information on regional marine turtle interaction rates and compositions. For reference, catch data indicates that there are fewer *C. caretta* and *E. imbricata* interactions in the ECOTF when compared to *C. mydas* and *N. depressus* (Department of Agriculture and Fisheries, 2023b).

Across the complex, the use of a Turtle Excluder Device (TED) contributed to the marine turtle complex receiving ratings at the lower end of the risk spectrum (Table 4; Data Report: Appendix B). The use of a TED remains a pivotal component of the broader ECOTF management regime and it is arguably the most effective risk-mitigation strategy employed for this subgroup. Research has shown that the use of a TED, combined with a Bycatch Reduction Device (BRD), can reduce landing rates for marine turtles by 97–99 per cent (Brewer *et al.*, 2006; Campbell *et al.*, 2020; Department of Agriculture and Fisheries, 2012; National Oceanic and Atmospheric Administration Fisheries, 2021). While similar turtle exclusion rates could be expected within the Central Trawl Region, further information is required on the effectiveness of TEDs at a species, regional and whole-of-fishery level.

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 (Business Queensland, 2022; Department of Agriculture and Fisheries, 2012). 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 (e.g. internal and

[9] While a single *C. caretta* nesting site has been recorded from Mackay in central Queensland, the most frequently used nesting sites for this species are located further south (Limpus, 2008b). Nesting site data for *E. imbricata* suggests that there is at least one nesting site in central Queensland. However, the majority and most significant *E. imbricata* nesting sites are located in far north Queensland and northern Australia (Department of the Environment and Energy, 2017).

external injuries incurred during the net retrieval/landing process and/or being crushed by the weight of the catch). When a marine turtle is caught within the sweep of the net, the majority will experience a contact without capture event (Brewer *et al.,* 2006; Campbell *et al.,* 2020; Dedini *et al.,* 2023). These types of events are less likely to result in significant injuries and pose a lower long-term risk to the effected individual. These benefits were reflected in the outputs of this assessment and previous ERAs where the use of a TED, combined with declining effort levels, contributed to the complex receiving lower risk ratings (Table 4; Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b).

More broadly, the marine turtle complex will be afforded considerable protection through a range of legislative instruments. For example, most nesting sites situated in central Queensland occur in habitats now protected under marine parks legislation or the Queensland *Nature Conservation Act 1992* (Limpus, 2007a; b; 2008a; b; c; 2009). For a number of the species, these protections extend to their preferred coastal foraging habitats. The level of protection will vary between species and may be less effective for highly migratory species like *E. imbricata* (Limpus, 2007b). These measures though help to reduce the exposure of this complex to trawl fishing and restrict or prohibit activities in areas where marine turtles are found in higher abundances throughout the year (Great Barrier Reef Marine Park Authority, 2022; 2023; Undated). These factors were taken into consideration as part of the LCA and supported the assignment of lower risk ratings (Table 4; Data Report: Appendix B).

Data compiled through the TEPA logbook contains fewer than 100 marine turtle interactions across the entire ECOTF (2006–2021 data; Department of Agriculture and Fisheries, 2023b).[10] The veracity of this data has yet to be fully tested as the ECOTF does not currently operate with an effective mechanism to validate regional bycatch compositions, interaction rates or release fates.[11] This creates uncertainty surrounding the accuracy of marine turtle interaction-rate data and increases the risk of non-compliance and under-reporting. At the time of this assessment, marine turtle interaction rates could not be confirmed for the Central Trawl Region.

The inability to validate TEPA logbook data increases the level of uncertainty surrounding the extent of marine turtle interactions in the Central Trawl Region. However, cross comparisons with analogous fisheries lend support to the hypothesis that marine turtle interactions are under-reported across the entire ECOTF. For example, the Northern Prawn Fishery (NPF) observer program recorded 525 marine turtle interactions between 2018 and 2022 inclusive (Australian Fisheries Management Authority, 2023b).[12] Over this same period, the entire ECOTF reported 35 marine turtle interactions through the TEPA logbook (Department of Agriculture and Fisheries, 2023b). 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 (Department of Agriculture and Fisheries, 2023b; Patterson *et al.*, 2022). This uncertainty was a key consideration in the current assessment and contributed to a number of the species receiving marginally higher risk ratings (Table 4).

[10] Includes data from the previous Species of Conservation Interest (SOCI) logbook. The TEPA logbook superseded the SOCI logbook in 2021 as part of broader review of the logbook reporting requirements.

[11] Independent data validation is an integral component of the “Improved monitoring and research” foundational reform outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018b). A trial of independent data validation in the ECOTF is well advanced. However, data validation has yet to be fully implemented across the ECOTF. More information on the mechanisms being used to address the long-term data validation risk has been provided in the Level 2 ERA (Dedini *et al.*, 2023).

[12] The NPF operates in northern Australia, has Marine Stewardship Council (MSC) certification and has a multi-faceted catch validation program that includes crew member observers and scientific observers (Australian Fisheries Management Authority, 2023a; Marine Stewardship Council, 2023).

With the ongoing rollout of the *Data Validation Plan*, expectations are that the level of information on marine turtle interactions will improve across the ECOTF and within each of the five management regions (Department of Agriculture and Fisheries, 2018b; 2023a; Queensland Government, Undated). The outputs of this program may be the key determinant in terms of the need to update the LCA for this complex within the Central Trawl Region.

#### 4.2.2.2 Sea Snakes

The Central Trawl Region had one of the highest sea snake representations with all 13 species included in the assessment. This was to be expected given that the tropical waters of the Great Barrier Reef encompass some of the more prominent sea snake habitats (Udyawer *et al.*, 2020).

While not universal, sea snakes were generally assigned higher risk ratings in the Central Trawl Region (Table 4). Of the species assessed, 10 were classified as a low-medium or medium risk which contrasts with just three species in the Northern Trawl Region and four species in the Southern Inshore Trawl Region (Table 4). These results align with our current understanding of bycatch patterns in the ECOTF and the prevalence of sea snakes in the red spot king prawn (*Melicertus longistylus*) sector. *Melicertus longistylus* is primarily targeted in the Central Trawl Region and research indicates that this sector is responsible for the majority of trawl-related sea snake interactions and mortalities (Courtney *et al.*, 2010). While this research pre-dates some of the more significant reforms and effort reductions, expectations are that the number of sea snake interactions are still disproportionately skewed towards the Central Trawl Region (Courtney *et al.*, 2010; Dedini *et al.*, 2023; Department of Agriculture and Fisheries, 2023b; Pears *et al.*, 2012a).

Sea snake catch data for the ECOTF has poor species resolution and provides limited insight into catch compositions within the Central Trawl Region. At a whole-of-fishery level, sea snakes are the most reported complex in the TEPA logbook data with an average of 1,655 sea snake interactions (*range* = 336–4,753) recorded from the ECOTF each year (2003–2021 data; Department of Agriculture and Fisheries, 2023b).[13] Based on the available data, a high percentage of these interactions will occur within the Central Trawl Region and are more likely to involve the horned sea snake (*Hydrophis peronii*), the small-headed sea snake (*H. macdowelli*), the spine-bellied sea snake (*H. curtus*) and the reef shallows sea snake (*Aipysurus duboisii*; Courtney *et al.,* 2010). All four of these species were assigned a medium-risk rating for the Central Trawl Region LCA (Table 4).

Research has shown that BRD designs like the Fisheye and Square Mesh Codend are effective at excluding sea snakes from the trawl catch (Courtney *et al.*, 2010; Dedini *et al.*, 2023; Milton *et al.*, 2009; Queensland Government, 2022). In some instances, the use of these designs combined with a TED can reduce sea snake landing rates by up to 63 per cent (Courtney *et al.,* 2010). These findings have been accounted for in regional management regimes and are proven mitigators of risk for this subgroup. One of the inherent benefits of excluding sea snakes from the trawl catch is that they are more likely to experience a contact without capture event. Contact without capture events are less likely to result in the death of the animal and/or impede their long-term survivability. This was taken into consideration as part of the regional assessment in the Central Trawl Region.

Data compiled through the TEPA logbook indicates that between three and 30 per cent of landed sea snakes die due to drowning or injuries sustained during a trawl fishing event (Dedini *et al.*, 2023;

[13] Includes data from the previous Species of Conservation Interest (SOCI) logbook. The TEPA logbook superseded the SOCI logbook in 2021 as part of broader review of the logbook reporting requirements.

Department of Agriculture and Fisheries, 2023b). Analysis of observer data from the NPF also places sea snake trawl mortality rates between 16 and 25 per cent (Australian Fisheries Management Authority, 2023b; Dedini *et al.*, 2023). Without a mechanism to validate regional TEPA logbook data, it is difficult to determine if mortality rate percentages for the entire ECOTF hold true for the Central Trawl Region. Conversely, it is difficult to ascertain if sea snake mortality rates in the Central Trawl Region are higher than the fishery-wide average. Without this data, the LCA adopted a more precautionary approach and assumed that sea snake interactions and mortalities will be higher in the Central Trawl Region. This was reflected in the risk ratings assigned to this complex (Table 4; Data Report: Appendix B).

The level of information on sea snake bycatch in the Central Trawl Region will improve with the continued roll-out of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018b; Queensland Government, Undated). Research has also commenced on a project exploring avenues to reduce the impact of the fishery on threatened, endangered and protected species including sea snakes (Fisheries Research and Development Corporation, 2023a). The outputs of these data improvement initiatives may alter the risk profile of this complex and help refine the findings of the Central Trawl Region LCA. Depending on the outputs, there may be greater need to update the risk profiles of this complex within this region.

Given the significance of this region in relation to the ECOTF sea snake bycatch management, any update to the LCA outputs should consider ancillary assessments including updates to the extinction risk classifications (International Union for Conservation of Nature's Red List of Threatened Species, 2022). At present, all but one of the sea snakes have an extinction risk classification of Least Concern under the IUCN Red List and/or the *Action Plan for Australian Lizards and Snakes* (Chapple *et al.*, 2019; Department of Climate Change Energy the Environment and Water, Undated; International Union for Conservation of Nature's Red List of Threatened Species, 2022). The extinction risk classification for the beaked sea snake (*H. zweifeli*) is currently defined as Data Deficient (Rasmussen, 2018). While the assessments are based at a global level, at least two species have a reported declining population trend: *A. duboisii* (medium risk) and the turtle-headed sea snake (*Emydocephalus annulatus*, low risk) (Lukoschek *et al.*, 2010; Lukoschek, 2010).

As this is the first regional assessment undertaken for the ECOTF, there are limited avenues to compare the results of this LCA with previous ERAs. The most tangible results being from a previous qualitative ERA examining the risk posed by trawl fishing activities within the Great Barrier Reef Marine Park (GBRMP; Pears *et al.*, 2012b). The outputs of this assessment showed broad similarities with the LCA in that the majority of sea snakes were situated at the lower end of the risk spectrum. This study relied on similar inputs (e.g. Courtney *et al.,* 2010) and, not surprisingly, drew similar conclusions e.g. the red spot king prawn fishery was a key consideration in terms of sea snake mortalities, total interaction rates are likely to be underestimated and risk levels have (likely) declined through time with effort reductions (Pears *et al.,* 2012b). Direct comparisons between the two assessments though are not recommended as methods used to construct the GBRMP Trawl ERA differs from that used in the regional assessments (Pears *et al.*, 2012b).

#### 4.2.2.3 Syngnathids

Risk considerations for the Syngnathidae complex showed less variability across the five trawl management regions. Key risk factors for this group included poor TED/BRD efficiency, limited information on regional catch compositions and an increased potential for *in-situ* mortalities (Dedini *et*

*al.,* 2023). If caught in the sweep of the net, seahorse and pipefish are unlikely to be excluded from the catch via the TED or BRD. Once caught, there is an increased probability that the animal will be landed in a dead or moribund state due to injuries incurred during the trawl fishing event.

Syngnathid catch rates and compositions are not well understood in the Central Trawl Region and logbook data provides limited insight into species-specific rates of fishing mortality (Department of Agriculture and Fisheries, 2023b). These limitations reflect broader deficiencies in the amount of available data on trawl-caught syngnathids. One of the challenges of monitoring syngnathid catch rates in a trawl fishery is that that they can be difficult to detect due to their size and cryptic lifestyles. As a consequence, there is an increased probability that a trawl-caught seahorse or pipefish will go undetected within a multi-species trawl catch. This has likely contributed to an underreporting of syngnathid interaction rates in the ECOTF; particularly for non-retainable species.

A review of historical catch locations showed that syngnathid interactions were higher in central and southern Queensland (Connolly *et al.*, 2001; Dodt, 2005). Some of these areas are now located within the Central Trawl Region (Dodt, 2005). This report is almost 20 years old and, given the extent of subsequent reforms and effort reductions, will be less applicable to the current fishing environment. It did, however, identify the Duncker's pipehorse (*Solegnathus dunckeri*) and the Pallid pipehorse (*S. hardwickii*) as two of the more abundant species surveyed (Dodt, 2005). These two species are the only syngnathids that can be retained for sale in the ECOTF.[14] The remainder must be discarded as bycatch and their capture recorded in the TEPA logbook (Queensland Government, 2024).

In the Central Trawl Region, operators will only retain *S. hardwickii* as K'gari (formerly Fraser Island) represents the northern limit of the *S. dunckeri* range (Bray & Thompson, 2020). This factor was considered as part of the LCA and contributed to *S. hardwickii* receiving a marginally higher risk rating (Table 4). Quantifying the composition of the remaining catch is more difficult and is complicated by uncertainty surrounding the taxonomy and distribution of regional syngnathids. These deficiencies were discussed at length in the Level 2 ERA which included recommendations on how these long-term risk areas could be addressed (Dedini *et al.,* 2023).

While not universal, fine-scale habitat preferences are a risk-limiting factor for this subgroup. Many syngnathids are predominantly associated with highly structured habitats such as coral reefs and garden bottoms which are avoided by trawl operations (Kuiter, 2000; Lourie, 2016; Pears *et al.*, 2012b). This helps limit the interaction potential and is one of the reasons why syngnathids are frequently assigned ratings in the low to medium risk categories (Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b). Conversely, research has suggested that syngnathid catch rates tend to increase with proximity to reefs (Connolly *et al.*, 2001; Dodt, 2005; Dunning *et al.*, 2001). While this hypothesis has yet to be tested within the current fishing environment, it implies that syngnathids could be more susceptible to capture in trawl operations working in closer proximity to reef systems i.e. trawl operations targeting *M. longistylus*.

In the Central Trawl Region LCA, information on habitat preferences was used in a weight-of-evidence approach to assign lower risk scores to several species (Table 4; Data Report: Appendix B). This approach considered additional protections provided to this subgroup through the *Great Barrier Reef Marine Park Zoning Plan*, third party assessments like IUCN Red List extinction risk evaluations and

[14] While permitted for retention within the ECOTF, regulations specify that pipefish have a combined trip limit of 50 individuals for each vessel (State of Queensland, 2019).

information contained in the Species Profile and Threats Database (Department of Climate Change Energy the Environment and Water, Undated; International Union for Conservation of Nature's Red List of Threatened Species, 2022).[15] Further avenues to refine and improve the risk profiles of this subgroup may evolve with the ongoing roll out of the *Data Validation Plan* and ancillary projects examining the impact of trawl fishing on non-target species (Department of Agriculture and Fisheries, 2018b; Fisheries Research and Development Corporation, 2023a; Queensland Government, Undated).

#### 4.2.2.4 Sharks

Eight of the 12 shark species were included in the Central Trawl Region LCA (Fig. 2; Table 4). The distributions and depth profiles of the four remaining species did not include this management region and/or reduced their interaction potential (Fig. 3; Data Report: Appendix B).

Sharks have a *k*-selected life-history that increases their long-term vulnerability to trawl fishing activities (Dedini *et al.,* 2023). While noting these vulnerabilities, the best available information indicates that these risks are being largely managed within the current fishing environment. The brownbanded bamboo shark (*Chiloscyllium punctatum*), eastern banded catshark (*Atelomycterus marnkalha*), zebra shark (*Stegostoma tigrinum*), Australian weasel shark (*Hemigaleus australiensis*), pale spotted catshark (*Asymbolus pallidus*) and piked spurdog (*Squalus megalops*) are all classified as Least Concern under the IUCN Red List extinction risk criteria (Kyne *et al.*, 2021). Complementary analyses have also classified the fishing status of these six species as either Negligible (catch limited) or Sustainable across their known distributions (Kyne *et al.*, 2021; Kyne *et al.*, 2023a; Kyne *et al.*, 2023b; Kyne *et al.*, 2023c; e; f; n).[16] These findings indicate that the probability of these species experiencing an undesirable event in the Central Trawl Region is currently low or, in the case of *S. megalops*, low-medium (Table 4; Data Report: Appendix B).

The two notable exceptions were the Colclough's shark (*Brachaelurus colcloughi*) and the eastern angelshark (*Squatina albipunctata*). These species are classified as Vulnerable under the IUCN Red List criteria and both have broader conservation concerns. For example, an assessment of the health of regional *S. albipunctata* stocks determined that the species is in decline on the Australian east coast (Kyne *et al.*, 2023d). A closer inspection of the stock status assessment indicates that the main threats for this species are located in New South Wales and in the Commonwealth-managed Southern and Eastern Scalefish and Shark Fishery (Kyne *et al.*, 2023d). When compared, *S. albipunctata* will experience lower fishing pressures in northern Queensland where its depth profile (35–415 m) affords the species with a degree of natural protection from trawl fishing activities (Kyne *et al.*, 2021; Kyne *et al.*, 2023d). The extent of this protection in central Queensland remains uncertain due, in part, to an absence of information on regional catch rates and compositions. As a consequence *S. albipunctata* was assigned a marginally higher risk rating in the Central Trawl Region LCA (Table 4).

*Brachaelurus colcloughi* is a rare, endemic species and it is likely to occur at a naturally low abundance. Information sets for *B. colcloughi* are less developed and datasets for this species are based on fewer than 80 individuals (Kyne *et al.*, 2011; Kyne *et al.*, 2021). There remains considerable

[15] The *Great Barrier Reef Marine Park Zoning Plan* does not contain syngnathid-specific closures or fisheries-protection measures. However, the plan will afford protection to structured habitats preferred by these species including rocky reef assemblages, seagrass beds and coral reef systems.

[16] Status assessments compiled as part of the *Shark and Ray Report Card* consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

uncertainty surrounding the distribution of *B. colcloughi* and its capacity to interact with the ECOTF. On the Queensland east coast, the available evidence indicates that *B. colcloughi* are more likely to interact with the Southern Inshore, Southern Offshore and (potentially) Moreton Bay Trawl Regions (Kyne *et al.*, 2015; Kyne *et al.*, 2021; Kyne *et al.*, 2023l). However, specimens have been reported from as far north as Swains Reef National Park and Flock Pigeon Island (Jacobsen, 2007; Kyne *et al.*, 2023l; Rigby *et al.*, 2016b). These locations lie in close proximity to the Central Trawl Region boundary and interactions with regional trawl operations cannot be ruled out (Department of Agriculture and Fisheries, 2021b).

While regional risk levels are comparatively low, fishing activities within the Central Trawl Region will need to be considered when examining the extent of any cumulative fishing pressures. The importance of understanding these cumulativ) pressures will be higher for species like *S. albipunctata* and *B. colcloughi*. These longer-term pressures or vulnerabilities were discussed in more detail in the Level 2 ERA (Dedini *et al.*, 2023). At a regional level, the LCA indicates that current fishing activities within this region pose a lower risk to most of the species assessed. This situation may change if (e.g.) there is a notable shift from the current fishing environment, there is an observed decline in the conservation status of one or more species and/or new evidence indicates that operators in this region interact with a more diverse range of species.

#### 4.2.2.5 Batoids

When compared to more southerly trawl grounds, there is generally less information on batoid interaction rates in the Central Trawl Region (Campbell *et al.*, 2017; Campbell, 2022; Courtney *et al.*, 2014; Rigby *et al.*, 2016b). However, research has shown that trawl operators targeting tiger (*P. esculentus, P. semisulcatus*), endeavour (*Metapenaeus endeavouri*) and banana (*P. indicus* and *P. merguiensis*) prawns will interact with a diverse array of benthic batoids (Courtney *et al.*, 2007; Jacobsen, 2007; Kyne, 2008; Kyne *et al.*, 2021; Salini *et al.*, 2007; Stobutzki *et al.*, 2001; White *et al.*, 2019). While noting this diversity, only 22 batoids were considered for inclusion in the regional risk assessments (Table 4). The remaining species were excluded from the analysis through a detailed species rationalisation process conducted as part of the Level 2 ERA (Dedini *et al.*, 2023). The Level 2 ERA provides a full account of this process including the justifications used to include or omit a species from the analysis (Appendix A and B of Dedini *et al.*, 2023).

Of the 22 batoids considered, 14 were assessed as part of the Central Trawl Region LCA (Fig. 2; Table 4). The remaining eight species had distributions and depth profiles that did not encroach on this management region and/or reduced their interaction potential (Table 4; Data Report: Appendix B). Key species groups excluded from the Central Trawl Region LCA included stingarees and skates which are more commonly encountered in the Southern Offshore Trawl Region (Kyne *et al.*, 2021; Last *et al.*, 2016).

All but two of the 14 batoids included in the Central Trawl Region LCA were assigned risk ratings above low (Table 4; Data Report: Appendix B). The Australian whipray (*Himantura australis*; 183 cm disc width) and the giant guitarfish (*Glaucostegus typus*, 284 cm total length) grow to a considerable size and they will quickly exceed the TED bar spacings (Kyne *et al.*, 2021; Last *et al.*, 2016). Sub-adult and adults of these two species are more likely to be excluded from the catch with individuals experiencing a contact without capture event (Dedini *et al.*, 2023; Kyne *et al.*, 2021; Last *et al.*, 2016). Contact without capture events are difficult to quantify as they will often go unobserved. Expectations

are though that the vast majority of animals will survive this type of interaction and have fewer long-term injuries.

The majority of the remaining batoids (*n* = 10) were classified as being at a low-medium risk within the Central Trawl Region. These species have higher biological vulnerabilities and there is a marginally higher risk of trawl fishing activities impacting regional populations (Table 4). While noting these vulnerabilities, most of the species at low-medium risk have few sustainability concerns within Australian waters and are expected to be in high abundance within their preferred habitats (Kyne *et al.*, 2021; Last *et al.*, 2016). For example, all but one of the 10 species have extinction risk classifications of Least Concern or Near Threatened (Kyne *et al.,* 2021) and have been assessed as Sustainable across their known distributions (Kyne *et al.*, 2021; Kyne *et al.*, 2023o; p; q; s; v; w; x; z; Kyne *et al.*, 2023ag).[17] The notable exception being the narrow sawfish (*Anoxypristis cuspidata*) which is classified as Vulnerable under the IUCN Red List criteria with a depleting population trend (Kyne *et al.*, 2021; Kyne *et al.*, 2023u).

There are notable concerns surrounding the long-term conservation status of *A. cuspidata* and the species has experienced historical range contractions and population declines. Given these concerns, some consideration was given to assigning this species a higher risk rating in the Central Trawl Region. However, the distribution of this species makes interactions more likely in the Northern Trawl Region (Kyne *et al.*, 2021; Last *et al.*, 2016). Evidence also suggests that, when compared to other sawfish, *A. cuspidata* is more abundant, has faster growth and improved fecundity (Haque *et al.*, 2023; Kyne *et al.*, 2021; Kyne *et al.*, 2023u). These traits improve the robustness of regional *A. cuspidata* populations and increase the species capacity to absorb regional fishing mortalities (Dedini *et al.*, 2023). These factors were taken into consideration as part of the LCA and contributed to *A. cuspidata* receiving a marginally lower risk rating (Data Report: Appendix B). The key caveat being that this assessment is based on the current fishing environment and should be reviewed if (new) evidence indicates that regional operators are interacting more frequently with this species.

The two remaining species, the estuary stingray (*Hemitrygon fluviorum*) and the green sawfish (*Pristis zijsron*) registered higher risk ratings (Table 4; Data Report: Appendix B). Biological vulnerabilities for these species will be similar to other batoids in that they are long-lived, have a delayed onset of sexual maturity and lower levels of fecundity. However, *H. fluviorum* and *P. zijsron* have also experienced substantial range contractions and population declines across the Queensland east coast. These declines/contractions are most significant for *P. zijsron* and the species may now be regionally extirpated south of the Whitsundays (Department of the Environment, 2019). Of notable importance, commercial fishing activities has been identified as a contributing factor in terms of the declines observed in both species (Department of the Environment, 2015a; Kyne *et al.*, 2023y; 2023aa; Last *et al.*, 2016).

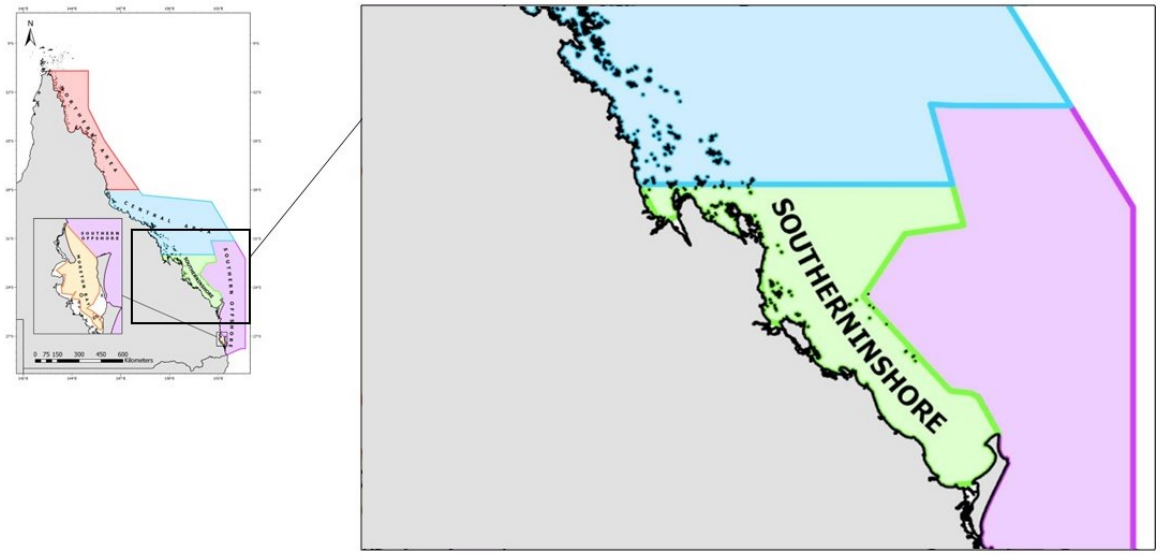
*Hemitrygon fluviorum* and *P. zijsron* have extinction risk classifications of Vulnerable and Critically Endangered (respectively) with complementary analyses indicating that both species have compromised populations (Kyne *et al.*, 2021; Kyne *et al.*, 2023y; 2023aa). These concerns are also reflected in legislation with *H. fluviorum* listed as Near Threatened under the Queensland *Nature Conservation Act 1992* and *P. zijsron* listed as Vulnerable under the EPBC Act. However, the *Action Plan for Australian Sharks and Rays* has recommended that the *P. zijsron* classification be elevated to

[17] Status assessments compiled as part of the *Shark and Ray Report Card* consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

Critically Endangered (Kyne *et al.,* 2021). While the action plan does not recommend further listings for *H. fluviorum*, the species has been identified as a priority for data collection (Kyne *et al.,* 2021).

For species at medium (*H. fluviorum*) and high risk (*P. zijsron*), fishing activities in the Central Trawl Region have a greater potential to impact regional populations and contribute to ongoing declines (Kyne *et al.*, 2023u; y; 2023aa). These impacts could occur at low levels of fishing mortality with the consequences including further range contractions, reduced genetic diversity and the fragmentation of remnant populations. The outputs of this report highlights the need to improve the level of information on batoid interaction rates within and across the Central Trawl Region. This is of particular relevance to sawfish as evidence suggests that northern Australia is one of the few remaining strongholds for Indo-West Pacific species (Kyne *et al.,* 2021).

### 4.2.3 Southern Inshore Trawl Region




Of the 62 species considered for assessment, 46 had distributions that overlapped with the Southern Inshore Trawl Region (Department of Agriculture and Fisheries, 2021e). All five subgroups were represented in the study including all marine turtle (*n* = 6) and sea snake (*n* = 13) species (Fig, 2; Table 4). Of the remaining subgroups, the Southern Inshore Trawl Region LCA included seven syngnathids, seven sharks and 13 batoids (Fig. 2; Table 4). Sixteen species had distributions and depth profiles that negated or significantly reduced their interaction potential in this region. These species were excluded from the Southern Inshore Trawl Region LCA and assigned a 'Not Assessed' classification (Fig. 3; Table 4).

The vast majority of species included in this assessment registered risk ratings of low (*n* = 20) or low-medium (*n* = 21). Of the remainder, three species were classified as a medium risk (two syngnathids and one sea snake) with the Colclough's shark (*Brachaelurus colcloughi*) and the green sawfish (*Pristis zijsron*) both registering a high-risk rating (Fig. 3; Table 4). While not universal, ongoing conservation concerns, an increased interaction potential and uncertainty surrounding interaction rates and release fates were identified as the key contributors of risk.

Operators in this region have historically targeted saucer scallops (*Ylistrum balloti*) which are classified as a Tier 1 species under the *Trawl Fishery (Southern Inshore Region) Harvest Strategy: 2021–2026* (Department of Agriculture and Fisheries, 2021e). Research into the health of regional *Y. balloti* stocks indicated that a) the Queensland east coast saucer scallop stock has been the subject of an extended period of overfishing and b) biomass levels have failed to rebound to a level that would support larger-scale fishing activities (Wortmann, 2022; Wortmann *et al.*, 2020). In response to these findings, the management regime for saucer scallops was significantly reformed and the species classified as no-take in the Southern Inshore Trawl Region to assist with stock recovery (Department of Agriculture and Fisheries, 2021a).

Prohibiting the take of a Tier 1 species will affect the risk profile of the Southern Inshore Trawl Region. The extent of this effect will depend on a range of factors including any (potential) decline in annual effort levels, shifts in fishing behaviours / effort usage patterns (i.e. increased targeting of Tier 2 and Tier 3 species), the adoption of alternate gear configurations and any flow-on effects for bycatch compositions and volumes. In terms of the LCA, one of the biggest challenges was determining how this change impacted the risk profiles of individual species. This problem is compounded by the fact that bycatch information for the ECOTF is often based at a higher level or, if available at a regional level, does not have comparable data sets e.g. validated data collected through dedicated bycatch monitoring programs. This limits the extent of any assessment examining how the saucer scallop closure has impacted the risk profiles of key species.

#### 4.2.3.1 Marine Turtles

Marine turtle risk profiles in the Southern Inshore Trawl Region showed broad similarities with the Northern and Central Trawl Regions. Four species were assigned risk ratings of low-medium with the remaining two species assessed as a low risk (Table 4).

One of the species assigned a low-risk rating was the leatherback turtle (*Dermochelys coriacea*). The available evidence suggests that the life history of *D. coriacea* has a stronger correlation with pelagic-water environments (Department of the Environment, 2023a; Department of the Environment and Energy, 2017; Eckert *et al.*, 2012; Limpus, 2009). These life-history traits combined with the habitat preferences of the primary (*Y. balloti*) and secondary targets (Penaeid prawns, *Penaeus* spp. and Moreton Bay bugs, *Thenus* spp.), reduce the probability of a *D. coriacea* interaction occurring in this region. However, these preferences do not completely mitigate the interaction risk and a small number of *D. coriacea* have been reported as bycatch within the broader ECOTF (Department of Agriculture and Fisheries, 2023b). These interactions, combined with uncertainty surrounding the accuracy of data compiled through the Threatened, Endangered and Protected Animals (TEPA) logbook (Dedini *et al.*, 2023), supported the inclusion of *D. coriacea* in the Southern Inshore Trawl Region LCA.

The second species assigned a low-risk rating in the Southern Inshore Trawl Region was the olive ridley turtle (*Lepidochelys olivacea*). *Lepidochelys olivacea* is primarily found in tropical waters and major nesting sites for this species are located in northern Australia (Department of the Environment and Energy, 2017; Limpus, 2008a). These life-history preferences reduce the likelihood of *L. olivacea* interacting with trawl operations in the Southern Inshore Trawl Region; an inference that is supported by the TEPA logbook data (Department of Agriculture and Fisheries, 2023b). However, the species has a broad range and it has been reported from waters as far south as Moreton Bay in south-east Queensland (Department of Environment Science and Innovation, 2021; Department of the Environment and Energy, 2017). Given these factors, the decision was made to include *L. olivacea* in

the Southern Inshore Trawl Region LCA as a precautionary measure. With improved data validation, it is conceivable that the *L. olivacea* risk profile could be refined and/or the species removed from future regional assessments as a low-risk element.

Distributional and habitat data for the remaining species indicate that they have an increased potential to interact with trawl operations in the Southern Inshore Trawl Region. Most interactions will involve the green turtle (*Chelonia mydas*) which is found in higher abundances along the Queensland east coast (Department of the Environment, 2023b; Limpus, 2008c). The loggerhead turtle (*Caretta caretta*) and flatback turtle (*Natator depressus*) also have nesting/rookery sites located within the Southern Inshore Trawl Region (Limpus, 2007a; 2008b; 2009). The presence of these nesting sites increase the interaction potential for all three species, albeit remaining below the expected interaction rates with *C. mydas*.

The situation surrounding the hawksbill turtle (*Eretmochelys imbricata*) is more complicated. Australia supports some of the largest remaining Indian Ocean – Western Pacific Ocean breeding stocks and the distribution of this species extends from mid-western Western Australia to southern Queensland (Department of the Environment, 2023d; Limpus, 2007b; Queensland Government, 2020). However, key rookeries for this species are largely confined to far north Queensland, Torres Strait and Arnhem Land (Limpus, 2007b). For reference, just one *E. imbricata* nesting site has been recorded on the Queensland east coast to the south of Princess Charlotte Bay in the Great Barrier Reef Marine Park (GBRMP; Limpus, 2007b). With that said, *E. imbricata* is migratory (Limpus, 2007b) and individuals forage over coral reefs, rock outcroppings and seagrass beds. These behavioural patterns may increase the species exposure to trawl fishing activities.

*Eretmochelys imbricata* has been recorded as bycatch in the ECOTF and stock dispersal records for this species overlap with the Southern Inshore Trawl Region (Department of Agriculture and Fisheries, 2021e). However, there is a degree of uncertainty surrounding the accuracy of the TEPA logbook data and its ability to accurately account for regional interaction rates (Dedini *et al.*, 2023). For *E. imbricata*, information on nesting sites, foraging areas and migration patterns suggests that the interaction potential for this species may be lower in the Southern Inshore Trawl Region (Department of the Environment and Energy, 2017; Limpus, 2007b). This by extension lends support to the hypothesis that operations in the Northern and Central Trawl Regions pose a higher risk to this species. While these factors were considered as part of the LCA, information levels were not considered sufficient to assign *E. imbricata* a regional risk rating below low-medium (Table 4; Data Report: Appendix C).

Across the complex, the use of a Turtle Excluder Device (TED) contributed to the marine turtle complex receiving ratings at the lower end of the risk spectrum (Table 4; Data Report: Appendix C). The use of a TED remains a pivotal component of the broader ECOTF management regime and it is arguably the most effective risk-mitigation strategy employed for this subgroup. Research has shown that the combined use of a TED, with a Bycatch Reduction Device (BRD), can reduce landing rates for marine turtles by 97–99 per cent (Brewer *et al.*, 2006; Campbell *et al.*, 2020; Department of Agriculture and Fisheries, 2012; National Oceanic and Atmospheric Administration Fisheries, 2021). While similar turtle exclusion rates could be expected in the Southern Inshore Trawl Region, further information is required on the effectiveness of TEDs at a species, regional and whole-of-fishery level.

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 (Business Queensland, 2022; Department of Agriculture and Fisheries, 2012). 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 (e.g. internal and external injuries incurred during the net retrieval/landing process and/or being crushed by the weight of the catch). When a marine turtle is caught within the sweep of the net, the majority will experience a contact without capture event (Brewer *et al.,* 2006; Campbell *et al.,* 2020; Dedini *et al.,* 2023). These types of events are less likely to result in significant injuries and pose a lower long-term risk to the effected individual. These benefits were reflected in the outputs of this assessment and previous ERAs where the use of a TED, combined with declining effort levels, contributed to the complex receiving lower risk ratings (Table 4; Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b).

More broadly, the marine turtle complex will be afforded considerable protection through a range of legislative instruments. For example, most nesting sites situated on the Queensland east coast occur in habitats now protected under marine parks legislation or the Queensland *Nature Conservation Act 1992* (Limpus, 2007a; b; 2008a; b; c; 2009). For a number of the species, these protections extend to their preferred coastal foraging habitats. The level of protection will vary between species and may be less effective for highly migratory species like *E. imbricata* (Limpus, 2007b). These measures though help to reduce the exposure of this complex to trawl fishing and restrict or prohibit activities in areas where marine turtles are found in higher abundances throughout the year (Department of Environment and Science, 2020a; Great Barrier Reef Marine Park Authority, 2022; 2023; Undated). These factors were taken into consideration as part of the LCA and supported the assignment of lower risk ratings (Table 4; Data Report: Appendix C).

Data compiled through the TEPA logbook contains fewer than 100 marine turtle interactions across the entire ECOTF (2006–2021 data; Department of Agriculture and Fisheries, 2023b).[18] The veracity of this data has yet to be fully tested as the ECOTF does not currently operate with an effective mechanism to validate regional bycatch compositions, interaction rates or release fates.[19] This creates uncertainty surrounding the accuracy of marine turtle interaction-rate data and increases the risk of non-compliance and under-reporting. At the time of this assessment, marine turtle interaction rates could not be confirmed for the Southern Inshore Trawl Region.

This inability to validate TEPA logbook data increases the level of uncertainty surrounding the extent of marine turtle interactions in the Southern Inshore Trawl Region. However, cross comparisons with analogous fisheries lend support to the hypothesis that marine turtle interactions are under-reported across the entire ECOTF. For example, the Northern Prawn Fishery (NPF) observer program recorded 525 marine turtle interactions between 2018 and 2022 inclusive (Australian Fisheries Management Authority, 2023b).[20] Over this same period, the entire ECOTF reported 35 marine turtle interactions through the TEPA logbook (Department of Agriculture and Fisheries, 2023b). This differential occurred despite the NPF having a smaller operating potential: NPF: 52 licences, ~8,000 annual effort days;

[18] Includes data from the previous Species of Conservation Interest (SOCI) logbook. The TEPA logbook superseded the SOCI logbook in 2021 as part of a broader review of the logbook reporting requirements.

[19] Independent data validation is an integral component of the “Improved monitoring and research” foundational reform outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018b). A trial of independent data validation in the ECOTF is well advanced. However, data validation has yet to be fully implemented across the ECOTF. More information on the mechanisms being used to address the long-term data validation risk has been provided in the Level 2 ERA (Dedini *et al*., 2023).

[20] The NPF operates in northern Australia, has Marine Stewardship Council (MSC) certification and has a multi-faceted catch validation program that includes crew member observers and scientific observers (Australian Fisheries Management Authority, 2023a; Marine Stewardship Council, 2023).

ECOTF: ~300 active licences, >30,000 effort days (Department of Agriculture and Fisheries, 2023b; Patterson *et al.*, 2022). This uncertainty was a key consideration in the current assessment and contributed to a number of the species receiving marginally higher risk ratings.

With the ongoing rollout of the *Data Validation Plan*, expectations are that the level of information on marine turtle interactions will improve across the ECOTF and within each of the five management regions (Department of Agriculture and Fisheries, 2018b; 2023a; Queensland Government, Undated). The outputs of this program may be the key determinant in terms of the need to update the LCA for this complex within the Southern Inshore Trawl Region.

#### 4.2.3.2 Sea Snakes

The Southern Inshore Trawl Region incorporates sections of the GBRMP and risk assessments for this complex share similarities with the Central Trawl Region (Department of Agriculture and Fisheries, 2021b; e). However, sea snake interaction rates for the Southern Inshore Trawl Region will be lower as operators do not target red spot king prawns (*Melicertus longistylus*).

All 13 sea snakes were assessed for the Southern Inshore Trawl Region with nine classified as being at a low risk in this area (Table 4). The four remaining species are more likely to interact with regional trawl fishing operations and/or have been observed in higher numbers in the scallop (primary target), tiger prawn (secondary target) and banana prawn (secondary target) sectors (Courtney *et al.*, 2010; Department of Agriculture and Fisheries, 2021e).

Sea snake catch data for the ECOTF has poor species resolution and provides limited insight into regional catch compositions. At a whole-of-fishery level, sea snakes are the most reported complex in the TEPA logbook data with an average of 1,655 sea snake interactions (*range* = 336–4,753) recorded from the ECOTF each year (2003–2021 data; Department of Agriculture and Fisheries, 2023b).[21] While difficult to quantify, a high percentage of these interactions will occur further north in the Central Trawl Region. This region incorporates the *M. longistylus* fishery which is the main source of ECOTF sea snake interactions and mortalities (Courtney *et al.*, 2010; Department of Agriculture and Fisheries, 2021b; d). For context, Courtney *et al.* (2010) reported that over half of the sea snake interactions (59 per cent) and 85 per cent of the sea snake mortalities occurred in trawl operations targeting *M. longistylus*. When compared to central Queensland, trawl operators in the Southern Inshore Trawl Region will pose a lower (general) risk to this complex.

Research has shown that BRD designs like the Fisheye and a Square Mesh Codend are effective at excluding sea snakes from the trawl catch (Courtney *et al.*, 2010; Dedini *et al.*, 2023; Milton *et al.*, 2009; Queensland Government, 2022). In some instances, the use of these designs combined with a TED can reduce sea snake landing rates by up to 63 per cent (Courtney *et al.,* 2010). These findings have been accounted for in regional management regimes and are proven mitigators of risk for this subgroup. One of the inherent benefits of excluding sea snakes from the trawl catch is that they are more likely to experience a contact without capture event. Contact without capture events are less likely to result in the death of the animal and/or impede their long-term survivability. This was taken into consideration as part of the regional assessment and factored into sea snakes receiving lower risk ratings in the Southern Inshore Trawl Region.

[21] Includes data from the previous Species of Conservation Interest (SOCI) logbook. The TEPA logbook superseded the SOCI logbook in 2021 as part of broader review of the logbook reporting requirements.

Data compiled through the TEPA logbook indicates that between three and 30 per cent of landed sea snakes die due to drowning or injuries sustained during a trawl fishing event (Dedini *et al.*, 2023; Department of Agriculture and Fisheries, 2023b). Analysis of observer data from the NPF also places sea snake trawl mortality rates between 16 and 25 per cent (Australian Fisheries Management Authority, 2023b; Dedini *et al.*, 2023). Without a mechanism to validate regional TEPA logbook data, it is difficult to determine if mortality rate percentages for the entire ECOTF hold true for the Southern Inshore Trawl Region and/or if they have been influenced by more recent management reforms and declining effort (Table 4; Data Report: Appendix C). From an ERA perspective, this increases a level of assessment uncertainty and requires the adoption of a more precautionary approach.

The level of information on sea snake bycatch in the Southern Inshore Trawl Region will improve with the continued roll-out of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018b; Queensland Government, Undated). Research has also commenced on a project exploring avenues to reduce the impact of the fishery on threatened, endangered and protected species including sea snakes (Fisheries Research and Development Corporation, 2023a). The outputs of these data improvement initiatives may alter the risk profile of this complex and help refine the findings of the Southern Inshore Trawl Region LCA. Depending on the outputs, there may be a greater need to update the risk profiles of this complex within this region.

As this is the first regional assessment completed for the ECOTF, there are limited avenues to compare the results of the Southern Inshore Trawl Region LCA with previous assessments. The most tangible results being from two previous qualitative ERAs examining trawl fishing activities inside the GBRMP (Pears *et al.*, 2012b) and in southern Queensland (Jacobsen *et al.*, 2015). The results of Pears *et al.* (2012b) and Jacobsen *et al.* (2015) show broad similarities with the LCA in that the majority of sea snakes are situated at the lower end of the risk spectrum. While the outputs of the two qualitative assessments were marginally higher, both assessments considered trawl fishing activities across a wider sample area. The assessment methodology also differed and is more analogous to that used in the Level 2 ERA (Dedini *et al.,* 2023).

#### 4.2.3.3 Syngnathids

Risk considerations for the Syngnathidae complex showed less variability across the five trawl management regions. Key risk factors for this group included poor TED/BRD efficiency, limited information on regional catch compositions and an increased potential for *in-situ* mortalities (Dedini *et al.,* 2023). If caught in the sweep of the net, seahorse and pipefish are unlikely to be excluded from the catch via the TED or BRD. Once caught, there is an increased probability that the animal will be landed in a dead or moribund state due to injuries incurred during the trawl fishing event.

Syngnathid catch rates and compositions are not well understood in the Southern Inshore Trawl Region and logbook data provides limited insight into species-specific rates of fishing mortality (Department of Agriculture and Fisheries, 2023b). These limitations reflect broader deficiencies in the amount of available data on trawl-caught syngnathids. One of the challenges of monitoring syngnathid catch rates in a trawl fishery is that that they can be difficult to detect due to their size and cryptic lifestyles. As a consequence, there is an increased probability that a trawl-caught seahorse or pipefish will go undetected within a multi-species trawl catch. This has likely contributed to an underreporting of syngnathid interaction rates in the ECOTF; particularly for non-retainable species.

A review of historical catch locations showed that syngnathid interactions were higher in central and southern Queensland (Connolly *et al.*, 2001; Dodt, 2005). Some of these areas are now located within the Southern Inshore Trawl Region (Dodt, 2005). This report is almost 20 years old and, given the extent of subsequent reforms and effort reductions, will be less applicable to the current fishing environment. It did, however, identify the Duncker's pipehorse (*Solegnathus dunckeri*) and the Pallid pipehorse (*S. hardwickii*) as two of the more abundant species surveyed (Dodt, 2005). These two species are the only syngnathids that can be retained for sale in the ECOTF.[22] The remainder must be discarded as bycatch and their capture recorded in the TEPA logbook (Queensland Government, 2024).

In the Southern Inshore Trawl Region, the retained component of the Syngnathidae catch will include both *S. hardwickii* and *S. dunckeri* (Table 4; Data Report: Appendix C). This differs from the Central and Northern Trawl Regions which are situated above the northern limit of the *S. dunckeri* range (Bray & Thompson, 2020). This factor was considered as part of the LCA and contributed to *S. hardwickii* and *S. dunckeri* receiving marginally higher risk ratings (Table 4). Quantifying the composition of the remaining catch may be more difficult and will be complicated by uncertainty surrounding the taxonomy and distribution of regional syngnathid species. These deficiencies were discussed at length in the Level 2 ERA report which included recommendations on how these long-term risk areas could be addressed (Dedini *et al.,* 2023).

While not universal, fine-scale habitat preferences are a risk-limiting factor for this subgroup. Many syngnathids are predominantly associated with highly structured habitats such as coral reefs and garden bottoms which are avoided by trawl operations (Kuiter, 2000; Lourie, 2016; Pears *et al.*, 2012b). This helps limit the interaction potential and is one of the reasons why syngnathids are frequently assigned ratings in the low to medium risk categories (Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b). In the Southern Inshore Trawl Region LCA, information on the habitat preferences was used in a weight-of-evidence approach to assign some species a lower score for the likelihood component (Table 4; Data Report: Appendix C). This approach considered additional protections provided to this subgroup through the *Great Barrier Reef Marine Park Zoning Plan*, third party assessments like the IUCN Red List extinction risk evaluations and information contained in the Species Profile and Threats Database (Department of Climate Change Energy the Environment and Water, Undated; International Union for Conservation of Nature's Red List of Threatened Species, 2022).[23]

With improved data on Syngnathidae catch rates and locations, a more refined assessment of these risk-limiting factors could be undertaken. For example, research has shown that *S. hardwickii* and *S. dunckeri* are less likely to be caught in waters shallower than 25 m (Connolly *et al.*, 2001). In the current assessment, it was difficult to determine the wider applicability of these findings due to the increased level of uncertainty surrounding a) total rates of fishing mortality (retained plus discards) and b) catch location coverage (Dedini *et al.*, 2023). These data deficiencies are now being actively addressed through fisheries logbook improvements, the *Data Validation Plan* and ancillary projects examining the impact of trawl fishing on non-target species (Department of Agriculture and Fisheries,

[22] While permitted for retention within the ECOTF, regulations specify that pipefish have a combined trip limit of 50 individuals for each vessel (State of Queensland, 2019).

[23] The *Great Barrier Reef Marine Park Zoning Plan* does not contain syngnathid-specific closures or fisheries-protection measures. However, the plan will afford protection to structured habitats preferred by these species including rocky reef assemblages, seagrass beds and coral reef systems.

2018b; Fisheries Research and Development Corporation, 2023a; Queensland Government, 2024; Undated).

#### 4.2.3.4 Sharks

The shark complex had fairly low representation with just seven of the 12 available species included in the Southern Inshore Trawl Region LCA (Fig. 2; Table 4). The distributions and depth profiles of the five remaining species did not include this management region and/or reduced their interaction potential (Table 4; Data Report: Appendix C). It is recognised that species like the pale spotted catshark (*Asymbolus pallidus*), grey spotted catshark (*A. analis*) and orange spotted catshark (*A. rubiginosus*) may interact infrequently with trawl operations in this region. These interactions are not expected to pose a significant threat to the long-term sustainability of these species (Data Report: Appendix C; Kyne *et al.*, 2023c; j; Kyne *et al.*, 2023m).

Sharks have a *k*-selected life-history that increases their long-term vulnerability to trawl fishing activities (Dedini *et al.,* 2023). While noting these vulnerabilities, the best available information indicates that these risks are being largely managed within the current fishing environment. The brownbanded bamboo shark (*Chiloscyllium punctatum*), eastern banded catshark (*Atelomycterus marnkalha*), zebra shark (*Stegostoma tigrinum*), Australian weasel shark (*Hemigaleus australiensis*), and piked spurdog (*Squalus megalops*) are all classified as Least Concern under the IUCN Red List extinction risk criteria (Kyne *et al.*, 2021). Complementary analyses have also classified the fishing status of these five species as either Negligible (catch limited) or Sustainable across their known distributions (Kyne *et al.*, 2023a; Kyne *et al.*, 2023b; Kyne *et al.*, 2023e; f; n).[24] These findings indicate that there is a lower probability of these species experiencing an undesirable event in the Southern Inshore Trawl Region (Data Report: Appendix C).

The sixth species assigned a low-risk rating, the eastern angelshark (*Squatina albipunctata*), has more notable conservation concerns. This species has an IUCN Red List classification of Vulnerable and evidences suggests that populations on the Australian east coast are in decline (Kyne *et al.*, 2021; Kyne *et al.*, 2023d). A closer inspection of the stock status assessment indicates that the main threats for this species are located in New South Wales and in the Commonwealth-managed Southern and Eastern Scalefish and Shark Fishery (Kyne *et al.*, 2023d). When compared, *S. albipunctata* will experience lower fishing pressures in Queensland where its depth profile (35–415 m) affords the species with a degree of natural protection from trawl fishing activities (Kyne *et al.*, 2021; Kyne *et al.*, 2023d). These factors were given significant weighting when determining the regional *S. albipunctata* risk rating and improvements to the regional catch composition data could facilitate its removal from future ERAs involving this region.

The most notable risks for the shark complex in the Southern Inshore Trawl Region involve the Colclough's shark (*Brachaelurus colcloughi*) (Table 4). *Brachaelurus colcloughi* is a rare, endemic species and it is likely to occur at a naturally low abundance. Information sets for *B. colcloughi* are less developed and datasets for this species are based on fewer than 80 individuals (Kyne *et al.*, 2011; Kyne *et al.*, 2021). There remains considerable uncertainty surrounding the distribution of *B. colcloughi* and its capacity to interact with the ECOTF. On the Queensland east coast, the available evidence indicates that *B. colcloughi* are more likely to interact with the Southern Inshore, Southern

[24] Status assessments compiled as part of the *Shark and Ray Report Card* consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

Offshore and (potentially) Moreton Bay Trawl Regions (Kyne *et al.*, 2015; Kyne *et al.*, 2021; Kyne *et al.*, 2023l). At present, the northern extent of the *B. colcloughi* range extends to Swains Reef National Park and Flock Pigeon Island (Jacobsen, 2007; Kyne *et al.*, 2023l; Rigby *et al.*, 2016b).

It is difficult to ascertain how frequently *B. colcloughi* interacts with southern Queensland trawl operations or provide a precise assessment of regional risk levels. The catch of this species is not reported through the TEPA logbook and the ECOTF does not have an effective mechanism in place to monitor interaction rates for bycatch species.[25] This creates a level of uncertainty surrounding regional catch rates and, in an ERA context, requires the adoption of a more precautionary assessment approach. With the ongoing rollout of the *Data Validation Plan*, information levels may improve to the point where a more informed assessment of the *B. colcloughi* distribution and interaction potential could be undertaken (Department of Agriculture and Fisheries, 2018b; 2023a; Queensland Government, Undated). The extent of any risk score refinements will depend on the quality and quantity of the available data.

As this is the first Southern Inshore Trawl Region ERA, there are limited avenues to compare the results of this LCA with previous assessments. However, Campbell *et al.* (2017) included a range of shark species in an ERA examining the risk posed by trawl fishing activities in southern Queensland. When compared, both the LCA and Campbell *et al.* (2017) assigned identical risk ratings to *C. punctatum S. albipunctata*. *S. tigrinum* and *H. australiensis* (Table 4). The ratings for *B. colcloughi* and *S. megalops* though showed more variability. In the Campbell *et al.* (2017) assessment, *B. colcloughi* and *S. megalops* were assigned a low and high risk rating respectively. These results were reversed in the Southern Inshore Trawl Region LCA where *B. colcloughi* was assessed as a high risk and *S. megalops* a low risk (Table 4).

The observed difference in *B. colcloughi* risk ratings can be attributed to the LCA applying a more precautionary approach to data deficiencies. In an ERA framework, data deficiencies increase the level of uncertainty and frequently result in the assignment of more precautionary risk ratings. The situation surrounding *S. megalops* differs in that the observed variability is due to the two ERAs having different sample areas. Campbell *et al.* (2017) primarily focused on fishing grounds now encompassed within the Southern Offshore Trawl Region. Operators in this region target eastern king prawns (*Melicertus plebejus*) in deeper water environments and they are more likely to interact with *S. megalops* (Department of Agriculture and Fisheries, 2021c). It also means that the effort footprint used in the Campbell *et al.* (2017) assessment had greater overlap with the habitats and water depths preferred by this species (Ebert *et al.*, 2021; Kyne *et al.*, 2023n; Rigby *et al.*, 2016b). This inference is supported by the outputs of the Southern Offshore Trawl Region LCA which assigned *S. megalops* a higher risk rating (Table 4; Data Report: Appendix D).

While regional risk levels are comparatively low, fishing activities within the Southern Inshore Trawl Region will need to be considered when examining the extent of any cumulative fishing pressures. The importance of understanding these cumulative pressures will be higher for species like *B. colcloughi* where there are more notable conservation concerns (Kyne *et al.*, 2015; Kyne *et al.*, 2011; Kyne *et al.*, 2023l). These longer-term pressures or vulnerabilities were discussed in more detail in the

[25] Independent data validation is an integral component of the “Improved monitoring and research” foundational reform outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018b). A trial of independent data validation in the ECOTF is well advanced. However, data validation has yet to be fully implemented across the ECOTF. More information on the mechanisms being used to address the long-term data validation risk has been provided in the Level 2 ERA (Dedini *et al.*, 2023).

Level 2 ERA (Dedini *et al.*, 2023). At a regional level, the LCA indicates that the current fishing environment poses a lower risk to most of the species assessed. This situation may change if (e.g.) there is a notable shift from the current fishing environment, there is an observed decline in the conservation status of one or more species and/or new evidence indicates that operators in this region interact with a more diverse range of species.

#### 4.2.3.5 Batoids

Research has shown that operators targeting scallops (*Y. balloti*),[26] prawns (*P. esculentus* and *P. semisulcatus, Metapenaeus endeavouri* and *P. indicus* and *P. merguiensis*) and Moreton Bay bugs (*Thenus* spp.) will interact with a diverse array of benthic batoids. While noting this diversity, only 22 batoids were considered for inclusion in the regional risk assessments (Table 4). The remaining species were excluded from the analysis through a detailed species rationalisation process conducted as part of the Level 2 ERA (Dedini *et al.*, 2023). The Level 2 ERA provides a full account of this process including the justifications used to include or omit a species from the analysis (Appendix A and B of Dedini *et al.*, 2023).

Of the 22 batoids considered, 13 were assessed as part of the Southern Inshore Trawl Region LCA (Fig. 2; Table 4). The nine remaining species had distributions and depth profiles that did not encroach on this management region and/or reduced their interaction potential (Table 4; Data Report: Appendix C). Key species excluded from the Southern Inshore Trawl Region LCA include stingarees and most of the skates which are more commonly encountered in the Southern Offshore Trawl Region (Kyne *et al.*, 2021; Last *et al.*, 2016).

Three of the 13 species included in the Southern Inshore Trawl Region LCA were assigned low-risk ratings (Table 4). The Australian whipray (*Himantura australis*; 183 cm disc width) and the giant guitarfish (*Glaucostegus typus*, 284 cm total length) grow to a considerable size and they will quickly exceed the TED bar spacings (Kyne *et al.*, 2021; Last *et al.*, 2016). Sub-adult and adults of these two species are more likely to be excluded from the catch with individuals experiencing a contact without capture event (Dedini *et al.*, 2023; Kyne *et al.*, 2021; Last *et al.*, 2016). Contact without capture events are difficult to quantify as they will often go unobserved. Expectations are though that the vast majority of animals will survive this type of interaction and have fewer long-term injuries.

The third species at low risk in the Southern Inshore Trawl Region LCA was the Argus skate, *Dentiraja polyommata* (Table 4). *Dentiraja polyommata* is more commonly found in deeper waters and the species is caught by fishers targeting eastern king prawns (*Melicertus plebejus*; Courtney *et al.*, 2007; Rigby *et al.*, 2016a; Rigby *et al.*, 2016b). *Dentiraja polyommata* was included in the Southern Inshore Trawl Region as a precautionary measure and the extent of any interactions will be limited by its depth profile (>100 m). The situation was partly mirrored for the patchwork stingaree (*Urolophus flavomosaicus*) whose depth profile (60–320 m) likely exceeds that of regional trawl operations (Kyne *et al.*, 2021; Last *et al.*, 2016). However, *U. flavomosaicus* was assigned a marginally higher risk score as it is also found in shallower waters (Table 4). Interaction rates for both species are expected to be low and improvements in the data on regional bycatch compositions may facilitate their removal from future assessments.

[26] Saucer scallops (*Y. balloti*) are a Tier 1 species in the Southern Inshore Trawl Region and have historically been a key target for operators in this area. The take of *Y. balloti* is currently prohibited in this region as part of a broader stock-rebuilding strategy (Department of Agriculture and Fisheries, 2021a; e; Wortmann, 2022).

The majority of the remaining species (*n* = 9) were classified as a low-medium risk within the Southern Inshore Trawl Region (Table 4). These species, as with other batoids, have higher biological vulnerabilities and there is a marginally higher risk of trawl fishing activities impacting regional populations (Dedini *et al.,* 2023). While noting these vulnerabilities, the whiprays (*Maculabatis astra*, *M. toshi*), maskrays (*Neotrygon picta, N. trigonoides*), Australian butterfly ray (*Gymnura australis*), bottlenose wedgefish (*Rhynchobatus australiae*), eastern shovelnose ray (*Aptychotrema rostrata*) and *U. flavomosaicus* have fewer sustainability concerns within Australian waters. All are expected to occur in high abundance within their preferred habitats and have extinction risk classifications of Least Concern or Near Threatened (Kyne *et al.*, 2021; Last *et al.*, 2016). Similarly, the fishing status for these eight species has been assessed as Sustainable across their known distributions (Kyne *et al.*, 2023o; p; q; r; s; v; w; x; z; Kyne *et al.*, 2023ag).[27]

The risk profile of the estuary stingray (*Hemitrygon fluviorum*), the ninth species at low-medium risk, is more complicated (Table 4). While the species has similar biological vulnerabilities, its conservation status is more precarious. *Hemitrygon fluviorum* has experienced substantial range contractions and population declines across the Queensland east coast. These declines have resulted in the species being assigned an extinction risk classification of Vulnerable under the IUCN Red List criteria with a declining population trend (Kyne *et al.*, 2023y). At a State level, *H. fluviorum* is listed as Near Threatened under the Queensland *Nature Conservation Act 1992* and both fishing activities and habitat degradation have been identified as regional threats (Department of the Environment, 2015a; Kyne *et al.*, 2023u; y; 2023aa; Last *et al.*, 2016).

Of notable importance, the historical targeting of *Y. balloti* in the Southern Inshore Trawl Region would see fishers operating in areas where *H. fluviorum* are less likely to be encountered. Anecdotal evidence suggests that these patterns have not changed substantially since the introduction of the scallop prohibition with operators continuing to fish for *Thenus* spp. in similar areas. This factor was taken into consideration as part of the regional LCA and contributed to the species receiving a lower risk rating (Table 4). This assessment though may need to be reviewed if fishing behaviours shift in the Southern Inshore Trawl Region and effort becomes more prevalent in inshore environments.

The green sawfish (*Pristis zijsron*) registered one of the highest risk scores in the Southern Inshore Trawl Region LCA (Table 4). *Pristis zijsron*, as with *H. fluviorum*, has experienced range contractions and population declines on the Queensland east coast. These declines/contractions though are more significant and *P. zijsron* may now be regionally extirpated in waters south of the Whitsundays (Department of the Environment, 2019). The species is considered Critically Endangered under the IUCN Red List criteria with complementary analyses assessing the stock status as Depleted (Kyne *et al.*, 2021; Kyne *et al.*, 2023aa). While *P. zijsron* is currently listed as Vulnerable under the EPBC Act, the *Action Plan for Australian Sharks and Rays* recommends that this classification be elevated to Critically Endangered (Kyne *et al.,* 2021).

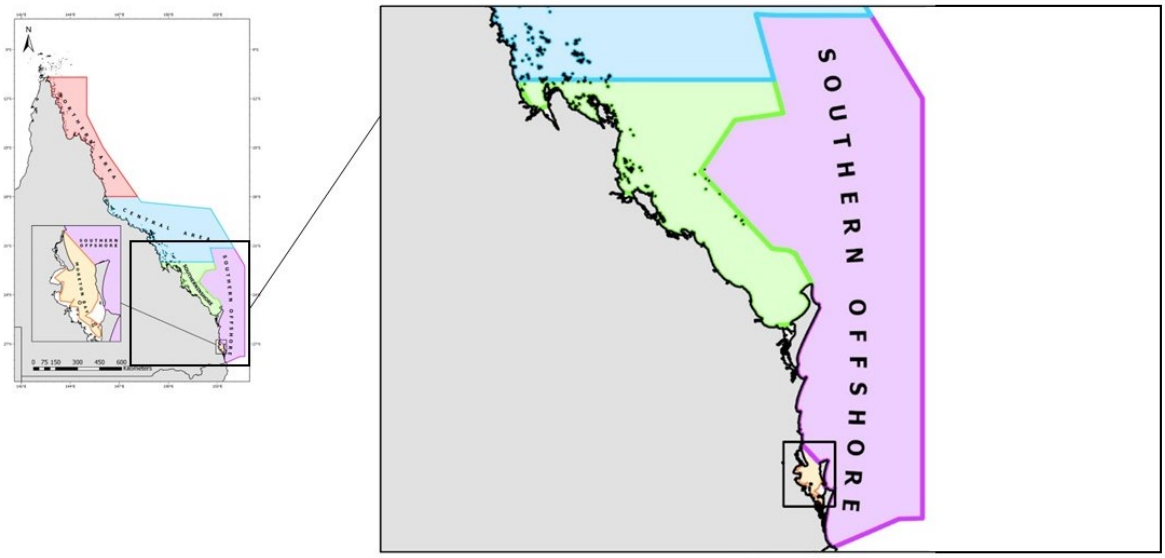
Range contractions suggest that there is a low probability of *P. zijsron* interacting with operators in the Southern Inshore Trawl Region. This low interaction potential is in direct response to a decline in population health and the impact of cumulative pressures or threats including historic commercial fishing activities. This is an important distinction to make when comparing *P. zijsron* with other batoids whose habitat and depth profiles limit their exposure to trawl fishing. In the Southern Inshore Trawl

[27] Status assessments compiled as part of the *Shark and Ray Report Card* consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

Region, any interaction (if applicable) will be with a remnant population and may have significant, long-term implications for *P. zijsron*. Given the extent of historic populations declines, this will occur at low levels of fishing mortality and may result in further range contractions, reduced genetic diversity and further fragmentation of regional populations. These concerns were ultimately reflected in the risk rating assigned to *P. zijsron* in the Southern Inshore Trawl Region LCA (Table 4).

For species at high risk (*P. zijsron*), fishing activities in the Southern Inshore Trawl Region have a greater potential to impact regional populations and contribute to ongoing declines (Kyne *et al.*, 2023u; y; 2023aa). The outputs of this report highlights the need to improve the level of information on batoid interaction rates within and across the Southern Inshore Trawl Region. This is of particular relevance to sawfish as evidence suggests that northern Australia is one of the few remaining strongholds for Indo-West Pacific species (Kyne *et al.,* 2021).

### 4.2.4 Southern Offshore Trawl Region




Of the 62 species considered for assessment, 49 had distributions that overlapped with the Southern Offshore Trawl Region (Department of Agriculture and Fisheries, 2021c). The LCA included all six marine turtle species and it had the highest regional representation for elasmobranchs (batoids, *n* = 20; sharks, *n* = 11). Conversely, just five sea snakes and seven syngnathids required assessment in the Southern Offshore Trawl Region LCA (Fig. 2; Table 4). The remaining 13 species had distributions and depth profiles that negated or significantly reduced their interaction potential in this region. These species were excluded from the Southern Offshore Trawl Region LCA and assigned a ‘Not Assessed. classification (Fig. 3; Table 4).

The vast majority of species included in this assessment registered risk ratings of low (*n* = 16) or low-medium (*n* = 23). Nine species were classified as a medium risk (two syngnathids, two sharks and five batoids), with the Colclough’s shark (*Brachaelurus colcloughi*) registering the only high-risk rating in the Southern Offshore Trawl Region LCA (Table 4). While not universal, ongoing conservation concerns, an increased interaction potential and uncertainty surrounding interaction rates and release fates were identified as the key contributors of risk.

The outputs of the Southern Offshore Trawl Region LCA reflects the varied dynamics of a multi-species fishery. Operators primarily target eastern king prawns (*Melicertus plebejus*) and more readily access trawl grounds in deeper waters. However, fishers will also target brown (*Penaeus esculentus*) and grooved (*P. semisulcatus*) tiger prawns in southern, inshore waters extending down to the New South Wales border (Department of Agriculture and Fisheries, 2021c).[28] This spread of effort across water depths and habitats increases the interaction potential for a number of key groups including deepwater shark and stingaree species. These deepwater species were, for the most part, excluded from assessments involving the Southern Inshore, Central and Northern Trawl Regions (Table 4).

#### 4.2.4.1 Marine Turtles

When compared to management regions situated further north, the Southern Offshore Trawl Region poses a lower overall risk to the marine turtle complex. Of the six species assessed, three were assigned a low-risk rating with the remainder registering a marginally higher rating of low-medium (Fig. 3; Table 4).

Of the species assessed, operators in the Southern Offshore Trawl Region are more likely to interact with the green turtle, *Chelonia mydas*. *Chelonia mydas* is found in higher abundances along the Queensland east coast and it has prominent breeding and nesting sites in central and south-east Queensland (Limpus, 2008c). While population numbers for the loggerhead turtle (*Caretta carreta*) are lower, this species also has rookeries, nesting sites and migratory patterns that increase its interaction potential in the Southern Offshore Trawl Region (Limpus, 2008b). While noting this potential, regional risk levels for these species remain comparatively low (Table 4).

The olive ridley turtle (*Lepidochelys olivacea*) and the flatback turtle (*Natator depressus*) were two of the species assigned low-risk ratings for this region (Table 4). *Lepidochelys olivacea* is primarily found in tropical waters and major nesting sites for this species are located in northern Australia (Department of the Environment and Energy, 2017; Limpus, 2008a). These habitat preferences limit its interaction potential in this region, with *L. olivacea* more likely to be encountered in the Northern and Central Trawl Regions (Department of Agriculture and Fisheries, 2021d). In the unlikely event that *L. olivacea* interacts with trawl operations in the Southern Offshore Trawl Region, the frequency of these events are unlikely to have a significant, long-term or detrimental impact on the Australian population.

*Natator depressus* has nesting beaches, rookeries and post-nesting dispersal records that extend south to Mon Repos and Curtis Island in central Queensland (Limpus, 2007a). Adults of this species tend to inhabit sub-tidal, soft bottom habitats and have foraging distributions that extend from Hervey Bay to the Torres Strait (Limpus, 2007a). These preferences will likely see the species encountered with more regularity in the Southern Inshore, Central and Northern Trawl Regions (Department of Agriculture and Fisheries, 2021b; d; e). While *N. depressus* interactions may still occur in this region, the frequency of these events are unlikely to have a long-term impact on the conservation status of this species; particularly given the use of Turtle Excluder Devices (TEDs).

The remaining species at low risk in the Southern Offshore Trawl Region was the leatherback turtle (*Dermochelys coriacea*). Available data indicates that the life history of *D. coriacea* has a stronger correlation with pelagic-water environments and the species is less likely to interact with the ECOTF

[28] Other species retained in this region include saucer scallops (*Ylistrum balloti*), Moreton Bay bugs (*Thenus* spp.) and Balmain bugs (*Ibacus* spp.) which, along with *P. esculentus* and *P. semisulcatus* are identified as Tier 2 species under the *Trawl Fishery (Southern Offshore A and B Regions) Harvest Strategy: 2021–2026*.

(Department of the Environment, 2023a; Eckert *et al.*, 2012; Limpus, 2009). However, these preferences do not completely mitigate the interaction risk, with both nesting and non-nesting *D. coriacea* being reported throughout south-east Queensland (Limpus, 2009). There have also been a small number of reports of *D. coriacea* being caught as bycatch within the broader ECOTF (Department of Agriculture and Fisheries, 2023b). Given the foraging preferences of *D. coriacea* (Department of the Environment and Energy, 2017), it is conceivable that some of these interactions occurred in waters now encompassed within the Southern Offshore Trawl Region (Department of Agriculture and Fisheries, 2021c). These interactions combined with uncertainty surrounding the accuracy of data compiled through the Threatened, Endangered and Protected Animals (TEPA) logbook (Dedini *et al.*, 2023), supported the inclusion of *D. coriacea* in the regional assessment.

The situation surrounding the hawksbill turtle (*Eretmochelys imbricata*) is more complicated. Australia supports some of the largest remaining Indian Ocean – Western Pacific Ocean breeding stocks and the distribution of this species extends from mid-western Western Australia to southern Queensland (Department of the Environment, 2023d; Limpus, 2007b; Queensland Government, 2020). However, key rookeries for this species are largely confined to far north Queensland, Torres Strait and Arnhem Land (Limpus, 2007b). For reference, just one *E. imbricata* nesting site has been recorded on the Queensland east coast to the south of Princess Charlotte Bay in the Great Barrier Reef Marine Park (GBRMP; Limpus, 2007b). With that said, *E. imbricata* is migratory (Limpus, 2007b) and individuals forage over coral reefs, rock outcroppings and seagrass beds. These behavioural patterns may increase the species exposure to trawl fishing activities.

*Eretmochelys imbricata* has been recorded as bycatch in the ECOTF and stock dispersal records for this species overlap with the Southern Offshore Trawl Region (Department of Agriculture and Fisheries, 2021e). However, there is a degree of uncertainty surrounding the accuracy of the TEPA logbook data and its ability to accurately account for regional interaction rates (Dedini *et al.*, 2023). For *E. imbricata*, information on nesting sites, foraging areas and migration patterns suggests that the interaction potential for this species may be lower in the Southern Offshore Trawl Region (Department of the Environment and Energy, 2017; Limpus, 2007b). This by extension lends support to the hypothesis that operations in the Northern and Central Trawl Regions pose a higher risk to this species. While these factors were considered as part of the LCA, information levels were not considered sufficient to assign *E. imbricata* a regional risk rating below low-medium (Table 4; Data Report: Appendix D).

Across the complex, the use of a TED contributed to the marine turtle complex receiving ratings at the lower end of the risk spectrum (Table 4; Data Report: Appendix D) . The use of a TED remains a pivotal component of the broader ECOTF management regime and it is arguably the most effective risk-mitigation strategy employed for this subgroup. Research has shown that the combined use of a TED, with a Bycatch Reduction Device (BRD), can reduce landing rates for marine turtles by 97–99 per cent (Brewer *et al.*, 2006; Campbell *et al.*, 2020; Department of Agriculture and Fisheries, 2012; National Oceanic and Atmospheric Administration Fisheries, 2021). While similar turtle exclusion rates could be expected in the Southern Offshore Trawl Region, further information is required on the effectiveness of TEDs at a species, regional and whole-of-fishery level.

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 (Business Queensland, 2022; Department of Agriculture and Fisheries, 2012). 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 (e.g. internal and external injuries incurred during the net retrieval/landing process and/or being crushed by the weight of the catch). When a marine turtle is caught within the sweep of the net, the majority will experience a contact without capture event (Brewer *et al.,* 2006; Campbell *et al.,* 2020; Dedini *et al.,* 2023). These types of events are less likely to result in significant injuries and pose a lower long-term risk to the effected individual. These benefits were reflected in the outputs of this assessment and previous ERAs where the use of a TED, combined with declining effort levels, contributed to the complex receiving lower risk ratings (Table 4; Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b).

More broadly, the marine turtle complex will be afforded considerable protection through a range of legislative instruments. For example, most nesting sites on the Queensland east coast occur in habitats now protected under marine parks legislation or the Queensland *Nature Conservation Act 1992* (Limpus, 2007a; b; 2008a; b; c; 2009). For a number of the species, these protections extend to their preferred coastal foraging habitats. Given the locality of fishing operations, marine park protections will be less beneficial in the Southern Offshore Trawl Region. Trawl operations in this region though are subject to spatial and temporal closures which includes a region-wide cessation of fishing activities between 20 September to 1 November (Department of Agriculture and Fisheries, 2021c; State of Queensland, 2019).

Data compiled through the TEPA logbook contains fewer than 100 marine turtle interactions across the entire ECOTF (2006–2021 data; Department of Agriculture and Fisheries, 2023b).[29] The veracity of this data has yet to be fully tested as the ECOTF does not currently operate with an effective mechanism to validate regional bycatch compositions, interaction rates or release fates.[30] This creates uncertainty surrounding the accuracy of marine turtle interaction-rate data and increases the risk of non-compliance and under-reporting. At the time of this assessment, marine turtle interaction rates could not be confirmed for the Southern Offshore Trawl Region.

The inability to validate TEPA logbook data increases the level of uncertainty surrounding the extent of marine turtle interactions in the Southern Offshore Trawl Region. However, cross comparisons with analogous fisheries lend support to the hypothesis that marine turtle interactions are under-reported across the entire ECOTF. For example, the Northern Prawn Fishery (NPF) observer program recorded 525 marine turtle interactions between 2018 and 2022 inclusive (Australian Fisheries Management Authority, 2023b).[31] Over this same period, the entire ECOTF reported 35 marine turtle interactions through the TEPA logbook (Department of Agriculture and Fisheries, 2023b). 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 (Department of Agriculture and Fisheries, 2023b; Patterson *et al.*, 2022). This uncertainty was a key consideration in the current assessment and contributed to a number of the species receiving marginally higher risk ratings (Table 4).

[29] Includes data from the previous Species of Conservation Interest (SOCI) logbook. The TEPA logbook superseded the SOCI logbook in 2021 as part of a broader review of the logbook reporting requirements.

[30] Independent data validation is an integral component of the “Improved monitoring and research” foundational reform outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018b). A trial of independent data validation in the ECOTF is well advanced. However, data validation has yet to be fully implemented across the ECOTF. More information on the mechanisms being used to address the long-term data validation risk has been provided in the Level 2 ERA (Dedini *et al*., 2023).

[31] The NPF operates in northern Australia, has Marine Stewardship Council (MSC) certification and has a multi-faceted catch validation program that includes crew member observers and scientific observers (Australian Fisheries Management Authority, 2023a; Marine Stewardship Council, 2023).

With the ongoing rollout of the *Data Validation Plan*, expectations are that the level of information on marine turtle interactions will improve across the ECOTF and within each of the five management regions (Department of Agriculture and Fisheries, 2018b; 2023a; Queensland Government, Undated). The outputs of this program may be the key determinant in terms of the need to update the LCA for this complex within the Southern Offshore Trawl Region.

#### 4.2.4.2 Sea Snakes

Of the 13 species considered for inclusion in the Southern Offshore Trawl Region LCA, only five were progressed to a final assessment. This reduced representation was based on a review of catch, taxonomic and distributional data along the Queensland east coast (Courtney *et al.*, 2010; Udyawer *et al.*, 2020). It is recognised that regional trawl operations will interact with other species including the reef shallows sea snake (*Aipysurus duboisii*) and the Stoke's sea snake (*Hydrophis stokesii*) (Courtney *et al.*, 2010). The review indicated that these species are more likely to interact with trawl fishers operating in tropical waters and they were omitted from the analysis (Courtney *et al.*, 2010; Dedini *et al.*, 2023; Department of Agriculture and Fisheries, 2021b; e; Pears *et al.*, 2012a).

The spotted sea snake (*H. ocellatus*), olive sea snake (*A. laevis*) and olive-headed sea snake (*H. major*) were included in the assessment as a precautionary measure. All three are caught as bycatch in the ECOTF and have occurrence records that overlap with this region (Courtney *et al.*, 2010; Udyawer *et al.*, 2020). Based on their known distributions and habitat preferences, interactions with these three species are more likely to occur in trawl operations targeting prawns in shallower waters (Courtney *et al.*, 2010). Within this region, most of these operations will fish within Southern Offshore Trawl Region B (Department of Agriculture and Fisheries, 2021c).

The mosaic sea snake (*A. mosaicus*) is commonly found in estuaries or shallow bays and across soft, muddy substrates down to water depths of 50 m (Rasmussen *et al.*, 2021). These habitat preferences will increase the exposure of this species to shallow-water trawl fishing operations, particularly those located in waters adjacent to K'gari (formerly Fraser Island) and south to the New South Wales border (i.e. Southern Offshore Trawl Region B; Department of Agriculture and Fisheries, 2021c). Conversely, these habitat preferences will afford the species with a degree of natural protection in regions where operators fish in deeper water environments. This would include most, if not all, fishing activities in Southern Offshore Trawl Region A (Department of Agriculture and Fisheries, 2020; 2021c).

The elegant sea snake (*H. elegans*) is one of the largest Australian sea snakes and research indicates that the distribution of this species has a moderate to high overlap with the ECOTF effort footprint (Courtney *et al.*, 2010). While *H. elegans* is commonly found in soft-sediment habitats below 30 m, research has shown that the species will be caught in trawls depths greater than 100 m (Courtney *et al.*, 2010; Milton, 2010). As a larger sea snake, *H. elegans* may be more susceptible to trawl-related injuries and, by extension, experience higher post-trawl mortalities (Courtney *et al.*, 2010). This problem is potentially compounded by the fact that *H. elegans* has a low rate of natural mortality and may be more prone to overfishing (Milton, 2010; Milton *et al.*, 2007).

While noting the above, Courtney *et al.* (2010) estimated that there was a low risk of localised sea snake extinctions occurring on the east coast due to trawl fishing activities. However, this assessment included a number of notable caveats surrounding the need to improve the accuracy of distributional

data underpinning this estimate.[32] Importantly, third-party assessments completed since Courtney *et al.* (2010) have determined that *A. mosaicus* and *H. elegans* have stable population trends and extinction risk classifications of Least Concern (Milton, 2010; Rasmussen *et al.*, 2021). These assessments lend support to the hypothesis that trawl fishing activities in the Southern Offshore Trawl Region currently pose a lower risk to the sea snake complex. The key caveat being that catch composition data underpinning these assessments are limited and are subject to change (e.g.) with changing effort patterns, conservation status or fishing patterns.

Sea snake catch data for the ECOTF has poor species resolution and provides limited insight into regional catch compositions. At a whole-of-fishery level, sea snakes are the most reported complex in the TEPA logbook data with an average of 1,655 sea snake interactions (*range* = 336–4,753) recorded from the ECOTF each year (2003–2021 data; Department of Agriculture and Fisheries, 2023b).[33] While difficult to quantify, a high percentage of these interactions will occur in the Central Trawl Region and involve the spine bellied sea snake (*H. curtus*), the horned sea snake (*H. peronii*), *H. elegans, A. duboisii* and *A. laevis* (Courtney *et al.*, 2010). The vast majority of these species did not require assessment in the Southern Offshore Trawl Region LCA (Fig. 2; Table 4; Data Report: Appendix D).

Research has shown that BRD designs like the Fisheye and a Square Mesh Codend are effective at excluding sea snakes from the trawl catch (Courtney *et al.*, 2010; Dedini *et al.*, 2023; Milton *et al.*, 2009; Queensland Government, 2022). In some instances, the use of these designs combined with a TED can reduce sea snake landing rates by up to 63 per cent (Courtney *et al.,* 2010). These findings have been accounted for in regional management regimes and are proven mitigators of risk for this subgroup. One of the inherent benefits of excluding sea snakes from the trawl catch is that they are more likely to experience a contact without capture event. Contact without capture events are less likely to result in the death of the animal and/or impede their long-term survivability. This was taken into consideration as part of the regional assessment and factored into sea snakes frequently receiving ratings at the lower end of the risk spectrum (Table 4; Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b).

Data compiled through the TEPA logbook indicates that between three and 30 per cent of landed sea snakes die due to drowning or injuries sustained during a trawl fishing event (Dedini *et al.*, 2023; Department of Agriculture and Fisheries, 2023b). Analysis of observer data from the NPF also places sea snake trawl mortality rates between 16 and 25 per cent (Australian Fisheries Management Authority, 2023b; Dedini *et al.*, 2023). Without a mechanism to validate regional TEPA logbook data, it is difficult to determine if mortality rate percentages for the entire ECOTF hold true for the Southern Offshore Trawl Region and/or if they have been influenced by more recent management reforms and declining effort (Table 4; Data Report: Appendix D). From an ERA perspective, this increases assessment uncertainty and requires the adoption of a more precautionary approach.

The level of information on sea snake bycatch in the Southern Offshore Trawl Region will improve with the continued roll-out of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018b;

[32] Courtney *et al.* (2010) noted that the results of the assessment were heavily dependent on the accuracy of the predicted sea snake distributions at that point in time. It was further recognised that "models used to generate the maps had received little scrutiny and it's possible that some of the predicted distributions from the models are poor."

[33] Includes data from the previous Species of Conservation Interest (SOCI) logbook. The TEPA logbook superseded the SOCI logbook in 2021 as part of a broader review of the logbook reporting requirements.

Queensland Government, Undated). Research has also commenced on a project exploring avenues to reduce the impact of the fishery on threatened, endangered and protected species including sea snakes (Fisheries Research and Development Corporation, 2023a). The outputs of these data improvement initiatives may alter the risk profile of this complex and help refine the findings of the Southern Offshore Trawl Region LCA. Depending on the outputs of these programs, there may be a greater need to expand the scope of the regional LCA for this complex and/or to update the risk profiles for *A. mosaicus* and *H. elegans*.

Overall, current fishing activities in the Southern Offshore Trawl Region are expected to pose a comparatively low risk to the sea snake complex (Table 4). As this is the first regional assessment, there are limited avenues to compare the results of this LCA with previous ERAs. The most tangible results being from a previous qualitative ERA examining the risk posed by trawl fishing activities in southern Queensland (Jacobsen *et al.*, 2015). The results of this assessment showed broad similarities with the LCA in that the majority of sea snakes were situated at the lower end of the risk spectrum. While the outputs of the previous ERA were marginally higher, the scope and methodology differed from that used in the LCA. Accordingly, determining risk trends through a direct comparison of the ERA outputs is not recommended.

#### 4.2.4.3 Syngnathids

Risk considerations for the Syngnathidae complex showed less variability across the five trawl management regions. Key risk factors for this group included poor TED/BRD efficiency, limited information on regional catch compositions and an increased potential for *in-situ* mortalities (Dedini *et al.,* 2023). If caught in the sweep of the net, seahorse and pipefish are unlikely to be excluded from the catch via the TED or BRD. Once caught, there is an increased probability that the animal will be landed in a dead or moribund state due to injuries incurred during the trawl fishing event.

Syngnathid catch rates and compositions are not well understood in the Southern Offshore Trawl Region and logbook data provides limited insight into species-specific rates of mortality (Department of Agriculture and Fisheries, 2023b). These limitations reflect broader deficiencies in the amount of available data on trawl-caught syngnathids. One of the challenges of monitoring syngnathid catch rates in a trawl fishery is that that they can be difficult to detect due to their size and cryptic lifestyles. As a consequence, there is an increased probability that a trawl-caught seahorse or pipefish will go undetected within a multi-species trawl catch. This has likely contributed to an underreporting of syngnathid interaction rates in the ECOTF; particularly for non-retainable species.

A review of historical catch locations showed that syngnathid interactions were higher in central and southern Queensland (Connolly *et al.*, 2001; Dodt, 2005). Some of these areas are now located within the Southern Offshore Trawl Region (Dodt, 2005). This report is almost 20 years old and, given the extent of subsequent reforms and effort reductions, will be less applicable to the current fishing environment. It did, however, identify the Duncker's pipehorse (*Solegnathus dunckeri*) and the Pallid pipehorse (*S. hardwickii*) as two of the more abundant species surveyed (Dodt, 2005). These two species are the only syngnathids that can be retained for sale in the ECOTF.[34] The remainder must be discarded as bycatch and their capture recorded in the TEPA logbook (Queensland Government, 2024).

[34] While permitted for retention within the ECOTF, regulations specify that pipefish have a combined trip limit of 50 individuals for each vessel (State of Queensland, 2019).

In the Southern Offshore Trawl Region, the retained component of the Syngnathidae catch will include both *S. hardwickii* and *S. dunckeri* (Table 4; Data Report: Appendix D). This factor was considered as part of the LCA and contributed to *S. hardwickii* and *S. dunckeri* receiving marginally higher risk ratings (Table 4). Quantifying the composition of the remaining catch may be more difficult and will be complicated by uncertainty surrounding the taxonomy and distribution of regional syngnathid species. These deficiencies were discussed at length in the Level 2 ERA report which included recommendations on how these long-term risk areas could be addressed (Dedini *et al.,* 2023).

While not universal, fine-scale habitat preferences are a risk-limiting factor for this subgroup. Many syngnathids are predominantly associated with highly structured habitats such as coral reefs and garden bottoms which are avoided by trawl operations (Kuiter, 2000; Lourie, 2016; Pears *et al.*, 2012b). This helps limit the interaction potential and is one of the reasons why syngnathids are frequently assigned ratings in the low to medium risk categories (Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b). With improved data on Syngnathidae catch rates and locations, a more refined assessment of these risk-limiting factors could be undertaken. For example, research has shown that *S. hardwickii* and *S. dunckeri* are less likely to be caught in waters shallower than 25 m (Connolly *et al.*, 2001). However, it was difficult to determine how applicable these results are to the current fishing environment as there are higher levels of uncertainty surrounding a) total rates of fishing mortality (retained plus discards) and b) catch location coverage (Dedini *et al.*, 2023).

In the Southern Offshore Trawl Region LCA, information on habitat preferences was used in a weight-of-evidence approach to assign some species a lower score for the likelihood component (Table 4; Data Report: Appendix D). This approach considered third party assessments like IUCN Red List extinction risk evaluations and information contained in the Species Profile and Threats Database (Department of Climate Change Energy the Environment and Water, Undated; International Union for Conservation of Nature's Red List of Threatened Species, 2022). Further avenues to refine and improve the risk profiles of this subgroup may evolve with the ongoing roll out of the *Data Validation Plan* and ancillary projects examining the impact of trawl fishing on non-target species (Department of Agriculture and Fisheries, 2018b; Fisheries Research and Development Corporation, 2023a; Queensland Government, Undated).

#### 4.2.4.4 Sharks

The Southern Offshore Trawl Region LCA had the largest shark representation and included species that interact with different components of the fishery. For the three catsharks (*Asymbolus pallidus*, *A. analis* and *A. rubiginosus*), eastern angelshark (*Squatina albipunctata*) and piked spurdog (*Squalus megalops*), interactions will be largely confined to deep-water trawl operations such as those targeting eastern king prawns (*Melicertus plebejus*) in Offshore Trawl Region A (Ebert *et al.*, 2021; Kyne *et al.*, 2021; Last & Stevens, 2009). Conversely, species like the collared carpetshark (*Parascyllium collare*), zebra shark (*Stegostoma tigrinum*), brownbanded bambooshark (*Chiloscyllium punctatum*) and crested hornshark (*Heterodontus galeatus*) are more abundant in shallow-water environments and interactions are most likely to occur in Offshore Trawl Region B (Ebert *et al.*, 2021; Kyne *et al.*, 2021; Last & Stevens, 2009).

The depth profiles of the deepwater species have considerable range and, in most instances, exceed the maximum operating capacity of the ECOTF. For example, maximum depth ranges for the three *Asymbolus* species extend from 200 m to 540 m, with *S. albipunctata* and *S. megalops* reported in waters down to 415 m and 732 m respectively (Ebert *et al.*, 2021; Kyne *et al.*, 2021). This preference

for deeper-water environments provides regional populations with a high degree of natural protection from trawl fishing activities. With that said, research has shown that *S. megalops, A. pallidus* and *S. albipunctata* make up a notable proportion of the elasmobranch bycatch in Offshore Trawl Region A (Rigby, 2015; Rigby *et al.*, 2016b). As the *A. analis* and *A. rubiginosus* distribution does not extend beyond K'gari (formerly Fraser Island), interactions with these two species will be confined to Offshore Trawl Region B (Courtney *et al.*, 2007; Kyne, 2008; Kyne *et al.*, 2021).

The life-history of many deepwater shark species (e.g. slower rates of growth, long-lived, low fecundity and delayed onset of sexual maturity) makes them more vulnerable to trawl fishing activities (Dedini *et al.*, 2023; Kyne *et al.*, 2021; Rigby, 2015; Rigby *et al.*, 2016b). While noting these vulnerabilities, the available evidence suggests that fishing-related risks for the *Asymbolus* species are being managed within the current fishing environment. Extinction risk assessments for *A. pallidus*, *A. analis*, and *A. rubiginosus* classified all three as Least Concern with corresponding status assessments determining that these species are being sustainably fished across their known distributions (Kyne *et al.*, 2021; Kyne *et al.*, 2023c; j; m).[35] These findings were given considerable weighting in the LCA and contributed to the species being assigned lower risk scores for the Southern Offshore Trawl Region LCA (Table 4; Data Report: Appendix D).

The situation surrounding *S. megalops* and *S. albipunctata* is more complicated and both received more precautionary risk ratings (Table 4). *Squalus megalops*, as with other deepwater species, has an extinction risk classification of Least Concern and a status assessment of Sustainable (Kyne *et al.*, 2021; Kyne *et al.*, 2023n). However, *S. megalops* was also identified as a high-risk species in a quantitative ERA examining trawl-related risks in southern Queensland (Campbell *et al.*, 2017).[36] This study incorporated areas now encompassed within the Southern Offshore Trawl Region and identified life-history constraints and trawl effort exposure as two of the key risk areas (Campbell *et al.*, 2017). These results were taken into consideration as part of the LCA and contributed to *S. megalops* receiving a medium-risk rating within the current fishing environment (Data Report: Appendix D).

The risk profile of *S. albipunctata* differed slightly in that Campbell *et al.* (2017) assigned this species a low-risk rating in southern Queensland. However, *S. albipunctata* has been assessed as Vulnerable under the IUCN Red List criteria and evidence suggests that populations on the Australian east coast are in decline (Kyne *et al.*, 2021; Kyne *et al.*, 2023d). A closer inspection of the status evaluation revealed that the key sources of fishing mortality for *S. albipunctata* are located further south in New South Wales and in the Commonwealth-managed Southern and Eastern Scalefish and Shark Fishery (Kyne *et al.*, 2021; Kyne *et al.*, 2023d). Fishing mortality rates for this species are expected to be lower in Queensland which represents the northern extent of its range.

For *S. albipunctata*, the Southern Offshore Trawl Region will be a contributor of risk *versus* the main driver of risk (Kyne *et al.*, 2023d; Pogonoski *et al.*, 2016). At present, it is difficult to determine how extensively this species interacts with regional operations and/or the extent of any trawl-related mortalities. This makes it difficult to assess how regional fishing activities contribute to the broader vulnerabilities of this species. For this reason, *S. albipunctata* was assigned a more precautionary risk

[35] Status assessments compiled as part of the *Shark and Ray Report Card* consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

[36] The risk assessment used the Sustainability Assessment for Fishing Effects (SAFE) method (Campbell *et al.*, 2017). SAFE is a fully quantitative risk assessment method and has been found to produce fewer false positives when compared to semi-quantitative assessments like the Productivity and Susceptibility Analysis (Zhou & Griffiths, 2008; Zhou *et al.*, 2016).

score for the Southern Offshore Trawl Region (Table 4; Data Report: Appendix D). With improved information on regional catch rates and release fates, it is conceivable that the risk rating assigned to this species could be refined and potentially reduced. It is further recognised that fishing pressures for this species will be higher in New South Wales and commonwealth-managed fisheries (Kyne *et al.*, 2023d).

Of the remaining species, the most notable risks relate to the Colclough's shark (*Brachaelurus colcloughi*) and its potential to interact with trawl fishers in southern Queensland. *Brachaelurus colcloughi* is a rare, endemic species and it is likely to occur at a naturally low abundance. Information sets for *B. colcloughi* are less developed and datasets for this species are based on fewer than 80 individuals (Kyne *et al.*, 2011; Kyne *et al.*, 2021). There remains considerable uncertainty surrounding the distribution of *B. colcloughi* and its capacity to interact with the ECOTF. However, the species is found in water depths from 4 to 417 m with specimens reported as far north as Swains Reef National Park and Flock Pigeon Island (Jacobsen, 2007; Kyne *et al.*, 2023l; Rigby *et al.*, 2016b).

On the Queensland east coast, the available evidence indicates that *B. colcloughi* are more likely to interact with the Southern Inshore, Southern Offshore and (potentially) Moreton Bay Trawl Regions (Kyne *et al.*, 2015; Kyne *et al.*, 2021; Kyne *et al.*, 2023l). It is difficult to ascertain how frequently *B. colcloughi* interacts with regional trawl operations or provide an accurate assessment of fishing mortality rates. Further, *B. colcloughi* interactions are not reported through the TEPA logbook and the ECOTF does not have an effective mechanism in place to monitor interaction rates for bycatch species.[37]

Of note, *B. colcloughi* was classified as a low-risk species in a previous ERA examining trawl-related risks in southern Queensland (Campbell *et al.*, 2017). This assessment was compiled using the Sustainability Assessment for Fishing Effects (SAFE) and considered a large proportion of the *B. colcloughi* range. While noting these results, there are broader concerns surrounding the long-term viability of *B. colcloughi* populations on the Queensland east coast. For example, the species registered an extinction risk classification of Vulnerable under the IUCN Red List criteria with the assessment noting a downward population trend (Kyne *et al.*, 2015; Kyne *et al.*, 2021). These results did not translate directly to the *Shark and Ray Report Card* where data deficiencies made it more difficult to define a stock status (pers. comm. I. Jacobsen; Kyne *et al.*, 2023l).[38]

In the Southern Offshore Trawl Region LCA, it was determined that there was sufficient evidence to assign *B. colcloughi* with a more precautionary risk rating (Table 4; Data Report: Appendix D). There remains a high level of uncertainty surrounding this species and there is an increased risk that regional fishing activities will have a negative, long-term impact on regional populations. This risk is elevated by an absence of information on interaction rates in the ECOTF and the (overall) limited understanding of how this species survives a trawl interaction. This situation is expected to improve with the continued rollout of the *Data Validation Plan* and ancillary research examining the

[37] Independent data validation is an integral component of the "Improved monitoring and research" foundational reform outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018b). A trial of independent data validation in the ECOTF is well advanced. However, data validation has yet to be fully implemented across the ECOTF. More information on the mechanisms being used to address the long-term data validation risk has been provided in the Level 2 ERA (Dedini *et al*., 2023).

[38] The first iteration of the *Shark Report Card* initially classified this species status as Depleted. These status assessments are compiled as part of the *Shark and Ray Report Card* and consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

composition of the ECOTF catch (Department of Agriculture and Fisheries, 2018b; 2023a; Fisheries Research and Development Corporation, 2023a).

Risk classifications for the remaining shark species are lower and largely relate to Offshore Trawl Region B (Department of Agriculture and Fisheries, 2021c). The biology of *C. punctatum*, *P. collare*, *H. galeatus*, *S. tigrinum* and the Australian weasel shark (*Hemigaleus australiensis*) increase their overall vulnerability to trawl fishing activities (Dedini *et al.*, 2023). However, the available evidence indicates that fishing-related risks are being managed within the current fishing environment. All five have extinction risk classifications of Least Concern (Kyne *et al.*, 2021) and complementary analyses have determined that they are being fished sustainably across their known distributions (Kyne *et al.*, 2023b; Kyne *et al.*, 2023f; h; i; k).[39] These findings suggest that there is a lower risk of these species experiencing an undesirable event due to activities within the Southern Offshore Trawl Region.

While difficult to quantify without direct validation, expectations are that *C. punctatum* will be among the more frequently observed sharks in this region. Anecdotal evidence suggests that post-interaction survival rates for this species, along with *H. galeatus* and *S. tigrinum*, are relatively high (Braccini *et al.*, 2012; Kyne *et al.*, 2021). It is further hypothesised that *P. collare* will display a similar level of resilience. These inferences though require further testing and would benefit from additional information on the composition and release fate of sharks caught as bycatch in the Southern Offshore Trawl Region.

#### 4.2.4.5 Batoids

Research has shown that prawn trawl operations will interact with a diverse array of benthic batoids (Courtney *et al.*, 2007; Jacobsen, 2007; Kyne, 2008; Kyne *et al.*, 2021; Salini *et al.*, 2007; Stobutzki *et al.*, 2001; White *et al.*, 2019). While noting this diversity, only 22 batoids were considered for inclusion in the regional risk assessments (Table 4). The remaining species were excluded from the analysis through a detailed species rationalisation process conducted as part of the Level 2 ERA (Dedini *et al.*, 2023). The Level 2 ERA provides a full account of this process including the justifications used to include or omit a species from the analysis (Appendix A and B of Dedini *et al.*, 2023).

Of the 22 batoids considered, 20 were assessed as part of the Southern Offshore Trawl Region LCA (Fig. 2; Table 4). This region had the highest number of batoid assessments with the key difference being the inclusion of six stingarees (*Urolophus* spp., *Trygonoptera testacea*) and three skates (*Dentiraja* spp.; Fig. 2; Table 4). The eyebrow wedgefish (*Rhynchobatus australiae*) and the narrow sawfish (*Anoxypristis cuspidata*) were excluded from the analysis as their distribution does not include this management region (Table 4; Kyne *et al.*, 2021; Last *et al.*, 2016).

At least six stingarees have been confirmed as bycatch in the ECOTF: the yellowback stingaree (*Urolophus sufflavus*), sandyback stingaree (*U. bucculentus*), kapala stingaree (*U. kapalensis*), Coral Sea stingaree (*U. piperatus*), patchwork stingaree (*U. flavomosaicus*) and the common stingaree (*Trygonoptera testacea*; Campbell *et al.*, 2017; Courtney *et al.*, 2007; Kyne, 2008; Pears *et al.*, 2012b; Rigby *et al.*, 2016b). While bycatch surveys have yet to record a greenback stingaree (*U. viridis*) within the ECOTF, the distribution of this species shares similarities with *U. kapalensis* and *U. bucculentus* (Kyne *et al.*, 2021; Last *et al.*, 2016). Given the prevalence of these two species in elasmobranch trawl bycatch, it is conceivable that *U. viridis* also interacts with southern Queensland trawl operations.

[39] Stock status assessments are compiled as part of the *Shark and Ray Report Card* and consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

Accordingly, this species was included in the assessment as a precautionary measure (Data Report: Appendix D).

All of the assessed stingarees are endemic species and have restricted ranges on the Australian east coast (Kyne *et al.*, 2021). Most Australian stingarees (Family Urolophidae) are temperate-water species with restricted distributions within Queensland waters. This limits their interaction potential and suggests that the ECOTF will be a contributor of risk *versus* the main driver of risk for this complex. For example, northern range limits for *U. sufflavus*, *U. bucculentus*, *U. kapalensis*, *U. viridis* and *T. testacea* do not extend beyond K'gari (formerly Fraser Island; Kyne *et al.*, 2021; Last *et al.*, 2016). Interactions with these species (if applicable) will be confined to Southern Offshore Trawl Region B (Department of Agriculture and Fisheries, 2021c).

The situation surrounding *U. flavomosaicus* differs in that the distribution of this species extends into tropical waters. While *U. flavomosaicus* has been reported as bycatch in the ECOTF, the outputs of a deepwater bycatch survey indicates that these records were most likely *U. bucculentus* (Rigby *et al.*, 2016b). This report also recorded the capture of *U. piperatus* in this sector of the ECOTF. In the current assessment, *U. bucculentus* and *U. flavomosaicus* were included in the LCA based on depth profiles and descriptions provided in the *Action Plan for Australian Sharks and Rays* (Kyne *et al.*, 2021). Conversely, *U. piperatus* was not included in the regional assessments as its depth profile was considered a limiting factor in terms of the number of interactions (Dedini *et al.*, 2023). This decision may need to be reviewed if, for example, information compiled through the *Data Validation Plan* indicates that this species interacts more prevalently with the ECOTF.

The stingaree complex were assigned marginally higher ratings with four assessed as a low-medium risk and two a medium risk (Table 4). The impact of regional trawl fishing activities will vary and may be more pronounced in species with greater conservation concerns. For example third-party assessments have documented an inferred population decline for *U. sufflavus*¸ *U. bucculentus* and *U. viridis* (Kyne *et al.*, 2021; Kyne *et al.*, 2023ab; e; f). For these species, mortalities resulting from ECOTF activities have the potential to contribute to a decline in the broader health of regional populations. It is difficult to assess the extent of this (potential) contribution, as there is limited information on regional stingaree catch compositions, interaction rates, landing/release fates and ancillary impacts e.g. capture-induced parturition / aborted embryos (Adams *et al.*, 2018; de Sousa Rangel *et al.*, 2020).

Of note, all six stingaree species were included in a quantitative ERA examining trawl related risks in southern Queensland (Campbell *et al.*, 2017).[40] This study incorporated areas now encompassed within the Southern Offshore Trawl Region and assigned each species with a rating of low or medium (Campbell *et al.*, 2017). As the scope and methodology of the two assessments differed, direct comparisons of species-specific risk ratings (e.g. to infer risk trends) is not recommended. The results of both assessments though support a more generalised hypothesis that trawl fishing activities in this region currently pose a low to medium risk to this subgroup.

In addition to the stingaree species, three deepwater skate species were included in the Southern Offshore Trawl Region LCA: the Argus skate (*Dentiraja polyommata*), endeavour skate (*D.*

[40] This risk assessment used the Sustainability Assessment for Fishing Effects (SAFE) method (Campbell *et al.*, 2017). SAFE is a fully quantitative risk assessment method and has been found to produce fewer false positives when compared to semi-quantitative assessments like the Productivity and Susceptibility Analysis (Zhou & Griffiths, 2008; Zhou *et al.*, 2016).

*endeavouri*) and Sydney skate (*D. australis*). The depth profiles of *D. polyommata* (135–400 m) and *D. endeavouri* (110–370 m) will confine trawl interactions to the deepwater eastern king prawn sector (Courtney *et al.*, 2007; Kyne *et al.*, 2021; Rigby, 2015; Rigby *et al.*, 2016b). As *D. australis* has a broader depth profile (20–325 m), it may be encountered across a more diverse range of trawl operations. While lacking data, expectations are that all three have poor post-release survival rates and high on-deck mortalities (Kyne *et al.*, 2021).

The available data suggests that *D. polyommata* makes up a more notable portion of elasmobranch bycatch in Offshore Trawl Region A (Courtney *et al.*, 2007; Kyne, 2008; Rigby *et al.*, 2016b). This was reflected in the outputs of the LCA where *D. polyommata* was assigned a marginally higher risk rating. As this species is afforded a degree of natural protection (Kyne *et al.*, 2021), this rating may overestimate the risk posed to this species within the Southern Offshore Trawl Region. However, the adoption of a more precautionary approach was supported due to uncertainty surrounding catch rates, a heightened mortality risk and increased (regional) interaction potential. With improved information on regional skate bycatch compositions, the risk profile for this species could be refined and the rating potentially reduced.

The situation surrounding *D. endeavouri* and *D. australis* requires further investigations. Both species have similar distributions and interactions will be confined to operators fishing in Offshore Trawl Region B. However, the available information provides limited insight into the susceptibility of these species to regional trawl fishing activities. For example, it is unclear if both *D. endeavouri* and *D. australis* are regularly caught in the ECOTF and/or if one species makes a disproportionate contribution to elasmobranch bycatch. While noting these deficiencies, third-party assessments suggest that trawl fishing poses a greater risk to *D. endeavouri*. This species has been assessed as Near Threatened under the IUCN Red List criteria with a depleting population trend (Kyne *et al.*, 2023t; Rigby & Derrick, 2021a). *Dentiraja australis* has similar conservation concerns, although an observed population recovery has seen the status of this species improve from Vulnerable (Kyne *et al.*, 2021) to Near Threatened (Kyne *et al.*, 2023g).

The majority of the remaining species were classified as a low or low-medium risk within the Southern Offshore Trawl Region (Table 4). These species have higher biological vulnerabilities and trawl fishing activities have the potential to impact regional populations (Dedini *et al.,* 2023). While noting these vulnerabilities, the listed species have fewer sustainability concerns and are expected to be in high abundance within their preferred habitats (Kyne *et al.*, 2021; Last *et al.*, 2016). This has seen the majority of the species assigned an extinction risk classification of Least Concern and assessed as Sustainable across their known distributions (Fisheries Research and Development Corporation, 2023b; Kyne *et al.*, 2021).[41] For most of these species, a weight-of-evidence approach suggests that fishing-related risks are being managed within the current fishing environment.

As with the shark complex, there are a couple of notable exceptions such as the estuary stingray (*Hemitrygon fluviorum*) and the green sawfish (*Pristis zijsron*). In the Southern Offshore Trawl Region LCA, *H. fluviorum* was assigned a low-risk rating (Table 4). While noting this assessment, commercial fishing, recreational fishing and habitat degradation have been identified as key threats for this species. To this extent, regional trawl operations have the potential to contribute to a broader, cumulative risk. Determining the significance of this contribution (negligible, low, low-medium, medium

[41] Stock status assessments are compiled as part of the *Shark and Ray Report Card* and consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

or high) will require further information on the regional batoid bycatch compositions. In this region of the ECOTF, *H. fluviorum* interactions will be confined to Offshore Trawl Region B as the species prefers shallow-water environments (0–28 m) and mangrove-lined rivers, estuaries and embayments (Department of Agriculture and Fisheries, 2021c; Last *et al.*, 2016).

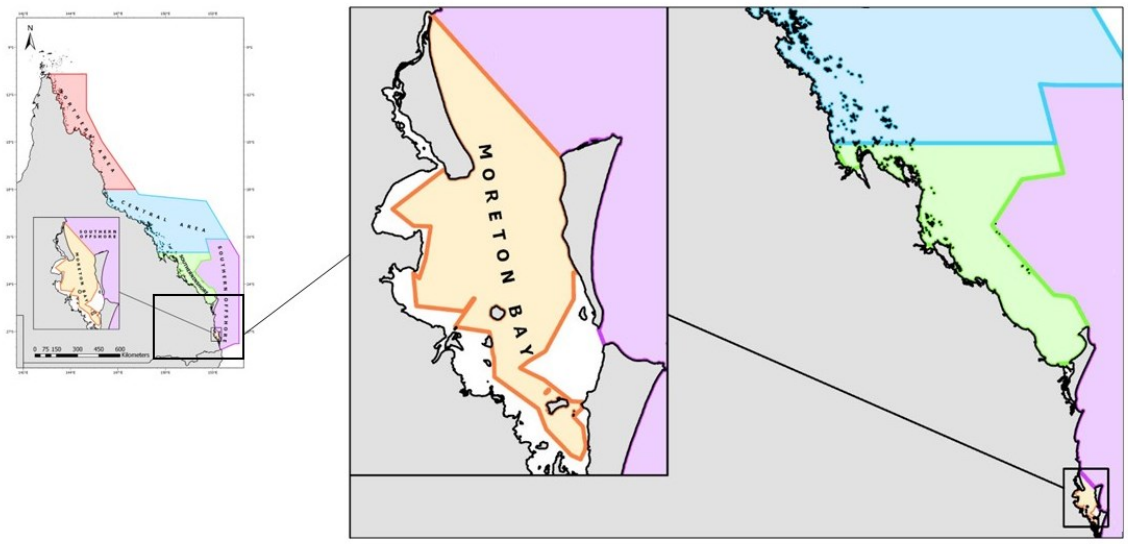
The situation with *P. zijsron* is more complicated as the species is the subject of more significant conservation concerns. *Pristis zijsron*, as with *H. fluviorum*, has experienced range contractions and population declines on the Queensland east coast. These declines/contractions though are more significant and *P. zijsron* may now be regionally extirpated in waters south of the Whitsundays (Department of the Environment, 2019). The species is considered Critically Endangered under the IUCN Red List criteria with complementary analyses assessing the stock status as Depleted (Kyne *et al.*, 2021; Kyne *et al.*, 2023aa). While *P. zijsron* is currently listed as Vulnerable under the EPBC Act, the *Action Plan for Australian Sharks and Rays* recommends that this classification be elevated to Critically Endangered (Kyne *et al.,* 2021).

Range contractions suggest that there is a low probability of *P. zijsron* interacting with operators in the Southern Offshore Trawl Region. This low interaction potential is in direct response to a decline in population health and the impact of cumulative pressures or threats including historic commercial fishing activities. This is an important distinction to make when comparing *P. zijsron* with other batoids whose habitat and depth profiles limit their exposure to trawl fishing. In the Southern Offshore Trawl Region, any interaction (if applicable) will be with a remnant population and may have significant, long-term implications for *P. zijsron*. Given the extent of historic populations declines, this will occur at low levels of fishing mortality and may result in further range contractions, reduced genetic diversity and further fragmentation of regional populations. These concerns were ultimately reflected in the risk rating assigned to *P. zijsron* in the Southern Offshore Trawl Region LCA (Table 4).

For most species included in this assessment, fishing activities in the Southern Offshore Trawl Region will pose a low risk. The inherent challenge being that there are (currently) limited avenues to document bycatch compositions in the ECOTF.[42] These deficiencies and limitations were discussed at length in the Level 2 ERA and resulted in a number of species being included in the LCA as a precautionary measure. The level of information on batoid bycatch compositions will improve with the continued roll-out of the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018b; Queensland Government, Undated). Research has also commenced on a project exploring avenues to reduce the impact of the fishery on threatened, endangered and protected species including sea snakes (Fisheries Research and Development Corporation, 2023a). The outputs of these data improvement initiatives will help refine the Southern Offshore Trawl Region LCA and the risk profiles of individual species.

[42] Independent data validation is an integral component of the “Improved monitoring and research” foundational reform outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018b). A trial of independent data validation in the ECOTF is well advanced. However, data validation has yet to be fully implemented across the ECOTF. More information on the mechanisms being used to address the long-term data validation risk has been provided in the Level 2 ERA (Dedini *et al.*, 2023).

### 4.2.5 Moreton Bay Trawl Region




The Moreton Bay Trawl Region has the smallest harvest area of the ECOTF. Operators fish exclusively within the Moreton Bay Marine Park and any expansion of the trawl effort footprint is limited by provisions governing the use of marine resources within this area (Department of Agriculture and Fisheries, 2021f; Department of Environment and Science, 2020b). Under these provisions, trawling is not permitted in any designated Marine National Park (Green) Zone (16 per cent), Conservation Park (Yellow) Zone (eight per cent) or Habitat Protection (Dark Blue) Zone (30 per cent). Conversely, trawling is only permitted in General Use (Light Blue) Zones which constitutes around 46 per cent of the marine park. However, not all areas within the General Use Zone are suitable for trawl fishing or are actively fished by regional operations (Department of Agriculture and Fisheries, 2021f; 2022a; 2023b). These constraints had a direct bearing on the scope of the Moreton Bay Trawl Region LCA.

Of the 62 species considered for assessment, 30 had distributions that overlapped with the Moreton Bay Trawl Region (Department of Agriculture and Fisheries, 2021f). The LCA included all six marine turtles, seven syngnathids, six sharks, 10 batoids and a single sea snake species (Fig. 2; Table 4). More than half of the species (*n* = 32, or 52 per cent) had distributions or depth profiles that negated or significantly reduced their interaction potential in this region. These species were excluded from the Moreton Bay Trawl Region LCA and assigned a ‘Not Assessed’ classification (Fig. 3; Table 4).

The vast majority of species included in this assessment registered risk ratings of low (*n* = 10) or low-medium (*n* = 15). Four species were classified as a medium risk (two syngnathids, one shark and one batoid), with the Colclough’s shark (*Brachaelurus colcloughi*) registering the only high-risk rating in the Moreton Bay Trawl Region LCA (Table 4). While not universal, ongoing conservation concerns, an increased interaction potential and uncertainty surrounding interaction rates and release fates were identified as the key contributors of risk.

#### 4.2.5.1 Marine Turtles

Moreton Bay Marine Park is considered an area of high conservation significance for the marine turtle complex. The region supports a comparatively large (collective) marine turtle population and six of the

world's seven species have been reported from this region (Fig. 2; Table 4). At least five of the marine turtles included in this LCA are considered 'resident' species and are observed in this region with more frequency: the green turtle (*Chelonia mydas*), loggerhead turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*), flatback turtle (*Natator depressus*) and the olive ridley turtle (*Lepidochelys olivacea*; Department of Environment Science and Innovation, 2021; Limpus, 2007a; b; 2008a; b; c; 2009).

Datasets for the leatherback turtle (*Dermochelys coriacea*) shows that the life-history of this species has a stronger correlation with pelagic-water environments (Department of the Environment, 2023a; Department of the Environment and Energy, 2017; Eckert *et al.*, 2012; Limpus, 2009). These life-history traits make interactions with this species less likely in the Moreton Bay Trawl Region. This species though has been reported from Moreton Bay and a small number of *D. coriacea* interactions have been reported across the broader ECOTF (Department of Agriculture and Fisheries, 2023b). These interactions combined with uncertainty surrounding the accuracy of data compiled through the Threatened, Endangered and Protected Animals (TEPA) logbook (Dedini *et al.*, 2023), supported the inclusion of *D. coriacea* in the Moreton Bay Trawl Region LCA. With improved information on regional turtle interaction rates and compositions, this species could potentially be removed from future risk assessments involving this region.

Of the remaining species, operators in the Moreton Bay Trawl Region are more likely to interact with *C. mydas*. Moreton Bay supports a strong *C. mydas* population and the region provides important feeding grounds for immature and adult turtles (Limpus, 2008c). Similarly, Moreton Bay Marine Park has been identified as one of the most important feeding areas for *C. caretta* (Department of Environment Science and Innovation, 2021). While the major *C. mydas* and *C. caretta* rookeries and nesting sites occur outside of Moreton Bay, the life-history and feeding behaviours of both species will bring them into areas that are actively fished (Department of Environment Science and Innovation, 2021; Department of the Environment, 2023b; c; Limpus, 2008b; c).

Interactions with the remaining three species are expected to be lower. While *L. olivacea*, *N. depressus* and *E. imbricata* have been recorded in the marine park, major nesting sites, rookeries and (if applicable) migratory routes are situated further north (Limpus, 2007a; b; 2008a). Stock dispersal records for all three species also suggests that they are less likely to occur in Moreton Bay. This is of particular relevance to *L. olivacea* which are more commonly encountered in tropical waters of northern Australia (Department of the Environment and Energy, 2017; Limpus, 2008a). When compared, the interaction potential for these three species will be higher in the Northern and Central Trawl Regions (Department of Agriculture and Fisheries, 2021b; d).

Across the complex, the use of a Turtle Excluder Device (TED) contributed to the marine turtle complex receiving ratings at the lower end of the risk spectrum (Table 4; Data Report: Appendix E) . The use of a TED remains a pivotal component of the broader ECOTF management regime and it is arguably the most effective risk-mitigation strategy employed for this subgroup. Research has shown that the combined use of a TED, with a Bycatch Reduction Device (BRD), can reduce landing rates for marine turtles by 97–99 per cent (Brewer *et al.*, 2006; Campbell *et al.*, 2020; Department of Agriculture and Fisheries, 2012; National Oceanic and Atmospheric Administration Fisheries, 2021). While similar turtle exclusion rates could be expected in the Moreton Bay Trawl Region, further information is required on the effectiveness of TEDs at a species, regional and whole-of-fishery level.

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 (Business Queensland, 2022; Department of Agriculture and Fisheries, 2012). 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 (e.g. internal and external injuries incurred during the net retrieval/landing process and/or being crushed by the weight of the catch). When a marine turtle is caught within the sweep of the net, the majority will experience a contact without capture event (Brewer *et al.,* 2006; Campbell *et al.,* 2020; Dedini *et al.,* 2023). These types of events are less likely to result in significant injuries and pose a lower long-term risk to the effected individual. These benefits were reflected in the outputs of this assessment and previous ERAs where the use of a TED, combined with declining effort levels, contributed to the complex receiving lower risk ratings (Table 4; Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b).

More broadly, the marine turtle complex will be afforded considerable protection through a range of legislative instruments. For example, most nesting sites situated on the Queensland east coast occur in habitats now protected under marine parks legislation or the Queensland *Nature Conservation Act 1992* (Limpus, 2007a; b; 2008a; b; c; 2009). Given the area of operation, this complex will derive considerable benefit from provisions governing the use of marine resources within the Moreton Bay Marine Park (Department of Environment and Science, 2020b; Department of National Parks Sport and Racing, 2015). These closures limit the exposure of this complex to regional trawl fishing activities and minimise the interaction risk in waters where marine turtles are found in higher abundances (e.g. key feeding and foraging grounds). When compared, marine turtles inhabiting Moreton Bay are more likely to experience injury or death as a result of boat strike which presents as a much larger and more significant risk (Biddle & Limpus, 2011; Department of Environment and Science, 2022; Greenland & Limpus, 2003; 2004; Greenland *et al.*, 2002; Haines *et al.*, 1999; Meager & Limpus, 2012).

Data compiled through the TEPA logbook contains fewer than 100 marine turtle interactions across the entire ECOTF (2006–2021 data; Department of Agriculture and Fisheries, 2023b).[43] The veracity of this data has yet to be fully tested as the ECOTF does not currently operate with an effective mechanism to validate regional bycatch compositions, interaction rates or release fates.[44] This creates uncertainty surrounding the accuracy of marine turtle interaction-rate data and increases the risk of non-compliance and under-reporting. At the time of this assessment, marine turtle interaction rates could not be confirmed for the Moreton Bay Trawl Region.

The inability to validate TEPA logbook data increases the level of uncertainty surrounding the extent of marine turtle interactions in the Moreton Bay Trawl Region. Cross comparisons with analogous fisheries though lend support to the hypothesis that marine turtle interactions are under-reported across the entire ECOTF. For example, the Northern Prawn Fishery (NPF) observer program recorded 525 marine turtle interactions between 2018 and 2022 inclusive (Australian Fisheries Management

[43] Includes data from the previous Species of Conservation Interest (SOCI) logbook. The TEPA logbook superseded the SOCI logbook in 2021 as part of a broader review of the logbook reporting requirements.

[44] Independent data validation is an integral component of the “Improved monitoring and research” foundational reform outlined in the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2018b). A trial of independent data validation in the ECOTF is well advanced. However, data validation has yet to be fully implemented across the ECOTF. More information on the mechanisms being used to address the long-term data validation risk has been provided in the Level 2 ERA (Dedini *et al.*, 2023).

Authority, 2023b).[45] Over this same period, the entire ECOTF reported 35 marine turtle interactions through the TEPA logbook (Department of Agriculture and Fisheries, 2023b). 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 (Department of Agriculture and Fisheries, 2023b; Patterson *et al.*, 2022). This uncertainty was a key consideration in the current assessment and was influential in terms of the number of species included in the Moreton Bay Trawl Region LCA (Table 4).

With the ongoing rollout of the *Data Validation Plan*, expectations are that the level of information on marine turtle interactions will improve across the ECOTF and within each of the five management regions (Department of Agriculture and Fisheries, 2018b; 2023a; Queensland Government, Undated). The outputs of this program may be the key determinant in terms of the need to update the LCA for this complex within the Morton Bay Trawl Region.

#### 4.2.5.2 Sea Snakes

The spatial extent of the Moreton Bay Trawl Region was the key determinant in terms of the number of sea snakes assessed. Of the 13 species considered for inclusion, only the elegant sea snake (*Hydrophis elegans*) was progressed to the final LCA (Fig. 2; Table 4). This species was the only sea snake identified from regional trawl bycatch research surveys and it has confirmed occurrence and trawl bycatch records along the Queensland east coast (Courtney *et al.*, 2010; Udyawer *et al.*, 2020). One other species, the mosaic sea snake (*Aipysurus mosaicus*), was considered for inclusion in the Moreton Bay Trawl Region LCA but was omitted from the analysis as a low-risk element (Table 4; Data Report: Appendix E). The need to subject *A. mosaicus* and other sea snakes to a more detailed regional risk assessment will be reviewed with the provision of any new, additional information.

*Hydrophis elegans* is one of the largest Australian sea snakes and research indicates that the distribution of this species has a moderate to high overlap with the ECOTF effort footprint (Courtney *et al.*, 2010). While *H. elegans* is commonly found in soft-sediment habitats below 30 m, research has shown that the species will be caught in trawl depths greater than 100 m (Courtney *et al.*, 2010; Milton, 2010). As a larger sea snake, *H. elegans* may be more susceptible to trawl-related injuries and, by extension, experience higher post-trawl mortalities (Courtney *et al.*, 2010). This problem is potentially compounded by the fact that *H. elegans* has a low rate of natural mortality and may be more prone to overfishing (Milton, 2010; Milton *et al.*, 2007).

*Hydrophis elegans* was assigned a low-risk rating in the Moreton Bay Trawl Region (Table 4) and regional operations are unlikely to pose a significant, long-term risk when considered in isolation. Trawl operations in this region though will contribute to the cumulative risk posed to this species across the broader ECOTF (Dedini *et al.*, 2023).

#### 4.2.5.3 Syngnathids

Risk considerations for the Syngnathidae complex showed less variability across the five trawl management regions. Key risk factors for this group included poor TED/BRD efficiency, limited information on regional catch compositions and an increased potential for *in-situ* mortalities (Dedini *et al.,* 2023). If caught in the sweep of the net, seahorse and pipefish are unlikely to be excluded from the

[45] The NPF operates in northern Australia, has Marine Stewardship Council (MSC) certification and has a multi-faceted catch validation program that includes crew member observers and scientific observers (Australian Fisheries Management Authority, 2023a; Marine Stewardship Council, 2023).

catch via the TED or BRD. Once caught, there is an increased probability that the animal will be landed in a dead or moribund state due to injuries incurred during the trawl fishing event.

Syngnathid catch rates and compositions are not well understood in the Moreton Bay Trawl Region and logbook data provides limited insight into regional rates of fishing mortality (Department of Agriculture and Fisheries, 2023b). These limitations reflect broader deficiencies in the amount of available data on trawl-caught syngnathids. One of the challenges of monitoring syngnathid catch rates in a trawl fishery is that that they can be difficult to detect due to their size and cryptic lifestyles. As a consequence, there is an increased probability that a trawl-caught seahorse or pipefish will go undetected within a multi-species trawl catch. This has likely contributed to an underreporting of syngnathid interaction rates in the ECOTF; particularly for non-retainable species.

A review of historical catch locations showed that syngnathid interactions were higher in central and southern Queensland, including Moreton Bay (Connolly *et al.*, 2001; Dodt, 2005). This report is almost 20 years old and, given the extent of subsequent reforms and effort reductions, will be less applicable to the current fishing environment. It did, however, identify the Duncker's pipehorse (*Solegnathus dunckeri*) and the Pallid pipehorse (*S. hardwickii*) as two of the more abundant species surveyed (Dodt, 2005). These two species are the only syngnathids that can be retained for sale in the ECOTF.[46] The remainder must be discarded as bycatch and their capture recorded in the TEPA logbook (Queensland Government, 2024).

In the Moreton Bay Trawl Region, the retained component of the Syngnathidae catch will include both *S. hardwickii* and *S. dunckeri* (Table 4; Data Report: Appendix E). This factor was considered as part of the LCA and contributed to *S. hardwickii* and *S. dunckeri* receiving marginally higher risk ratings (Table 4). Quantifying the composition of the remaining catch may be more difficult and will be complicated by uncertainty surrounding the taxonomy and distribution of regional syngnathid species**.** These deficiencies were discussed at length in the Level 2 ERA report which included recommendations on how these long-term risk areas could be addressed (Dedini *et al.,* 2023).

While not universal, fine-scale habitat preferences are a risk-limiting factor for this subgroup. Many syngnathids are predominantly associated with highly structured habitats such as coral reefs and garden bottoms which are avoided by trawl operations (Kuiter, 2000; Lourie, 2016; Pears *et al.*, 2012b). This helps limit the interaction potential and is one of the reasons why syngnathids are frequently assigned ratings in the low to medium risk categories (Dedini *et al.*, 2023; Jacobsen *et al.*, 2015; Pears *et al.*, 2012b). In this assessment, habitat preference information was used in a weight-of-evidence approach to assign several species lower risk scores (Table 4; Data Report: Appendix E). This approach considered additional protections provided to this subgroup through the *Moreton Bay Marine Park Zoning Plan*, third party assessments (i.e. IUCN Red List extinction risk evaluations) and information contained in the Species Profile and Threats Database (Department of Climate Change Energy the Environment and Water, Undated; International Union for Conservation of Nature's Red List of Threatened Species, 2022).[47]

[46] While permitted for retention within the ECOTF, regulations specify that pipefish have a combined trip limit of 50 individuals for each vessel (State of Queensland, 2019).

[47] The *Moreton Bay Marine Park Zoning Plan* does not contain syngnathid-specific closures or fisheries-protection measures. However, the plan will afford protection to structured habitats preferred by these species including rocky reef assemblages, seagrass beds and coral reef systems (Department of Environment and Science, 2020b; Department of Environment Science and Innovation, 2015).

With improved data on Syngnathidae catch rates and locations, a more refined assessment of the Syngnathidae risk-limiting factors could be undertaken. For example, research has shown that *S. hardwickii* and *S. dunckeri* are less likely to be caught in waters shallower than 25 m (Connolly *et al.*, 2001). In the current assessment, it was difficult to determine the wider applicability of these findings due to the increased level of uncertainty surrounding a) total rates of fishing mortality (retained plus discards) and b) catch location coverage (Dedini *et al.*, 2023). These data deficiencies are now being actively addressed as part of the *Data Validation Plan* and ancillary projects examining the impact of trawl fishing on non-target species (Department of Agriculture and Fisheries, 2018b; Fisheries Research and Development Corporation, 2023a; Queensland Government, Undated).

#### 4.2.5.4 Sharks

The Moreton Bay Trawl Region LCA included six shark species, most of which are widely dispersed and have fewer conservation concerns (Ebert *et al.*, 2021; Kyne *et al.*, 2021; Last & Stevens, 2009). Of the species assessed, the most notable conservation concerns relate to the capture of the Colclough's shark (*Brachaelurus colcloughi*).

*Brachaelurus colcloughi* is a rare, endemic species and it is likely to occur at a naturally low abundance. Information sets for *B. colcloughi* are less developed and datasets for this species are based on fewer than 80 individuals (Kyne *et al.*, 2011; Kyne *et al.*, 2021). There remains considerable uncertainty surrounding the distribution of *B. colcloughi* and its capacity to interact with the ECOTF. There has, however, been a number of confirmed reports of *B. colcloughi* interacting with commercial fisheries operating in Moreton Bay (Kyne *et al.*, 2023l). Across the broader ECOTF, interactions with this species are more likely to occur in the Southern Inshore, Southern Offshore and Moreton Bay Trawl Regions (Jacobsen, 2007; Kyne *et al.*, 2023l; Rigby *et al.*, 2016b). At present, the northern extent of the *B. colcloughi* range extends to Swains Reef National Park and Flock Pigeon Island (Jacobsen, 2007; Kyne *et al.*, 2023l; Rigby *et al.*, 2016b).

It is difficult to ascertain how frequently *B. colcloughi* interacts with southern Queensland trawl operations or provide an accurate assessment of the regional level of risk. The species though was classified as low risk in a previous ERA examining trawl-related risks in southern Queensland (Campbell *et al.*, 2017). This assessment was compiled using the Sustainability Assessment for Fishing Effects (SAFE) and considered a large proportion of the *B. colcloughi* range. While noting these results, there are broader concerns surrounding the long-term viability of *B. colcloughi* populations on the Queensland east coast. For example, the species registered an extinction risk classification of Vulnerable under the IUCN criteria with the assessment noting a downward population trend (Kyne *et al.*, 2015; Kyne *et al.*, 2021). These results did not translate directly to the *Shark and Ray Report Card* where data deficiencies made it more difficult to define a stock status (pers. comm. I. Jacobsen; Kyne *et al.*, 2023l).[48]

In the Moreton Bay Trawl Region LCA, it was determined that there was sufficient evidence to assign *B. colcloughi* a more precautionary risk rating (Table 4; Data Report: Appendix E). There remains a high level of uncertainty surrounding this species and there is an increased risk that regional fishing activities will have a negative, long-term impact on regional populations. This risk is elevated by an absence of information on interaction rates in the ECOTF and the (overall) limited understanding of

[48] The first iteration of the *Shark Report Card* initially classified this species status as Depleted. These status assessments are compiled as part of the *Shark and Ray Report Card* and consider all fishing activities, not just activities within the ECOTF (Fisheries Research and Development Corporation, 2023b).

how this species survives a trawl interaction. This situation is expected to improve with the continued rollout of the *Data Validation Plan* and ancillary research examining the composition of the ECOTF catch (Department of Agriculture and Fisheries, 2018b; 2023a; Fisheries Research and Development Corporation, 2023a).

The remaining shark species are more widespread, have fewer conservation concerns and are exposed to a lower level of risk (Table 4). The brownbanded bamboo shark (*Chiloscyllium punctatum*), collared carpetshark (*Parascyllium collare*), crested hornshark (*Heterodontus galeatus*), zebra shark (*Stegostoma tigrinum*) and Australian weasel shark (*Hemigaleus australiensis*) may be caught as prawn trawl bycatch in Moreton Bay. The extent of these interactions are largely unknown as this portion of the catch is not recorded or systematically monitored e.g. through electronic monitoring or observers. However, anecdotal evidence indicates that at least three of the species have reasonably good post-release survival rates: *C. punctatum*, *H. galeatus* and *S. tigrinum (*Kyne *et al., 2021).* It is further hypothesised that a fourth species, *P. collare*, will display similar levels of resilience (pers. comm. I. Jacobsen).

Without direct validation, it will be difficult to determine how frequently these species interact with trawl operations in Moreton Bay. While noting these deficiencies, previous assessments indicate that trawl fishing activities in southern Queensland pose a lower risk to most of the species assessed (Campbell, 2022; Jacobsen *et al.*, 2015). Similarly, all five were assessed as Least Concern under the IUCN Red List criteria (Kyne *et al.*, 2021) with complementary analyses determining that they are being sustainably fished across their known distributions (Kyne *et al.*, 2023b; Kyne *et al.*, 2023f; h; i; k).

#### 4.2.5.5 Batoids

Research has shown that prawn trawl operations will interact with a diverse array of benthic batoids (Courtney *et al.*, 2007; Jacobsen, 2007; Kyne, 2008; Kyne *et al.*, 2021; Salini *et al.*, 2007; Stobutzki *et al.*, 2001; White *et al.*, 2019). While noting this diversity, only 22 batoids were considered for inclusion in the regional risk assessments (Table 4). The remaining species were excluded from the analysis through a detailed species rationalisation process conducted as part of the Level 2 ERA (Dedini *et al.*, 2023). The Level 2 ERA provides a full account of this process including the justifications used to include or omit a species from the analysis (Appendix A and B of Dedini *et al.*, 2023).

Of the 22 batoids considered, 10 were assessed as part of the Moreton Bay Trawl Region LCA (Fig. 2; Table 4). This region had the smallest number of batoid assessments and did not include any deepwater stingaree (*Urolophus* spp.) or skate (*Dentiraja* spp.) species (Fig. 2; Table 4). Of the species included in the assessment, the vast majority have broad distributions, fewer conservation concerns and are relatively abundant within their preferred habitats (Kyne *et al.*, 2021). They will also derive benefit from fishing prohibitions implemented as part of the *Moreton Bay Marine Park Zoning Plan* (Department of Environment and Science, 2020b; Department of National Parks Sport and Racing, 2015).

Batoids have *k*-selected life-histories and biological traits that increase their long-term vulnerability to trawl fishing activities (Carrier *et al.*, 2004; Jacobsen & Bennett, 2011; Jacobsen & Bennett, 2010; Last *et al.*, 2016). While noting these vulnerabilities, the available evidence suggests that these vulnerabilities/risks are being managed within the current fishing environment. Of the 10 batoids assessed in Moreton Bay, eight were assigned risk ratings of low or low medium (Table 4). These eight species have been assigned extinction risk classifications of Least Concern or Near Threatened

(Kyne *et al.*, 2021) with corresponding assessments indicating current fishing levels are Sustainable (Kyne *et al.*, 2023p; v; w; x; z; 2023ac; d; Kyne *et al.*, 2023ag).[49] These findings support the hypothesis that regional fishing activities, at present, pose a lower risk to these species.

The risk profiles of the two remaining species, the estuary stingray (*Hemitrygon fluviorum*) and the green sawfish (*Pristis zijsron*), are more complicated (Table 4; Data Report: Appendix E). While the biological vulnerabilities of both species are similar to that reported for other batoids (e.g. long-lived, slow growth, delayed onset of sexual maturity and low fecundity), there are more notable concerns surrounding their long-term conservation status. These concerns primarily relate to observed population declines and range contractions along the Australian east coast (Department of the Environment, 2019; Kyne *et al.*, 2021; Pierce & Bennett, 2011). Such is the concern surrounding these two species, *H. fluviorum* has been listed as Near Threatened under the Queensland *Nature Conservation Act 1992* and *P. zijsron* is listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999.*

*Hemitrygon fluviorum* prefers shallow-water environments (0–28 m) and frequently inhabits mangrove-lined rivers, estuaries and embayments (Department of Agriculture and Fisheries, 2021c; Last *et al.*, 2016). Across its range, commercial fishing, recreational fishing and habitat degradation have all been identified as key threats for this species (Kyne *et al.*, 2021; Kyne *et al.*, 2023y; Pierce & Bennett, 2011). In south-east Queensland, *H. fluviorum* will interact with a range of commercial fisheries operating in estuarine and near-shore waters including the River and Inshore Beam Trawl Fishery and Ocean Beach Fishery (Jacobsen *et al.*, 2021; Walton *et al.*, 2019).

The current trawl effort footprint in Moreton Bay has less of an overlap with habitats preferred by *H. fluviorum*. Provisions governing the use of resources within the Moreton Bay Marine Park also provide this species with a degree of protection from trawl fishing activities (Department of Environment and Science, 2020b; Department of National Parks Sport and Racing, 2015). These measures will (likely) reduce the number and frequency of *H. fluviorum* interactions in the Moreton Bay Trawl Region. However, trawl operators will still interact with this species and the industry will contribute to the broader, cumulative risk. Catch data deficiencies make it difficult to assess the extent of this contribution or the frequency of *H. fluviorum* interactions within this region. These deficiencies combined with the declining status of the *H. fluviorum* stock (Kyne *et al.*, 2023y; Rigby & Derrick, 2021b) were taken into consideration as part of the current LCA (Table 4; Data Report: Appendix E).

The situation with *P. zijsron* is more complicated as the species is the subject of more significant conservation concerns. *Pristis zijsron*, as with *H. fluviorum*, has experienced range contractions and population declines on the Queensland east coast. These declines/contractions though are more significant and *P. zijsron* may now be regionally extirpated in waters south of the Whitsundays (Department of the Environment, 2019). For example, the last reported record of a green sawfish being caught in Moreton Bay is from the 1960s (Johnson, 1999; Kyne *et al.*, 2021; Simpfendorfer, 2013). The species is considered Critically Endangered under the IUCN Red List criteria with complementary analyses assessing the stock status as Depleted (Kyne *et al.*, 2021; Kyne *et al.*, 2023aa). While *P. zijsron* is currently listed as Vulnerable under the EPBC Act, the *Action Plan for*

[49] Status assessments conducted as part of the *Shark and Ray Report Card* consider fishing sustainability across a species entire distribution (Fisheries Research and Development Corporation, 2023b).

*Australian Sharks and Rays* recommends that this classification be elevated to Critically Endangered (Kyne *et al.,* 2021).

Range contractions suggest that there is a low probability of *P. zijsron* interacting with operators in the Moreton Bay Trawl Region. This low interaction potential is in direct response to a decline in population health and the impact of cumulative pressures or threats including historic commercial fishing activities. This is an important distinction to make when comparing *P. zijsron* with other batoids whose habitat and depth profiles limit their exposure to trawl fishing. In the Moreton Bay Trawl Region, any interaction (if applicable) will be with a remnant population and may have significant, long-term implications for *P. zijsron*. Given the extent of historic populations declines, this will occur at low levels of fishing mortality and may result in further range contractions, reduced genetic diversity and further fragmentation of regional populations. These concerns were ultimately reflected in the risk rating assigned to *P. zijsron* in the Moreton Bay Trawl Region LCA (Table 4).

# 5 Summary

Outputs of the regional Likelihood and Consequence Analyses indicates that trawl fishing activities pose a low to medium risk to most of the species assessed. For complexes like marine turtles, these results reflect the effectiveness of current risk mitigation strategies including the use of TEDs and spatial/temporal restrictions imposed through fisheries and non-fisheries legislation. The effectiveness of these measures vary between regions and species complexes, with each region having a number of species within the medium and high-risk categories.

When interpreting the results, it is important to consider the context of the assessment. As the LCA examines risk **within the current fishing environment** it, in effect, provides a snapshot of the risk profile within each management region. In doing so, the LCA provides further insight into the more pressing risk areas and the immediacy of the need for management review or intervention. The longevity of these assessments will depend on a range of factors and the outputs will become outdated if there is a notable shift in the fishing environment or within key elements of the assessment e.g. the downgrading of a conservation status of one or more species.

The above contrasts with the Level 2 ERA which provides a comprehensive forward-looking assessment of the species-specific vulnerabilities and the key drivers of risk. The Level 2 ERA considers a wider range of parameters and will be less sensitive to change. As it is a broader assessment, the Level 2 ERA also provides a more detailed examination of the cumulative fishing risks and the collective potential for trawl fishing activities to negatively impact non-target species. Similarly, it includes detailed recommendations on how these longer-term risks can be better understood, managed and (potentially) mitigated in this fishery. For these reasons, the Level 2 ERA is considered a better source to inform discussions surrounding the broader management of risk in the ECOTF, and the potential for this risk to come to fruition over the longer-term and negatively impact the sustainability of a species or its conservation status.

# References


Adams, K. R., Fetterplace, L. C., Davis, A. R., Taylor, M. D. & Knott, N. A. (2018). Sharks, rays and abortion: The prevalence of capture-induced parturition in elasmobranchs. *Biological Conservation* **217**, 11-27.

Australian Fisheries Management Authority (2023a). *Northern Prawn Fishery*. Available at https://www.afma.gov.au/fisheries/northern-prawn-fishery#referenced-section-2 (Accessed 3 April 2023).

Australian Fisheries Management Authority (2023b). *Threatened and Endangered Species Reporting.* Available at https://www.afma.gov.au/protected-species/threatened-and-endangered-species-reporting (Accessed 3 April 2023).

Biddle, T. M. & Limpus, C. J. (2011). *Marine Wildlife Stranding and Mortality Database Annual Reports 2005-2010. III. Marine Turtles.* Department of Environment and Heritage Protection, Queensland Government. Brisbane.

Braccini, M., Van Rijn, J. & Frick, L. (2012). High Post-Capture Survival for Sharks, Rays and Chimaeras Discarded in the Main Shark Fishery of Australia? *PLOS ONE* **7**, e32547.

Bray, D. J. & Thompson, V. J. (2020). *Solegnathus dunckeri* in Fishes of Australia. Available at https://fishesofaustralia.net.au/home/species/1469#summary (Accessed 17 July 2023).

Brewer, D., Heales, D., Milton, D., Dell, Q., Fry, G., Venables, B. & Jones, P. (2006). The impact of turtle excluder devices and bycatch reduction devices on diverse tropical marine communities in Australia's northern prawn trawl fishery. *Fisheries Research* **81**, 176-188.

Business Queensland (2022). *Turtle Excluder Devices, .* Available at https://www.business.qld.gov.au/industries/farms-fishing-forestry/fisheries/fisheries-profiles/trawl-fisheries/turtle-excluder-devices#:~:text=Turtle%20excluder%20devices%20(TEDs)%20modify,the%20beginning%20of%20the%20codend. (Accessed 8 March 2023).

Campbell, M., Courtney, A. J., Wang, N., McLennan, M. & Zhou, S. (2017). *Estimating the Impacts of Management Changes on Bycatch Reduction and Sustainability of High-risk Bycatch Species in the Queensland East Coast Otter Trawl Fishery*. FRDC Final Report Project number 2015/014. Brisbane, Queensland.

Campbell, M. J. (2022). Assessing ecological risk posed to common rays by prawn trawling. James Cook University.

Campbell, M. J., Tonks, M. L., Miller, M., Brewer, D. T., Courtney, A. J. & Simpfendorfer, C. A. (2020). Factors affecting elasmobranch escape from turtle excluder devices (TEDs) in a tropical penaeid-trawl fishery. *Fisheries Research* **224**.

Carrier, J. C., Musick, J. A. J. & Heithaus, M. (2004). *Biology of sharks and their relatives*.

Chapple, D., Tingley, R., Mitchell, N., Macdonald, S., Keogh, J., Shea, G., Bowles, P., Cox, N. & Woinarski, J. (2019). *Action Plan for Australian Lizards and Snakes 2017*.

Connolly, R. M., Cronin, E. R. & Thomas, B. E. (2001). *Trawl Bycatch of Syngnathids in Queensland: Catch Rates, Distribution and Population Biology of Solegnathus Pipehorses (Seadragons)*. Gold Coast: School of Environmental and Applied Sciences, Griffith University.

Courtney, A. J., Campbell, M. J., Tonks, M., Roy, D. P., Gaddes, S., Haddy, J., Kyne, P. M., Mayer, D. G. & Chilcott, K. (2014). Effects of bycatch reduction devices in Queensland's (Australia) deepwater eastern king prawn (*Melicertus plebejus*) trawl fishery. *Fisheries Research* **157**, 113-123.

Courtney, A. J., Haddy, J. A., Campbell, M. J., Roy, D. P., Tonks, M. L., Gaddes, S. W., Chilcott, K. E., O'Neill, M. F., Brown, I. W. & McLennan, M. (2007). *Bycatch Weight, Composition and Preliminary Estimates of the Impact of Bycatch Reduction Devices in Queensland's Trawl Fishery*. Department of Primary Industries and Fisheries, Queensland Government. Brisbane, Queensland.

Courtney, A. J., Schemel, B. L., Wallace, R., Campbell, M. J., Mayer, D. G. & Young, B. (2010). *Reducing the Impact of Queensland's Trawl Fisheries on Protected Sea Snakes*. Queensland Government & Fisheries Research and Development Corporation. Brisbane, Queensland.

de Sousa Rangel, B., de Castro Ribeiro, D., Chagas, J. M. A., Spada, L., Moreira, R. G. & da Silva Ribeiro, C. (2020). Effects of biological traits on capture-induced parturition in a freshwater stingray and perspectives for species management. *Journal of Fish Biology*.

Dedini, E., Jacobsen, I. & Zieth, J. (2023). *East Coast Otter Trawl Fishery Ecological Risk Assessment Species of Conservation Concern*. Queensland Government. Brisbane, Queensland.

Department of Agriculture and Fisheries (2012). *Turtle excluder devices: Technical information guide for commercial fishers and net makers*. https://www.daf.qld.gov.au/__data/assets/pdf_file/0006/61872/TED-guide_update_web_Part1.pdf

Department of Agriculture and Fisheries (2017). *Queensland Sustainable Fisheries Strategy 2017–2027*. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy-overview (Accessed 13 October 2020).

Department of Agriculture and Fisheries (2018a). Ecological Risk Assessment Guidelines. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy-overview (Accessed 13 October 2020).

Department of Agriculture and Fisheries (2018b). Data Validation Plan. Available at https://www.publications.qld.gov.au/dataset/fisheries-data-validation-plan (Accessed 24 July 2024).

Department of Agriculture and Fisheries (2020). Trawl Fishery Working Group - Communiques. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/fishery-working-groups/trawl-working-group/communiques (Accessed 7 September 2022).

Department of Agriculture and Fisheries (2021a). *New Management Arrangements for Queensland Saucer Scallop Fishery*. Available at https://www.daf.qld.gov.au/news-media/media-centre/fisheries/news/new-management-arrangements-for-queensland-saucer-scallop-fishery (Accessed 21 January 2022).

Department of Agriculture and Fisheries (2021b). *Trawl fishery (central region) harvest strategy: 2021–2026*. https://www.publications.qld.gov.au/dataset/b6593048-25b1-46c1-9feb-00a03d6501df/resource/b0d530dc-34ba-4dd7-9109-b79f3a785203/download/central-trawl-region-harvest-strategy.pdf

Department of Agriculture and Fisheries (2021c). *Trawl fishery (southern offshore A and B region) harvest strategy: 2021–2026*. https://www.publications.qld.gov.au/dataset/b6593048-25b1-46c1-9feb-00a03d6501df/resource/b23ffab7-c4b0-4441-b4f4-0ef040208f2a/download/southern-offshore-trawl-region-harvest-strategy.pdf

Department of Agriculture and Fisheries (2021d). *Trawl fishery (northern region) harvest strategy: 2021–2026*. https://www.publications.qld.gov.au/dataset/b6593048-25b1-46c1-9feb-00a03d6501df/resource/2d129e11-bfc9-4a41-a766-3104bbcaa677/download/northern-trawl-region-harvest-strategy.pdf

Department of Agriculture and Fisheries (2021e). *Trawl fishery (southern inshore region) harvest strategy: 2021–2026*. https://www.publications.qld.gov.au/dataset/b6593048-25b1-46c1-9feb-00a03d6501df/resource/25136e07-b01d-4809-b27d-34f6c9b24976/download/southern-inshore-trawl-region-harvest-strategy.pdf

Department of Agriculture and Fisheries (2021f). *Trawl fishery (Moreton Bay region) harvest strategy: 2021–2026*. https://www.publications.qld.gov.au/dataset/b6593048-25b1-46c1-9feb-00a03d6501df/resource/3e2440e2-c4ef-41cd-874e-c06a1c47baa8/download/moreton-bay-trawl-region-harvest-strategy.pdf

Department of Agriculture and Fisheries (2021g). Dashboard: Recreational Fishing Catch Estimates. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/monitoring-research/monitoring-reporting/recreational-fishing/statewide-recreational-fishing-surveys/dashboard (Accessed 14 May 2021).

Department of Agriculture and Fisheries (2022a). QFish. Available at http://qfish.fisheries.qld.gov.au/ (Accessed 9 May 2022).

Department of Agriculture and Fisheries (2022b). Ecological Risk Assessment. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/monitoring-research/data/ecological-risk-assessments (Accessed 11 January 2023).

Department of Agriculture and Fisheries (2023a). Data Validation Plan: Status Update 2023. Available at https://www.publications.qld.gov.au/dataset/fisheries-data-validation-plan (Accessed 24 July 2024).

Department of Agriculture and Fisheries (2023b). *Scoping Study - East Coast Otter Trawl Fishery*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia.

Department of Climate Change Energy the Environment and Water (2021). *Queensland East Coast Otter Trawl: Current Decisions*. Available at https://www.awe.gov.au/environment/marine/fisheries/qld/east-coast-otter-trawl (Accessed 15 May 2023).

Department of Climate Change Energy the Environment and Water (Undated). *Species Profile and Threats Database*. Available at http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl (Accessed 10 March 2023).

Department of Environment and Science (2020a). Great Sandy Marine Park: Management and Zoning. Available at https://parks.des.qld.gov.au/parks/great-sandy-marine/management-and-zoning (Accessed 4 September 2020).

Department of Environment and Science (2020b). Moreton Bay Marine Park: Management and Zoning. Available at https://parks.des.qld.gov.au/parks/great-sandy-marine/management-and-zoning (Accessed 4 September 2020).

Department of Environment and Science (2021). *Queensland Marine Turtle Conservation Strategy (2021 - 2031).* Brisbane: Queensland Government.

Department of Environment and Science (2022). Marine wildlife strandings annual reports. *State of Queensland*. Available at https://www.qld.gov.au/environment/plants-animals/wildlife/marine-strandings/stranding-data/annual-reports (Accessed 9 March 2023).

Department of Environment Science and Innovation (2015). *The Science Behind the Zoning Plan.* Available at https://parks.des.qld.gov.au/parks/moreton-bay/zoning/zoning-plan-history/the_science_behind_the_zoning_plan (Accessed 24 April 2024).

Department of Environment Science and Innovation (2021). *Turtles.* Available at https://parks.des.qld.gov.au/parks/moreton-bay/zoning/information-sheets/turtles (Accessed

Department of National Parks Sport and Racing (2015). *Moreton Bay Marine Park User Guide*. Queensland Government. Brisbane. https://parks.des.qld.gov.au/parks/moreton-bay/zoning/pdf/marine-park-user-guide.pdf

Department of the Environment (2015a). *Sawfish and River Sharks Multispecies Issues Paper*. Department of Environment, Australian Government. Canberra, ACT.

Department of the Environment (2015b). *Sawfish and River Sharks Multispecies Recovery Plan*. Department of Environment, Australian Government. Canberra, ACT. https://www.dcceew.gov.au/environment/biodiversity/threatened/publications/recovery/sawfish-river-sharks-multispecies-recovery-plan

Department of the Environment (2019). *Pristis zijsron* in Species Profile and Threats Database. Available at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68442 (Accessed 11 November 2019).

Department of the Environment (2023a). *Dermochelys coriacea* in Species Profile and Threats Database. Available at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1768 (Accessed 28 February 2023).

Department of the Environment (2023b). *Chelonia mydas* in Species Profile and Threats Database. Available at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1765 (Accessed 28 February 2023).

Department of the Environment (2023c). *Caretta caretta* in Species Profile and Threats Database. Available at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1763 (Accessed 28 February 2023).

Department of the Environment (2023d). *Eretmochelys imbricata* in Species Profile and Threats Database. Available at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1766 (Accessed 28 February 2023).

Department of the Environment and Energy (2017). Recovery Plan for Marine Turtles in Australia. Available at http://www.environment.gov.au/marine/publications/recovery-plan-marine-turtles-australia-2017 (Accessed 1 June 2018).

Dodt, N. (2005). Fisheries Long Term Monitoring Program: Syngnathids in the East Coast Trawl Fishery: a review and trawl survey. *Department of Primary Industries, Queensland*. Available at www.daff.qld.gov.au/fisheries/monitoring-our-fisheries/commercial-fisheries/species-specific-programs/monitoring-reporting/syngnathids-in-the-east-coast-trawl-fishery (Accessed 28 May 2018).

Dunning, M., Lightowler, M. & Jones, P. (2001). *Syngnathid (pipefish) harvest from the Queensland East Coast Trawl Fishery*. Department of Primary Industries, Queensland Government. Brisbane, Australia.

Ebert, D., Dando, M. & Fowler, S. (2021). *Sharks of the World: A Complete Guide*. United States of America: Princeton University Press.

Eckert, K. L., Fish, U. S. & Wildlife, S. (2012). *Synopsis of the Biological Data on the Leatherback Sea Turtle (Dermochelys coriacea)*.

Fisheries Research and Development Corporation (2023a). *Reducing impacts on threatened, endangered, and protected species in the Queensland East Coast Otter Trawl Fishery.* Available at https://www.frdc.com.au/project/2023-009 (Accessed 11 March 2023).

Fisheries Research and Development Corporation (2023b). Shark & Ray Report Card. Available at https://www.fish.gov.au/2019-shark-and-ray-reports (Accessed 13 March 2024).

Fletcher, W. J. (2015). Review and refinement of an existing qualitative risk assessment method for application within an ecosystem-based management framework. *ICES Journal of Marine Science* **72**, 1043-1056.

Fletcher, W. J., Chesson, J., Sainsbury, K. J., Hundloe, T. J. & Fisher, M. (2005). A flexible and practical framework for reporting on ecologically sustainable development for wild capture fisheries. *Fisheries Research* **71**, 175-183.

Great Barrier Reef Marine Park Authority (2022). Special Management Areas. Available at http://www.gbrmpa.gov.au/access-and-use/zoning/special-management-areas (Accessed 10 March 2023).

Great Barrier Reef Marine Park Authority (2023). *Protected Species.* Available at https://www2.gbrmpa.gov.au/learn/animals/protected-species (Accessed 16 February 2024).

Great Barrier Reef Marine Park Authority (Undated). *Zoning.* Available at https://www2.gbrmpa.gov.au/access/zoning (Accessed 27 July 2023).

Greenland, J. & Limpus, C. J. (2003). *Marine wildlife stranding and mortality database annual report 2003 - III. Marine Turtles*. Brisbane, Queensland.

Greenland, J. & Limpus, C. J. (2004). *Marine wildlife stranding and mortality database annual report 2004 - III. Marine Turtles*. Brisbane, Queensland.

Greenland, J., Limpus, C. J. & Currie, K. (2002). *Marine wildlife stranding and mortality database annual report 2001-2002 - III. Marine Turtles*. Brisbane, Queensland.

Haines, J. A., Limpus, C. J. & Flakus, S. (1999). *Marine wildlife stranding and mortality database annual report 1999 - III. Marine Turtle*. Queensland Parks and Wildlife Service. Brisbane.

Haque, A. B., Charles, R., D'Anastasi, B., Dulvy, N. K., Faria, V., Fordham, S., Grant, M. I., Harry, A. V., Jabado, R. W., Lear, K. O., Morgan, D. L., Tanna, A., Wakhida, Y. & Wueringer, B. E. (2023). *Anoxypristis cuspidata*. The IUCN Red List of Threatened Species 2023. Available at https://www.iucnredlist.org/species/39389/58304073 (Accessed 19 June 2024).

Harry, A. V., Everett, B., Faria, V., Fordham, S., Grant, M. I., Haque, A. B., Ho, H., Jabado, R. W., Jones, G. C. A., Lear, K. O., Morgan, D. L., Phillips, N., M., Spaet, J. L. Y., Tanna, A. & Wueringer, B. E. (2022). *Pristis zijsron*. The IUCN Red List of Threatened Species 2022. Available at https://www.iucnredlist.org/species/39393/58304631 (Accessed 13 March 2023).

International Union for Conservation of Nature's Red List of Threatened Species (2022). *The IUCN Red List of Threatened Species.* Available at https://www.iucnredlist.org/ (Accessed 24 August 2022).

Jacobsen, I. (2007). Biology of Five Benthic Elasmobranch Species from Northern and North-eastern Australia, Including a Taxonomic Review of Indo-West Pacific *Gymnuridae*. University of Queensland.

Jacobsen, I. & Bennett, M. (2011). Life history of the blackspotted whipray *Himantura astra*. *Journal of Fish Biology* **78**, 1249-1268.

Jacobsen, I., Walton, L. & Lawson, A. (2021). *East Coast Inshore Fishery Level 2 Ecological Risk Assessment (Ocean Beach)*. Queensland Government. Brisbane, Queensland.

Jacobsen, I., Zeller, B., Dunning, M., Garland, A., Courtney, T. & Jebreen, E. (2015). *An Ecological Risk Assessment of the Southern Queensland East Coast Otter Trawl Fishery and the River & Inshore Beam Trawl Fishery*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Queensland.

Jacobsen, I. P. & Bennett, M. B. (2010). Age and growth of *Neotrygon picta*, *Neotrygon annotata* and *Neotrygon kuhlii* from north-east Australia, with notes on their reproductive biology. *Journal of Fish Biology* **77**, 2405-2422.

Johnson, J. (1999). Annotated checklist of the fishes of Moreton Bay, Queensland, Australia. *Memoirs of the Queensland Museum* **43**, 709-762.

Kuiter, I. A. (2000). *Seahorses, pipefishes and their relatives: a comprehensive guide to syngnathiformes.* Chorleywood, UK: TMC Publishing.

Kyne, P. (2008). Chondrichthyans and the Queensland East Coast Trawl Fishery: Bycatch reduction, biology, conservation status and sustainability.

Kyne, P. M., Compagno, L. J. V., Last, P. R. & Stevens, J. D. (2015). *Brachaelurus colcloughi.* The IUCN Red List of Threatened Species 2015. Available at https://www.iucnredlist.org/species/39335/68610594 (Accessed 13 June 2022).

Kyne, P. M., Compagno, L. J. V., Stead, J., Jackson, M. V. & Bennett, M. B. (2011). Distribution, habitat and biology of a rare and threatened eastern Australian endemic shark: Colclough's shark, *Brachaelurus colcloughi* Ogilby, 1908. *Marine and Freshwater Research* **62**, 540-547.

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2021). *The Action Plan for Australian Sharks and Rays 2021*. National Environmental Science Program. Hobart, Australia.

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023a). *Shark & Report Card: Eastern Banded Catshark, Atelomycterus marnklha.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Atelomycterus_marnkalha_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023b). *Shark & Ray Report Card: Brownbanded Bambooshark, Chiloscyllium punctatum.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Chiloscyllium_punctatum_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023c). *Shark & Ray Report Card: Pale Spotted Catshark, Asymbolus pallidus.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Asymbolus_pallidus_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023d). *Shark & Ray Report Card: Eastern Angelshark, Squatina albipunctata.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Squatina_albipunctata_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023e). *Shark & Ray Report Card: Zebra Hornshark, Heterodontus zebra.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Heterodontus_zebra%20_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023f). *Shark & Ray Report Card: Australian Weasel Shark, Hemigaleus australiensis*. Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Hemigaleus_australiensis_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023g). *Shark & Ray Report Card: Sydney Skate, Dentiraja australis*. Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Dentiraja_australis_draft.pdf (Accessed 6 April 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023h). *Shark & Ray Report Card: Zebra Shark, Stegostoma tigrinum.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Stegostoma_tigrinum_final.pdf (Accessed 4 April 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023i). *Shark & Ray Report Card: Crested Hornshark, Heterodontus galeatus.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Heterodontus_galeatus%20_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023j). *Shark & Ray Report Card: Orange Spotted Catshark, Asumbolus rubiginosus.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Asymbolus_rubiginosus_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023k). *Shark & Ray Report Card: Collar Carpetshark, Parascyllium collare.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Parascyllium_collare%20_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023l). *Shark & Ray Report Card: Colclough's Shark, Brachaelurus colcloughi.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Brachaelurus_colcloughi_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023m). *Shark & Ray Report Card: Grey Spotted Catshark, Asymbolus analis.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Asymbolus_analis_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2023n). *Shark & Ray Report Card: Piked Spurdog, Squalus megalops.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Squalus_megalops_final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023o). *Shark & Ray Report Card: Eyebrow Wedgefish, Rhynchobatus palpebratus.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Rhynchobatus_palpebratus_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023p). *Shark & Ray Report Card: Blackspotted Whipray, Maculabatis astra.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Maculabatis_astra_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023q). *Shark & Ray Report Card: Patchwork Stingaree, Urolophus flavomosaicus.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Urolophus_flavomosaicus_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023r). *Shark & Ray Report Card: Argus Skate, Dentiraja polyommata*. Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Dentiraja_polyommata_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023s). *Shark & Ray Report Card: Speckled Maskray, Neotrygon picta.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Neotrygon_picta_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023t). *Shark & Ray Report Card: Endeavour Skate, Dentiraja endeavouri.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Dentiraja_endeavouri_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023u). *Shark & Ray Report Card: Narrow Sawfish, Anoxypristis cuspidata*. . Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Anoxypristis_cuspidata_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023v). *Shark & Ray Report Card: Australian Butterfly Ray, Gymnura australis.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Gymnura_australis_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023w). *Shark & Ray Report Card: Brown Whipray, Maculabatis toshi.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Maculabatis_toshi_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023x). *Shark & Ray Report Card: Bottlenose Wedgefish, Rhynchobatus australiae.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Rhynchobatus_australiae_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023y). *Shark & Ray Report Card: Estuary Stingray, Hemitrygon fluviorum.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Hemitrygon_fluviorum_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023z). *Shark & Ray Report Card: Coral Sea Maskray, Neotrygon trigonoides.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Neotrygon_trigonoides_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023aa). *Shark & Ray Report Card: Green Sawfish, Pristis zijsron.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Pristis_zijsron_Final.pdf (Accessed 24 August 2023).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023ab). *Shark & Ray Report Card: Yellowback Stingaree, Urolophus sufflavus.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Urolophus_sufflavus_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023ac). *Shark & Ray Report Card: Australian Whipray, Himantura australis.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Himantura_australis_Final.pdf (Accessed 13 March 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023ad). *Shark & Ray Report Card: Giant Guitarfish, Glaucostegus typus.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Glaucostegus_typus_Final.pdf (Accessed 26 April 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023ae). *Shark & Ray Report Card: Sandyback Stingaree, Urolophus bucculentus.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Urolophus_bucculentus_Final.pdf (Accessed 5 April 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A. & Rigby, C. L. (2023af). *Shark & Ray Report Card: Greenback Stingaree, Urolophus viridis.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Urolophus_viridis_Final.pdf (Accessed 5 April 2024).

Kyne, P. M., Heupel, M. R., White, W. T., Simpfendorfer, C. A., Rigby, C. L. & Peddemors, V. (2023ag). *Shark & Ray Report Card: Eastern Shovelnose Ray, Aptychotrema rostrata.* Available at https://www.fish.gov.au/docs/SharkReport/2023_FRDC_Aptychotrema_rostrata_Final.pdf (Accessed 13 March 2024).

Last, P., White, W., Séret, B., Naylor, G., de Carvalho, M. & Stehmann, M. (2016). *Rays of the World*. Clayton South: CSIRO Publishing.

Last, P. R. & Stevens, J. D. (2009). Sharks and rays of Australia. 645.

Limpus, C. J. (2007a). *A biological review of Australian marine turtle species. 5. Flatback turtle, Natator depressus (Garman)*. Environmental Protection Agency. Brisbane.

Limpus, C. J. (2007b). *A biological review of Australian marine turtle species. 3. Hawksbill Turtle, Eretmochelys imbricata (Linnaeus)*. Environmental Protection Agency. Brisbane.

Limpus, C. J. (2008a). *A biological review of Australian marine turtle species. 4. Olive Ridley turtle Lepidochelys olivacea (Eschscholtz)*. Environmental Protection Agency. Brisbane.

Limpus, C. J. (2008b). *A biological review of Australian marine turtle species. 1. Loggerhead turtle, Caretta caretta (Linneaus)*. Environmental Protection Agency. Brisbane.

Limpus, C. J. (2008c). *A biological review of Australian marine turtle species. 2. Green turtle, Chelonia mydas (Linnaeus)*. Environmental Protection Agency. Brisbane.

Limpus, C. J. (2009). *A biological review of Australian marine turtle species. 6. Leatherback turtle, Dermochelys coriacea (Vandelli)*. Environmental Protection Agency. Brisbane. http://austurtle.org.au/SeaTurtleBiology/Leatherback_Vandelli.pdf

Lourie, S. A. (2016). *Seahorses: A Life-size Guide to Every Species*: University of Chicago Press.

Lukoschek, V., Guinea, M., Milton, D., Courtney, T. & Fletcher, E. (2010). *Aipysurus duboisii.* The IUCN Red List of Threatened Species 2010. Available at https://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T176748A7296594.en (Accessed 31 January 2023).

Lukoschek, V., Guinea, M., Rasmussen, A., Courtney, T., Read, M. & Gatus, J. (2010). *Emydocephalus annulatus*. The IUCN Red List of Threatened Species 2010. Available at https://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T176720A7290209.en (Accessed 19 October 2023).

Marine Stewardship Council (2023). *Fisheries.* Available at https://www.msc.org/for-business/fisheries#:~:text=MSC%20certification%20is%20a%20way,they're%20buying%20is%20sustainable. (Accessed 4 April 2023).

Meager, J. J. & Limpus, C. J. (2012). *Marine wildlife stranding and mortality database annual report 2011. III. Marine Turtle*. Conservation Technical and Data Report 2012. Department of Environment and Heritage Protection, Queensland Government. Brisbane.

Milton, D., Courtney, T., Guinea, M. & Lukoschek, V (2010). *Hydrophis elegans*. The IUCN Red List of Threatened Species 2010. Available at https://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T176734A7292879.en (Accessed 15 August 2023).

Milton, D., Zhou, S., Fry, G. & Dell, Q. (2007). Risk assessment and mitigation for sea snakes caught in the Northern Prawn Fishery.

Milton, D. A., Fry, G. C. & Dell, Q. (2009). Reducing impacts of trawling on protected sea snakes: by-catch reduction devices improve escapement and survival. *Marine and Freshwater Research* **60**, 824-832.

National Oceanic and Atmospheric Administration Fisheries (2021). *Turtle Excluder Devices*. Available at https://www.fisheries.noaa.gov/southeast/bycatch/turtle-excluder-devices#:~:text=Current%20TED%20designs%20have%20been,effective%20ways%20to%20reduce%20bycatch. (Accessed 8 March 2023).

Patterson, H., Galeano, D., Larcombe, J., Timmiss, T., Woodhams, J. & Curtotti, R. (2022). *Fishery Status Report 2022*. Australian Bureau of Agricultural and Resource Economics and Sciences. Canberra, Australia.

Pears, R., Morison, A., Jebreen, E., Dunning, M., Pitcher, C., Courtney, A., Houlden, B. & Jacobsen, I. (2012a). Ecological risk assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef Marine Park: Data report.

Pears, R. J., Morison, A. K., Jebreen, E. J., Dunning, M. C., Pitcher, C. R., Courtney, A. J., Houlden, B. & Jacobsen, I. P. (2012b). *Ecological Risk Assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef Marine Park: Technical Report*. Great Barrier Reef Marine Park Authority. Townsville, Queensland. http://elibrary.gbrmpa.gov.au/jspui/bitstream/11017/1148/1/ECOTF_ERA_Technical_web.pdf

Pierce, S. & Bennett, M. (2011). Destined to decline? Intrinsic susceptibility of the threatened estuary stingray to anthropogenic impacts. *Marine and Freshwater Research* **61**.

Pogonoski, J., Pollard, D. A. & Rigby, C. L. (2016). *Squatina albipunctata*. The IUCN Red List of Threatened Species 2016. Available at https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T42729A68645549.en (Accessed 12 December 2022).

Queensland Government (2020). *Hawksbill Turtle*. Available at https://www.qld.gov.au/environment/plants-animals/animals/discovering-wildlife/turtles/species/hawksbill-turtle#:~:text=In%20Australia%20the%20hawksbill%20turtle,including%20the%20Great%20Barrier%20Reef. (Accessed 27 March 2024).

Queensland Government (2022). *Overview of Bycatch Reduction Devices.* Available at https://www.business.qld.gov.au/industries/farms-fishing-forestry/fisheries/fisheries-profiles/trawl-fisheries/reducing-bycatch/overview-devices (Accessed 28 April 2023).

Queensland Government (2024). *Commercial Fishing Logbooks.* Available at https://www.business.qld.gov.au/industries/farms-fishing-forestry/fisheries/commercial/report/logbook (Accessed 20 February 2024).

Queensland Government (Undated). *Commercial Fishing Onboard Camera Field Trial.* Available at https://daf.engagementhub.com.au/onboard-camera-trial (Accessed 5 April 2023).

Rasmussen, A. (2018). *Hydrophis zweifeli* (amended version of 2010 assessment). The IUCN Red List of Threatened Species 2018. Available at https://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T176716A134229775.en (Accessed 31 January 2023).

Rasmussen, A. R., Courtney, T. & Sanders, K. (2021). *Aipysurus mosaicus*. The IUCN Red List of Threatened Species 2021. Available at https://dx.doi.org/10.2305/IUCN.UK.2021-2.RLTS.T129302685A129302692.en (Accessed 31 January 2023).

Rigby, C. (2015). *Life History of Deepwater Chondrichthyans.* In *Centre for Sustainable Tropical Fisheries and Aquaculture*. Townsville.

Rigby, C., White, W., Smart, J. & Simpfendorfer, C. (2016a). Life histories of two deep-water Australian endemic elasmobranchs: Argus skate *Dipturus polyommata* and eastern spotted gummy shark *Mustelus walkeri*. *Journal of Fish Biology* **88**, 1149-1174.

Rigby, C. L. & Derrick, D. (2021a). *Dentiraja endeavouri. The IUCN Red List of Threatened Species 2021*. Available at https://dx.doi.org/10.2305/IUCN.UK.2021-2.RLTS.T195446A68620738.en (Accessed 20 December 2022).

Rigby, C. L. & Derrick, D. (2021b). *Hemitrygon fluviorum.* The IUCN Red List of Threatened Species 2021. Available at https://www.iucnredlist.org/species/41797/68618306 (Accessed 26 April 2024).

Rigby, C. L., White, W. T. & Simpfendorfer, C. A. (2016b). Deepwater Chondrichthyan Bycatch of the Eastern King Prawn Fishery in the Southern Great Barrier Reef, Australia. *PLOS ONE* **11**, e0156036.

Salini, J., McAuley, R., Blaber, S., Buckworth, R., Chidlow, J., Gribble, N., Ovenden, J., Peverell, S., Pillans, R., Stevens, J., Stobutzki, I., Tarca, C. & Walker, T. (2007). *Northern Australian Sharks and Rays: the Sustainability of Target and Bycatch Species, Phase 2*. Cleveland, Queensland: CSIRO Marine and Atmospheric Research.

Simpfendorfer, C. A. (2013). *Pristis zijsron.* The IUCN Red List of Threatened Species 2013. Available at https://www.iucnredlist.org/species/39393/18620401 (Accessed 11 December 2018).

State of Queensland (2019). *Fisheries Declaration 2019*.

Stobutzki, I. C., Miller, M. J., Jones, P. & Salini, J. P. (2001). Bycatch diversity and variation in a tropical Australian penaeid fishery; the implications for monitoring. *Fisheries Research* **53**, 283-301.

Teixeira, D., Janes, R. & Webley, J. (2021). *2019–20 Statewide Recreational Fishing Survey Key Results. Project Report.* Queensland Government. Brisbane, Queensland. https://era.daf.qld.gov.au/id/eprint/7879/

Udyawer, V., Oxenham, K., Hourston, M. & Heupel, M. (2020). Distribution, fisheries interactions and assessment of threats to Australia's sea snakes.

Udyawer, V., Read, M., Hamann, M., Heupel, M. R. & Simpfendorfer, C. A. (2016). Importance of shallow tidal habitats as refugia from trawl fishing for sea snakes. *Journal of Herpetology* **50**, 527-533.

Walton, L., Jacobsen, I. & Zeller, B. (2019). *River and Inshore Beam Trawl Fishery Level 1 Ecological Risk Assessment*. Queensland Government. Brisbane, Queensland. http://era.daf.qld.gov.au/id/eprint/7062/

Webley, J., McInnes, K., Teixeira, D., Lawson, A. & Quinn, R. (2015). *Statewide Recreational Fishing Survey 2013-14*. Queensland Government. Brisbane, Australia.

White, W. T., Baje, L., Simpfendorfer, C. A., Appleyard, S. A., Chin, A., Sabub, B., Rochel, E. & Naylor, G. J. P. (2019). Elasmobranch bycatch in the demersal prawn trawl fishery in the Gulf of Papua, Papua New Guinea. *Scientific Reports* **9**, 9254.

Wortmann, J. (2022). *Stock Assessment of Ballot's Saucer Scallop (Ylistrum balloti) in Queensland, Australia*. Department of Agriculture, Fisheries and Forestry. Brisbane.

Wortmann, J., O'Neill, M. F., Courtney, A. J. & Yang, W. H. (2020). *Stock Assessment of Ballot's Saucer Scallop (Ylistrum balloti) in Queensland*. Department of Agriculture, Fisheries and Forestry. Brisbane.

Zhou, S. & Griffiths, S. P. (2008). Sustainability Assessment for Fishing Effects (SAFE): A new quantitative ecological risk assessment method and its application to elasmobranch bycatch in an Australian trawl fishery. *Fisheries Research* **91**, 56-68.

Zhou, S., Hobday, A. J., Dichmont, C. M. & Smith, A. D. M. (2016). Ecological risk assessments for the effects of fishing: A comparison and validation of PSA and SAFE. *Fisheries Research* **183**, 518-529.

**The content of the accompanying Data Report includes:**

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| Data Report: Appendix A. | Preliminary scoring and justifications of the Likelihood and Consequence Analysis for species assessed as part of the Northern Trawl Regional Risk Assessment |
| Data Report: Appendix B. | Preliminary scoring and justifications of the Likelihood and Consequence Analysis for species assessed as part of the Central Trawl Regional Risk Assessment |
| Data Report: Appendix C. | Preliminary scoring and justifications of the Likelihood and Consequence Analysis for species assessed as part of the Southern Inshore Trawl Regional Risk Assessment |
| Data Report: Appendix D. | Preliminary scoring and justifications of the Likelihood and Consequence Analysis for species assessed as part of the Southern Offshore Trawl Regional Risk Assessment |
| Data Report: Appendix E. | Preliminary scoring and justifications of the Likelihood and Consequence Analysis for species assessed as part of the Moreton Bay Trawl Regional Risk Assessment |